The CO2 Question:

Technical Progress and the Climate Crisis[1]

PRELIMINARY

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Abstract

Who engages in green R&D and how is corporate behavior affected by green technical progress? Based on global patent filings, corporate financial reporting, and corporate carbon emissions we analyze corporate green and brown R&D activity and its effects in reducing carbon emissions. We find consistent support for the path-dependence hypothesis of innovation. In each sector around the world innovating companies with higher carbon emissions tend to engage more in brown R&D and less in green R&D. Despite a consistent rise in the share of green R&D over our sample period we find little effect of green innovation on future carbon emissions. Direct emissions of green innovating companies are not significantly affected by green innovation across all sectors and around the world, whether in the short term (one year after filing a green patent) or in the medium term (three years after filing). However, we find weak evidence of a small reduction in indirect upstream emissions following green patent filings.

JEL codes G12, G23, G30, D62, D83

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1

We are in the early stages of a sustainability revolution. It will have the magnitude of the industrial revolution yet the speed of the digital revolution. Al Gore (2020)

There is no doubt that the energy sector will only reach net-zero emissions if there is a significant and concerted global push to accelerate innovation Energy Policy Perspectives 2020 IEA

1. Introduction

How are technological advances shaped by the prospect of an approaching climate change crisis? In this paper, we explore corporate green innovation activity around the world and its effects on corporate behavior, in particular on future corporate carbon emissions. According to the latest IPCC (2021) report, to avoid an increase in average temperatures greater than $1.5°$ C global net carbon emissions must be reduced to zero by 2050. To have any hope of attaining this goal governments around the world have stepped up their policies to curb carbon emissions and accelerate the transition to renewable energy sources.

Yet nearly all analysts agree that a successful global decarbonization cannot be founded only on regulations. It necessarily entails major technical advances in substitute energy sources and other technologies to reduce or capture carbon emissions. According to the IEA (2020), "Reducing global CO2 emissions will require a broad range of different technologies working across all sectors of the economy in various combinations and applications. These technologies are at widely varying stages of development."

Much R&D that is touted as green mainly takes the form of efficiency improvements in energy use. Primary examples are fuel efficiency gains in transport, electricity efficiency gains in refrigeration, air-conditioning, computing, lighting, and heating. The promise of these technological improvements is that the environmental impact of consumption in terms of carbon emissions will become smaller and smaller. However, as Jevons (1865) first noted about coal consumption, greater energy efficiency—by lowering the energy cost of consumption—could induce an increase in aggregate demand for energy, which could undo the anticipated reduction in energy use: "It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption." Indeed, despite all the technological improvements in fossil energy use, we have still not seen a global decoupling of economic growth and carbon emissions.

The title of our paper is a reference to the title of Jevon's (1865) book, *The Coal Question*, as the same economic problem he saw for the consumption of coal, which is only available in limited supply, arises for CO2 concentration in the atmosphere, which can only be accumulated

to a limited amount if we are to avoid global overheating. The main question we are concerned with in this study is the impact of corporate green innovation on future corporate carbon emissions and other corporate decisions such as investment and capital expenditures. What has come to be known as the *Jevons paradox* (and is also referred to as the *rebound effect*) is a warning that green technological progress is not necessarily synonymous with carbon emission reductions. It is unclear a priori what the net effect is on carbon emissions of respectively green R&D and brown efficiency-improving R&D, given that consumption and production are endogenous, and that any successful innovation generates additional economic activity.

The other main question we are concerned with is what corporate characteristics determine whether a company is more likely to engage in green innovation activities. What companies, in which sectors, have been the source of most green R&D? We are able to address these questions by combining three global datasets on respectively corporate patent filings, corporate financial reports, and corporate (direct and indirect) carbon emissions covering the period from 2005 to 2020. All in all, our data covers more than 136 million patents held by 2.3 million firms. Based on the descriptions of the patents we can classify them into three broad categories, green patents (which concern technological improvements in terms of environmental impact), brown efficiency-improving patents (which achieve advances in fossil energy efficiency), and other patents that are not directly related to the environment or to energy. For each firm we can determine the intensity of their green or brown innovation activities by calculating the ratio of the number of their green (respectively brown) patents to the total number of patents they have filed. We calculate these ratios based on either worldwide patent filings or on filings with the European patent office, which are known to be more reliable. We can also weigh the importance of each patent based on the number of citations.

Our main analysis is to explore how these measures of corporate green (or brown) innovation activity are associated with firm characteristics and corporate outcomes. A strong point of our analysis is the comprehensive coverage of corporate innovative activity across firms, sectors, and countries, which allows us to control for country, sector, and firm characteristics. A first contribution of our study is to provide a picture of green innovation activity around the world, across sectors, and over time. For example, we find that 2/3 of publicly listed companies engage in innovation, while only 1/3 of private companies file patents. Furthermore, we find that the distribution of countries contributing at least one green patent is highly skewed, with the top ten countries contributing most green patents. This is also true for the distribution across sectors, with some sectors, such as multi-Utilities, Electric Utilities, Oil, Gas & Consumable Fuels, and Independent Power and Renewable Electricity production standing out for their high ratios of

green to total number of patents. Moreover, green innovation activity has steadily risen over our sample period, with the average patent ratio rising from 0.055 in 2005 to 0.073 in 2019.

The main finding of our study is that corporate green innovation activity has no significant impact on future carbon emissions. Whether in the short run (one year) or medium run (three years ahead), we do not find any significant effect of green innovation on direct emissions. Companies' green R&D activities are largely divorced from their other operations. Consistent with the Jevons paradox, a higher green innovation activity is not associated with future reductions in direct carbon emissions. Over our sample period the green industrial revolution has not yet materialized and the promise of green innovation to set the global economy on a sustainable path to net zero has not yet borne fruit.

A second main finding is that around the world and in all sectors corporate innovative activity is path dependent. Companies with higher emissions tend to do less green R&D and more brown efficiency-improving R&D. In sum, brown companies are found to engage in innovation activities that concern mostly efficiency improvements of their existing brown operations and on average do not seem to redirect their operations towards more environmentally friendly activities through more green innovation. Whereas green companies (those that already have lower carbon emissions) tend to reinforce their green adaptation by engaging in greener R&D.

A third set of findings concern the effects of external corporate governance on green innovation activities. Surprisingly, we find weak evidence suggesting that investors pay close attention to green innovation activities and that they pressure companies to redirect their innovation activities towards greener R&D. This finding is in line with Andriosopoulos, Czarnowski, and Marshall (2021) who find no valuation responses to corporate announcements of green innovation breakthroughs. However, when it comes to internal governance, we find that companies that have more women on the board of directors and a greater percentage of independent board members tend to focus more on green R&D. That is, the negative association between corporate carbon emissions and green patenting is weaker for companies with more diverse and independent boards.

The economics literature on innovation underlines that innovation is path dependent even if it can be directed in response to market pressures (Acemoglu, 2002). The closest studies in terms of findings to ours are by respectively Popp (2002) and Aghion, Dechezlepretre, Hemous, Martin, and Van Reenen (2016) who find that firms with a history of dirty innovation in the past are more likely to focus on dirty innovation in the future. They consider a panel of automobile manufacturers and explore the extent to which these companies produce innovations on combustion-engine cars versus electric, hydrogen or hybrid engine vehicles. Their main finding is that specialization in innovation activity on clean (vs brown) technologies is self-reinforcing. Our

4

study extends this evidence in support of the path-dependency view of innovation to all sectors, not just the automobile sector. Further, we examine not only the drivers but also consequences of green patenting activity. On an empirical front, we take advantage of the rich panel data on carbon emissions while their study utilizes differences across production processes. In this regard, our study is more aligned with the extensive debate on decarbonization policies.

Our findings on path dependency are also in contrast to those of Cohen, Gurun, and Nguyen (2022) who look at green innovation by U.S. listed companies and find that green innovation activity in the energy sector is higher than that in other sectors. We broadly confirm the cross-industry variation they find, but our main finding, however, is that *within* each sector brown companies (those with higher emissions) do less green R&D. This is true across all sectors and countries. More specific differences are that we extend our sample to firms that also file for patents outside the USPTO and firms that are located outside the U.S. We further distinguish between green, brown, and general efficiency patents, which allows us to evaluate the path-dependency hypothesis more explicitly. In this regard, we note that the classification of green patents used in their paper tends to nest what we define as brown efficiency patents. Finally, in their analysis they analyze ESG scores as a metric of environmental performance, which they motivate by the fact that asset managers tend to focus on such scores in their divestment screens. Our results, in turn, are strictly about the importance of carbon emissions for innovation and the consequence thereof for future emissions. In this regard, our paper is closer to the decarbonization efforts undertaken by the society.

An important aspect of green innovation is the role of government policies in supporting innovation (for a literature review, see Greaker and Popp, 2022). These policies are important and can induce a shift to green innovation (e.g., Popp, 2002; Aghion et al., 2016). Our study focuses on firm-level responses and how they depend on their characteristics, especially their carbon emissions. We absorb the impact of innovation policies using industry and country fixed effects, making an implicit assumption here that innovation policies are industry-wide and not firm-specific. Our findings reveal how firms in an industry differentially respond to these policy interventions and how their differential response is linked to firm characteristics such as carbon emissions.

Earlier studies on rebound effects have focused on specific activities or on sector or country-level data. Our study is the first to explore the effects of technological change on carbon emissions based on firm-level data. Findings on the size of rebound effects are mixed. For example, Schipper and Grubb (2000) have looked at aggregate data on energy use and found that car use and energy use in other activities have not changed much in response to technological improvements in energy efficiency. Based on these findings they conclude that rebound effects are

5

likely to be small. Sorrell, Dimitropoulos, and Summerville (2009) provide a review of prior empirical studies on rebound effects. They argue that many studies only look at partial rebound effects over limited time periods and over restricted consumption responses. For example, studies on the consumption response to fuel-efficiency improvements in automobiles only measure changes in mileage travelled and do not consider more long-term changes in vehicle size.

On a broad level, our paper contributes to the growing literature on the role of finance in the transition to green economy. Bolton and Kacperczyk (2021, 2022a) show that the transition is already reflected to a large extent in equity markets. Ilhan, Sautner, and Vilkov (2021) show that carbon risk is also priced in options. Engle et al. (2020) have constructed an index of climate news through textual analysis of the Wall Street Journal and other media and show how a dynamic portfolio strategy can be implemented that hedges transition risk with respect to climate change news. Sautner, Van Lent, Vilkov, and Zhang (2022) show that companies that report positive sentiment towards climate in their conference calls subsequently produce a greater number of green patents.

The remainder of the paper is organized as follows. Section 2 describes the data and provides summary statistics. Section 3 discusses the results on the drivers of green innovation. Section 4 provides the results on the impact of innovation on future emissions and other corporate decisions. Section 5 concludes.

2. Data

Our data construction starts with all global firms, both publicly listed and private, identified between 2005 and 2020 in the following data bases: Orbis Intellectual Property Financial, Orbis, Factset, and Worldscope for financial information (balance sheets and income statements). The financial data for public firms is based on all four. The financial data for private firms is based solely on Orbis IP Financial and Orbis. The latter data sets cover only the ten most recent years; hence, our subset of private firms is limited. To be included in the final sample, we require firm-year observations to have values for assets, book leverage, roe, and county of incorporation. We lose about 180,000 firm-year observations due to this restriction. In addition, we require public firms to have records for capex, previous year's December return, volatility, and market capitalization. This leads to another 200,000 firm-year observations being lost. In the paper, we refer to this filtered dataset as the "full sample".

We further combine the full sample with data from Trucost on firm-level carbon and other greenhouse gas emissions. Trucost reports yearly firm-level carbon and greenhouse gas emissions data for scope 1, 2, and 3 emissions in units of tons of CO_2 equivalent. Scope 1 emissions are

direct emissions from operations of affiliates that are owned or controlled by the company. Scope 2 emissions are those that come from the generation of purchased heat, steam, and electricity used by the company. Scope 3 emissions are indirect emissions caused by the company's operations and the use of its products. These include emissions from the production of purchased materials, product use, waste disposal, and outsourced activities. Establishing the scope 3 emissions of a company requires a detailed analysis of the share of emissions of producers in the supply chain that is attributable to the company's input purchases. This involves estimating an input-output model with sector-level emission factors. We further add data on institutional ownership and governance from Thomson Reuters as well as equity-analyst data from I/B/E/S. Finally, we include world index constituent data from MSCI. We use the ISIN identifier and company names to match these datasets.

Finally, we merge the full dataset with the Orbis Intellectual Property dataset, which provides a comprehensive coverage of patent filings and corporate ownership of patents by listed and unlisted companies in 81 countries. This dataset includes 136 million patents held by 2.3 million firms. A basic description of each patent is provided, which allows us to classify patents into four broad categories: i) "green" patents for environmental technologies; ii) "general efficiency improvement" patents that deal with technologies that improve process efficiency and therefore could reduce emission intensity; iii) "brown" patents that deal with technological innovation for fossil fuel based technologies; and, iv) "OECD" classified green patents, which include technologies related to environmental applications, such as climate mitigation, biodiversity, and waste water management. The dataset also provides patent citations, which are a good measure of the importance of the innovation of the patent. Henceforth, we refer to this dataset as the "patenting sample".

Table 1, Panel A provides a breakdown of our observations by country. In columns 2-4, we report the number of firm observations in our full sample and a breakdown of respectively the number of listed and privately held companies and the number of companies for which we have carbon emissions data from Trucost. The total number of firm-year observations in our sample is 776,007, of which 294,916 are observations from publicly listed companies and 481,086 from privately held firms. We have 122,730 carbon emissions observations from Trucost, which reflects the fact that Trucost only covers emissions from listed and larger companies. Countries with the largest number of full-sample observations include China, the United States, Italy, and Japan. Still, even excluding these countries, our sample has a wide cross-country representation. Notably, in the matched Trucost sample, the U.S. has the largest representation of all countries, which is consistent with the fact that it has the relatively larger fraction of publicly listed companies. In

columns 6-9, we further restrict the full sample to observations for which we have patent data from Orbis. The total number of observations in this sample is roughly a quarter of the universe of companies in our data, which reveals the fact that many companies do not get involved in any innovation activity. Interestingly, relative to the universe of companies in our data, publicly listed companies comprise about 2/3 of the sample with patents and private firms 1/3 of the total number of companies with patents. These ratios are almost reversed when we set them against the original sample, which means that public firms are significantly more likely to engage in innovative activities.

In Panel B, we report the distribution of observations conditional on a firm filing a "green" patent. In columns 2-5, we report the statistics for firms which file a green patent at any patent office in the world, whereas in columns 6-9 we condition on patent filings only at the European Patent Office (EUPO). As is well known, the filing process is most rigorous at the EUPO, so that these filings reflect more significant and enduring innovations. When it comes to worldwide patents, only about 8% of total observations come from companies with at least one green patent. In the cross-section, the U.S., Japan, and China again add the largest number of observations, each of them representing about 20% of the total number of observations. The distribution of countries contributing at least one green patent is skewed, with the top 10 countries contributing most green patents. Publicly listed companies account for 80% of firm-year observations. The fraction of observations that is covered by Trucost is roughly 50%, and about 70% of observations come from publicly listed companies. When we zoom in on EUPO filings, our sample reduces to 20,867 firm-year observations. In this sample, the U.S. and Japan represent almost 50% of all observations. Also, most of the observations come from publicly listed companies, which suggests that barriers to entry may be higher for private firms due to the more rigorous, and thus more costly listing rules. Finally, the Trucost sample is almost 80% of all observations relative to the listed firm universe.

In Panel C, we provide a similar breakdown for "brown" patents. First, we observe that a sample of firm-year observations in this group is about 40% of that for green patents, which means that green patents are a more popular category of innovation. Most firms with at least one brown patent are publicly listed companies. Among the individual countries, the U.S., Japan, China, and South Korea have the largest representation of such patents. The EUPO subsample is about 40% of the worldwide sample. Within that set, the Trucost subsample includes 5938 firm-year observations out of a total of 7360 for publicly listed companies. Overall, green and brown patents represent about 70,000 firm-year observations, which is slightly less than 10% of all observations in the unconditional sample. The number of firm-year observations with either of the two patents

8

that can be matched to Trucost, which is our primary source of information for carbon emissions, is approximately 38,000.

In Figure 1, we show the year-by-year distribution of firm-year observations with patenting activity based on the sample of firms with emission data in Trucost. We separate the data into different patent categories. Panel A presents observations for all firms that are available in Trucost. We observe a steady increase in observations from 2005 until 2015. More pronounced is the sharp increase in observations starting from 2016. This increase can be largely explained by the change in firm coverage by Trucost that took place post-Paris agreement. This can be better observed in Panel B, in which we restrict our observations to firms that are featured in Trucost prior to 2016. We still observe the increase in firm observations over time but the sharp increase in 2016 is no longer as pronounced. In Panel C, we further restrict our universe to firms that featured in Trucost prior to 2006.

In Figure 2, we further show the distribution of firm coverage conditional on the date when the firm first files a patent. We can observe that the number is steady over time for all types of patenting activity. By construction, there is a spike in firm observations in 2006 as this is the first year we trace the firms. Similarly, we can see the visible change in trends around 2016, which is predominantly driven by the change in sample coverage by Trucost. This claim is further verified in Panels B and C, in which we restrict our samples to firms with legacy prior to 2016 or 2006.

The patenting activity can vary across firms. To illustrate the variation in the intensity of patenting activity, we provide in Figure 3 a histogram of firm-year observations conditional on the number of patents in our sample. Panel A is for worldwide patents while Panel B is for EUPO patents. We can see that the worldwide (EUPO) patenting activity is largely skewed towards firms with less than 5 (2) patents, which cover more than 30% of the total firm-year observations.

The above statistics do not provide a full picture about the intensive margin of innovation activity. That is, individual companies may differ in terms of the numbers of patents each of them files. For that reason, we define two variables: GREENRATIOWW, which is the ratio of green patents filed at any patent office in the world over the total number of patent filings in that year, and GREENRATIOEP, which is the same green patent ratio but based only on patent filings at the European Patent Office (EUPO) (interestingly, the fraction of green innovations based on these latter filings is significantly lower, with less than half the same rate based on worldwide patent filings). We define similar ratios for brown patents as well. Table 2 provides information on the ratios of green or brown patents, and total patents, for each country, separately for patents filed anywhere worldwide (columns 2-5) and those filed at EUPO. In Panel A we focus on green patent ratios. The average green patent ratio equals 0.066 for the worldwide sample and 0.113 for the EUPO sample. Interestingly, the ratios do not differ greatly between publicly listed and private

9

companies. For the Trucost sample, the numbers are slightly higher, which is to be expected given the tilt towards larger companies. Furthermore, innovation activity (as measured by the number of firms with at least one patent) is proportional to the size and development of the economy. Among the countries with more than 100 companies owning at least one patent, the ones with the highest ratios of green to total number of patents are: Spain with a ratio of 0.153, Canada with a ratio of 0.124, and Denmark with a ratio of 0.121. In comparison the US that has a ratio of only 0.086, and China an even lower ratio of 0.033. Notably, Saudi Arabia reports a large fraction of green patents 0.153, which is interesting given its strong reliance on oil production. When we look at the EUPO sample, the ratios significantly increase, which means that many of the patents that are filed to EUPO are green patents. Also, many other countries report notable values of green patents, including South Korea, Japan, Belgium, Austria, Norway, and Germany, among others.

In Panel B we provide respective summary statistics based on brown patents. On average, brown patent ratios are significantly smaller. For worldwide patent filings the average number equals 0.016 while the number is 0.033 for the EUPO patents. The unconditional numbers do not deviate much from those based on the Trucost sample. Notable countries for significant brown patenting activity include Saudi Arabia, Italy, Norway, Canada, Austria, Germany, and the U.K. The respective numbers for the U.S. and China are 0.023 and 0.005. To provide additional micro-level evidence on our sample, we provide basic summary statistics for the top-50 firms based on their total emissions in Table A.I of the Appendix.

Table 3 breaks patent activity down by sector (GIC6-industry). In Panel A we present the results for green patents. Some sectors stand out for the intensity of their innovation activities. The Multi-Utilities industry has the highest ratio of green patents filed worldwide, with 0.313, followed up by Electric Utilities, Oil, Gas & Consumable Fuels, and Independent Power and Renewable Electricity Producers. These results are broadly consistent with those in Cohen, Gurun, and Nguyen (2022) for the U.S., even though some of the energy-intensive industries have lower ratios, such as Gas Utilities. On the other end of the green R&D spectrum, IT and healthcare sectors are the two industry groups with the lowest green patent ratios. The ratios are broadly within the same range for public and private firms. They are also not markedly different when we restrict our sample to Trucost observations, which is reassuring about any selection concerns one might have. When we look at the patenting activity at EUPO, we find that public and private firms innovate at similar rates across different industries. We also do not find striking differences with respect to the Trucost sample. At the level of individual industries, we observe similar rankings, but some interesting differences emerge. Electric Utilities and Independent Power and Renewable Electricity Producers are the two industries with the highest green patent ratios, each one exceeding 50%. Multi-Utilities, Oil, Gas &Consumable Fuels, and Gas Utilities are the next

10

three in the ranking, each one of them exceeding 35%. In Panel B, we report the results for brown patents. The ratios are generally larger for publicly listed firms, especially those sectors with higher ratios. Among the most active industries, Energy Equipment & Services leads with the highest ratio of 17.1%, followed by Multi-Utilities (8.4%), and Oil, Gas & Consumable Fuels (6.6%). The results for the restricted sample of EUPO patents reveal a similar ordering. The Energy Equipment ratio is now 20.3%, followed by Independent Power and Renewable Electricity Producers at 19.3%, and Automobiles at 14.1%.

Overall, our evidence indicates significant differences in patenting activity across industries, that is largely consistent with the perceived contribution of these industries to total emissions. Whether individual firms *within* these industries exhibit similar rates of patenting is the question we explore further in our regressions.

In Table 4, we report the distribution of patenting activity by year, with Panel A reporting green patenting activity over time and Panel B reporting brown patenting activity. Columns 2-4 in Panel A report the ratios of green patents based on worldwide filings (respectively brown patent ratios in Panel B), and columns 5-8 report the same ratios based on EUPO filings. Green patent ratios have steadily increased over time. For example, in column 1 we see that this ratio was below the average of 0.065 in 2005, with a ratio of 0.055, but above average in 2019 with a ratio of 0.073. The same increasing trend in green patent activity can be observed for listed companies (in column 2) and for Trucost companies, which are mostly listed companies (in column 4), but there is no trend increase in green patent activity for privately held companies (column 3). The same general pattern can be observed when we restrict attention to EUPO patent filings. Note, however, that for these filings there is also a trend increase in green patent filings for privately held companies. When it comes to brown patent filings (reported in Panel B) we see the opposite trend and a decline in R&D activity over time for brown technologies, but the rate of reduction is very small.

Finally, we also provide summary statistics for the main variables in our models, conditional on the sample of firms that have patents (broken down by patents that are registered worldwide and those that are filed at the EUPO) and firms without patents. We also report extreme deciles for each sample. In addition, we report complete summary statistics for publicly listed firms with emission data (those that can be matched to the Trucost dataset). Our empirical analysis in the subsequent sections is based on this restricted sample. Accordingly, these summary statistics provide information on how the broader universe of firms may differ from the Trucost universe.

We begin by defining all the variables. Our first category is variables related to innovation activity. Besides the variables measuring general innovation activity and respectively green innovation, and brown efficiency improvements that we defined above, we also include variables measuring the impact of patents by how widely cited they are. Thus, GREENCITRATIOWW,

11

GREENCITRATIOEP, BROWNEFFCITRATIOWW, BROWNEFFCITRATIOEP, GENEFFCITRATIOWW, GENEFFCITRATIOEP, OECDCITRATIOWW, and OECDCITRATIOEP are patent citation ratios based on forward citations (how often a patent has been cited in future work) for our different categories of patents.[1] In our second category we include variables measuring corporate carbon emissions (direct and indirect) when available, and standard variables capturing key corporate characteristics.[2] Thus, LOGS1TOT, LOGS2TOT, and LOGS3TOT respectively stand for the natural logarithm of firm-level scope 1, 2, and 3 total carbon emissions, and S1CHG, S2CHG, and S3CHG are the annual percentage change in total scope 1, 2, and 3 firm-level carbon emissions; finally, S1INT, S2INT, and S3INT are firm-level scope 1, 2, and 3 emission intensity variables defined as the level of emission divided by firm sales. In our third category we include the main variables reflecting key corporate characteristics: i) LOGSIZE which stands for the natural logarithm of a listed company's market capitalization (price times shares outstanding); ii) LOGPPE, which is given by the natural logarithm, of the firm's property, plant, and equipment (in $ million); iii) LEVERAGE, which is the ratio of debt to book value of assets; iv) ROE, which is given by the ratio of firm i's net yearly income divided by the value of its equity; v) M/B, which is the end of year market cap divided by the firm's book value; vi) BETA, which is the market beta of individual companies calculated over the preceding 12-month period; vii) VOLAT, which is the standard deviation of returns based on the past 12 monthly returns; viii) momentum, MOM, which is given by the average of the most recent 12 months' returns on stock i, leading up to and including month t-1; ix) short-term reversal, RET, which is the past year's December return on stock i in month t-1; x) capital expenditure INVEST/A, which we measure as the firm's capital expenditures divided by the book value of its assets; xi) MSCI, which is an indicator variable equal to one if a stock is part of the MSCI World index in year t, and zero otherwise; xii) LOGCAPEX, which is the natural logarithm of firm-level capital expenditures; and xiii) LOGCASH, which is the natural logarithm of firm-level cash positions. To mitigate the impact of outliers we winsorize M/B, LEVERAGE, INVEST/A, and ROE at the 2.5% level, and MOM and VOLAT at the 0.5% level.

In Table 5 we report the sample averages, medians, and standard deviations of these variables. Panel A is based on worldwide patenting, and Panel B on patenting at the European Patent Office. Columns 1 to 3 aggregate all firms with at least one patent. Columns 4 to 6 aggregate

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[1] Measuring the importance of patent value is generally a challenging question and, in this paper, we rely on the most basic measure of citation, particularly because of our global focus in the paper. Kogan et al. (2017) is an excellent study providing a more detailed discussion of these issues.

[2] Note that we do not have a complete coverage of all corporate emissions. The Trucost data covers around 85% of listed companies worldwide, and almost no privately held companies. The numbers we report are therefore an underestimate of total corporate emissions, and since a growing fraction of high emitting companies (or their affiliates) have delisted over the period we cover, this underestimate is likely to be larger in later years.

firms without any patents. Columns 7 to 9 aggregate firms in the bottom decile based on firms'
average GREENRATIOWW across the whole period. The bottom decile covers only firms with
no green patents and represents around 35% of observations. Columns 10 to 12 aggregate firms
in the top decile based on firms' average GREENRATIOWW across the whole period. Both
Panels A and B reveal considerable heterogeneity in innovative activity. Among the firms that hold
at least one patent, there is a wide dispersion in green innovation as reflected in the standard
deviation of GREENRATIOWW of 0.181 and the standard deviation of
GREENCITRATIOWW of 0.218. Interestingly, the average level of emissions of innovating
firms is significantly larger than that of non-innovating firms, with the mean of LOGS1TOT equal
to 5.863 for innovating firms but only 4.356 for non-innovating firms. A similar difference holds
for scope 2 and 3 emissions. Partly this difference could be attributed to the fact that innovating
firms are slightly larger (mean LOGSIZE is 7.599 for innovating firms versus 6.730 for non-
innovating firms). Patenting firms have also greater values of LOGPPE, LOGCAPEX, and
LOGCASH, and slightly higher values of M/B than non-patenting firms do. At the same time,
they do not differ much in terms of their BETA, VOLAT, MOM, and INVEST/A. Notably, we
observe similar relationships for variables that are observed for the full and restricted samples,
which suggests that the relationships we identify based on our restricted samples are not less likely
driven by specific selections along different observables.

3. Determinants of Green Innovation Activity

Why are firms engaging in green innovation activities? Basic economic analysis would suggest that
firms engage in green R&D if it is more profitable than both no R&D and other R&D. Another
consideration is comparative advantage—some firms, such as renewable energy companies, may
be both better equipped and benefit more from green R&D. Brown companies that rely on fossil
fuel energy may be better equipped to squeeze out efficiency gains in brown technologies. This is
referred to as the path-dependency hypothesis (Popp, 2002 and Aghion et al., 2016). Alternatively,
"khaki" R&D, that is, green innovation by brown companies, may be most profitable if fossil fuel
energy is increasingly regulated and expected to become obsolete. We explore these hypotheses in
this section and begin investigating the extent to which high carbon emitting firms are propelled
to reduce their emissions by investing in green R&D.

3.1 *Carbon emissions and green innovation*

3.1.1 Extensive Margin Results

Specifically, we study how green R&D, as measured by the ratio of green patents to total patents
held by a company, is associated with a firm's carbon emissions. We consider several different

patent ratios for our dependent variable. We begin by exploring how the green patent ratios are associated with the level of the company's direct emissions. We first focus on the metrics that allow for both extensive and intensive margin innovation. Because many firms may not report any green patents, a standard OLS regression may not be suitable to estimate the relationship in the data. For that reason, we estimate the following Pseudo Poisson Maximum Likelihood model:

$$\text{Patent Ratio}_{i,t} = a + b*\text{LOGS1TOT}_{i,t-1} + c*\text{Controls}_{i,t-1} + \text{Fixed Effects} + \varepsilon_{i,t} \tag{1}$$

where *Patent Ratio* is a generic variable that allows for different types of patents related to the total number of patents. *Controls* is a vector of the following variables: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. The model includes country and year fixed effects. In some specifications, the model also includes industry or industry-year fixed effects. Our baseline specification uses the Trucost sector classification of 431 industries. To allow for the cross-sectional and serial dependence in the residuals we double cluster standard errors at the firm and year dimensions. Our coefficient of primary interest is *b*.

We begin by reporting in Table 6 the results for two different types of green patent ratios. In Panel A, the dependent variable is GREENRATIOWW. In columns 1-3, we present the results without controls, while in columns 4-6 we also include time-varying controls. When industry fixed effects, or industry-year fixed effects, are not included in the model the coefficient of LOGS1TOT is statistically significant and positive, as can be seen in columns 1 and 4, respectively. Not controlling for industry, however, is misleading as technological differences and differences in emissions across industries are huge. The results of the regressions without industry fixed effects are therefore difficult to interpret. For that reason, we consider specifications that either absorb the time-invariant variation across industries or the time-varying differences through industry-year fixed effects.

When industry fixed effects and/or industry-year fixed effects are included then the coefficient of LOGS1TOT is highly significant and negative, especially in the specifications with controls, as in columns 5 and 6. These results have a clear interpretation: Brown companies (those with higher emissions) tend to do less green R&D. These results are consistent with the path-dependency hypothesis for R&D. To the extent that brown companies engage in innovation activities, their innovations are less likely to be directed towards green patents. In terms of economic significance, a one-standard deviation increase in LOGS1TOT is associated with a lower green patent ratio equal to about 30%-35% of the standard deviation of the dependent variable. Panel B of Table 3 reports the results for the dependent variable GREENRATIOEP. These results

14

are broadly in line with those in Panel A. If anything, they become more significant in regressions without controls and the coefficients are larger across the board, underscoring the well-known fact that world-wide patent filings are a noisier measure of innovation activity.[3] In the most comprehensive models, in columns 5 and 6, the economic significance of the result almost doubles.

In Table 7, we estimate the same regression model as above except that the dependent variables now are respectively BROWNEFFRATIOWW (in Panel A) and BROWNEFFRATIOEP (in Panel B). When industry fixed effects and/or industry-year fixed effects are included the coefficient of LOGS1TOT is now significant and positive. These results broadly confirm our findings for green innovative activity (when the dependent variable is GREENRATIOEP or GREENRATIOWW) and strengthen the interpretation that innovation is path dependent. To be sure, brown companies are found to engage in innovation activities that concern mostly efficiency improvements of their existing brown operations.

3.1.2 Robustness

As a robustness test to our extensive-margin results, we perform several additional tests. First, in Table A.II of the Appendix, we revisit the results of Tables 6 and 7 using two alternative definitions of industry, based on 6-digit and 8-digit GIC scores. The results from these tests are qualitatively similar. Second, we explore the impact of other emission measures on patent ratios. In Table A.III, we look at green innovation ratios, while in Table A.IV we look at brown efficiency innovation ratios. When it comes to green patents, we find that scope 2 and scope 3 emission levels have a very similar effect on green patent ratios as scope 1. At the same time, the results for intensity measures, though of similar direction, are statistically weaker. In turn, the relationship between changes in emissions and green patent ratios is positive. When we consider brown patent ratios, we find that scope 3 levels as well as scope 1 and scope 3 intensity have a similar positive effect on brown patent ratios. In turn, scope 2 levels and intensity have an opposite, negative effect on brown patent ratios. We find very little evidence of a significant relationship between emission changes and brown patent ratios.

Third, we look at the industry-by-industry relationship between scope 1 emission levels and green and brown ratios. In Table A.V we report the cross-industry coefficients of LOGSCOPE1. For 28 out of 61 GIC-six industries, the effect of scope 1 emissions is negative. Among the industries, the effect is the strongest for independent power & renewable electricity producers, and healthcare technologies. In Table A.VI we report corresponding results for brown

15

ratios. For 25 industries the effect of scope 1 emissions is positive. Fourth, we explore the importance of other patent types and classifications: general efficiency and OECD environmental technology. In both cases, we find that the relationship with scope 1 emissions is positive in the model without industry fixed effects and it is negative, but statistically insignificant when we control for industry types. The results are presented in Table A.VII.

Fifth, as an alternative to patent ratios we consider the importance of innovation by looking at citation counts of green, brown, general efficiency, an OECD patents. The results from these alternative tests mimic largely those we document for patent ratios and are presented in Table A.VIII. Sixth, and finally, we evaluate the role of sample selection for our results. In particular, we test whether our results hold if we restrict our sample of firms to those that have been covered by Trucost prior to 2015., prior to the data expansion period it has undertaken. We report the results in Table A.IX and Table A.X. They are qualitatively very similar. Thus, it does not appear that our results are driven by the specific subset of firms covered by Trucost. Another sample selection concern regards firms that subsequently get acquired in M&A transactions. In such instances ownership of patents for the bidders may not be probably accounted for if the company reports patents that it acquired in the merger. We test the importance of this reporting issue for our results by excluding all bidding companies engaged in the merger. Results in Table A.XI indicate no visible difference in the results. If anything, the results are statistically more significant relative to our baseline findings.

3.1.3 Intensive-Margin Results

Our findings so far have focused on the combined extensive and intensive-margin analysis, as we have included all companies, irrespective of how many green/brown patents they own. However, companies that do not have either green or brown patents may be very different from those that do. Hence, our results could be more indicative of the underlying selection across firms than of the strength of innovative activity as it relates to the company's operations and carbon emissions. To detach any selection effects, we focus more directly on the intensive margin and ask how much less green innovation activity a brown company might undertake. In this analysis we require that a company has at least one green or one brown patent; that is, we only focus on companies that are innovators. Along the intensive margin the patent ratio is a continuous variable, so that we estimate a linear regression model. The results are reported in respectively Tables 8 and 9 and are in line with our findings for the extensive margin: Brown companies do less green R&D. The browner they are, as measured by the size of their carbon emissions, the lower the fraction of green patents they own, and the higher the fraction of brown efficiency patents they have. The

latter result, however, is generally weaker, which suggests that brown efficiency is largely driven by the extensive margin of patenting.

3.2 *Governance and Innovation*

If path-dependency were the only driver of innovation, we would see almost no green R&D by brown companies. A green patent held by a brown company could possibly reflect the inherent uncertainty around scientific discovery, just an accidental discovery. Yet, as Popp (2002) and Aghion et al. (2016) have shown, there are other pressures influencing the direction of R&D, such as changes in taxes and subsidies, or changes in commodities prices. Among the influences that shape the direction of R&D is of course the purpose and aspirations of corporations themselves. If corporate leaders and firm stakeholders care more about the environmental impact of their activities, one would expect the corporation's innovative pursuits to be redirected further towards green R&D. We explore this hypothesis in this section by looking at how corporate governance is associated with green R&D. Similar to the empirical setting in Bolton and Kacperczyk (2022b), we distinguish between internal and external governance. The former concerns mostly the composition of boards of directors. The latter involves external monitoring mechanisms of corporations such as ownership concentration, analyst coverage, and media exposure.

Since we focus on both extensive and intensive margins of patenting, our model specification is again a Pseudo Poisson Maximum Likelihood model linking green R&D to various governance metrics. We are interested in finding out from our estimation how external governance forces moderate the effect of carbon emissions on patenting activity. To capture this effect, we consider the following specification:

$$\text{Patent Ratio}_{i,t} = a + b_1 * \text{LOGS1TOT}_{i,t-1} + b_2 * \text{GovernanceVar}_{i,t-1}$$
$$+ b_3 * \text{LOGS1TOT} * \text{GovernanceVar}_{i,t-1} + g * \text{Controls}_{i,t-1} + \text{Fixed Effects} + \varepsilon_{i,t.} \qquad (2)$$

Again, *Patent Ratio* refers in turn to both green and brown patenting, and worldwide or EUPO patent filings. Among the explanatory variables, *GovernanceVar* is a generic term for variables that relate to both external and internal governance forces. Our control variables are the same as those we included in model (1). In all specifications, we include country and year fixed effects. We also alternate our estimation between models with industry*year fixed effects (in odd-numbered columns) and firm fixed effects (in even-numbered columns). Finally, we double cluster standard errors at the firm and year dimensions.

We begin by considering the link between external governance and green R&D. Our dependent variables measuring green innovation are again GREENRATIOWW (in Panel A), and

17

GREENRATIOEP (in Panel B). Our external governance variables are: i) ANALYST, which is the natural logarithm of the number of equity analysts providing earnings forecast for a firm; ii) NOOWN, which is the natural logarithm of the number of institutional owners of the firm, a measure of ownership dispersion; iii) HERF, which is the Herfindahl index of ownership stakes, a measure of ownership concentration; and, iv) ESS, which is the fraction of positive media news stories about a firm covered by Dow Jones newswires over the previous one-year period, a measure of (positive) media focus.

We report the results in Table 10. It is not clear a priori how external governance would affect green innovation. Arguably, if green R&D is less profitable, then tighter external monitoring by investors mostly concerned with maximizing financial returns would discourage firms from pursuing such innovation activities. If, on the other hand, investors are more concerned about environmental impact than corporate executives, then greater external oversight ought to be associated with greener R&D. When we look at the cross-section of firms, in columns 1 and 3, we find that both analyst coverage and the scope of institutional ownership reduce the negative relationship between emissions and green patenting. The statistical significance of this effect, however, disappears when we condition our model on firm fixed effects. It is of course possible that these effects tied to external governance arise from intra-industry variations. As shown in Panel B of Table 10, neither financial analyst coverage nor ownership concentration significantly affect the relationship between carbon emissions and green patent ratios based on European Patent Office filings, irrespective of the specification we consider. Similarly, we do not find a significant effect for media sentiment. Overall, we find very weak evidence that investor pressure induces companies to redirect their innovation activities towards greener R&D.

We explore next the effects of internal governance on green R&D and report the results in Table 11. We consider again GREENRATIOWW (in Panel A), and GREENRATIOEP (in Panel B) as our dependent variables. We explore the effects of *Board Size*, the percentage of *women directors* on the board, the fraction of directors with a *finance background*, the average *tenure* of board members, the fraction of *nonexecutive directors*, the fraction of *independent* and *strictly independent* board members. Besides these board characteristics, we include two hostile takeover protection variables, *equal voting rights*, which captures the extent to which a company is controlled by a minority owner through a dual class share structure, and *number of antitakeover devices*, which shield the company from the discipline imposed by the threat of a hostile takeover. We also construct a *controversial company* variable, which is based on the number of articles and stories in the financial media on controversial decisions made by the firm.

The main findings that emerge from this analysis are: 1) Companies that have more women on the board of directors and a greater percentage of independent board members have a weaker

18

relationship between the level of the company's carbon emissions and green patenting. This is true whether we measure green R&D based on worldwide or on EUPO patent filings. In other words, companies with more diverse and independent boards tend to engage in greener innovation. 2) Brown companies (with high carbon emissions) that assign more equal voting rights to their shareholders are less likely to produce green patents. This is especially true when we measure green R&D based on worldwide patent filings. Companies with more equal voting rights are more exposed to the threat of a hostile takeover other things equal, so that the greater reluctance to engage in green R&D could be due to greater financial market pressure to maintain shareholder value. 3) Other aspects of internal governance do not seem to matter for how companies with different levels of carbon emissions conduct their green patenting activity.

We also examine the role of corporate governance in deepening path-dependency in innovation, by looking at how governance variables affect brown energy-efficiency innovation at brown companies. When it comes to external governance, we find that it plays essentially no role in affecting the rate of brown innovation. Table 12 presents the results. For worldwide patents, in Panel A, all the effects are statistically insignificant. In Panel B, where we use EUPO filings to measure R&D activity we find that analyst coverage plays a significant role. Companies with higher equity analyst coverage have a lower brown innovation ratio. However, this relationship is weaker for brown companies with higher levels of carbon emissions. This result obtains for specifications with both industry*year and firm fixed effects. Overall, these results suggests that analyst coverage is associated with greater path-dependency in innovation, with brown innovation more prevalent among companies with higher carbon emissions.

In Table 13, we present the results for internal governance. When we measure R&D activity through worldwide patent filings, in Panel A, a few interesting patterns emerge. First, companies with larger boards are less likely to engage in brown innovation. Second, companies with a greater percentage of board members with a finance background also engage in less brown innovation. Similar effects can be observed for companies with a greater percentage of women on the board, and for companies with a greater number of antitakeover provisions, but these results are statistically weaker. Finally, we find that companies with a greater fraction of nonexecutive board members are associated with more brown innovation. When we measure R&D activity through EUPO filings, we find (as reported in Panel B) that these results are slightly weaker statistically. Overall, this analysis reveals that governance does not play a major role in shaping R&D activity and in redirecting innovation towards green R&D.

3.3 *Regional and Industry Differences*

How does green R&D activity differ across countries and industries? We know that some parts of the world are already deeply dedicated to the energy transition, while other parts are lagging. How does the national context affect corporate green innovation? Similarly, the switch to non-carbon emitting economic activities is more urgent in some sectors than others. How do industry characteristics affect green R&D? These are the questions we explore in this section. If the global market economy operated frictionlessly we would not expect to see geographic location to matter much. The most efficient technologies would dominate worldwide in each sector and innovation activity would be concentrated at the most technologically advanced companies, wherever they are located. We are of course very far from such an idealized world. There are multiple institutional and cultural barriers to the diffusion of innovation, and public policy in each country to a large extent shapes which technologies are economically viable. Corporate innovative activity is influenced by all these factors, and much can be learned by exploring in which parts of the world and which sectors green R&D is most important.

Formally, we estimate the same Poisson model as in equation (1), first for green patent ratios and then for brown patent ratios (again measured through respectively Worldwide and European patenting office filings). We present the results in Table 14 for the specification that includes industry*year fixed effects.

In Panel A, we present the results for green innovation activity. Not surprisingly, we find stark differences across different regions of the world. In North America, highly polluting firms are associated with significantly lower green patenting activity than less polluting firms from the same industries (this effect holds both for worldwide and EUPO patent filings). In Europe there is no such effect when we measure R&D activity through worldwide patent filings. We, however, find a small negative relationship between green innovation and the level of carbon emissions when we use EUPO patent filings to measure innovation. Interestingly, we find a statistically insignificant effects of carbon emissions on green R&D in Asia and in other regions, such as Australia or South America.

In Panel B, we turn to the brown R&D and how it is affected by how brown the company's activities are. We find a strong positive relationship between the level of emissions and brown patenting for firms in Europe and Asia when we measure R&D activity through worldwide patent filings. This effect, however, is much smaller when we measure R&D through EUPO patent filings. Still, we do find a very weak relationship between corporate carbon emissions and brown R&D for firms located in North America.

3.4 *Changes in Climate Policy and Beliefs*

There has been a major shift in awareness about the challenges created by climate change over our sample period. Many countries have made commitments to introduce policies to mitigate climate change. Presumably, patenting activity may have responded to these changes in policy stance and climate beliefs. Around the world, companies may have perceived a tightening in regulations and investor pressure on carbon emissions, perhaps inducing them to shift their innovation activities more towards green technologies. This change in context could elicit diametrically opposed responses from companies. Larger emitters could decide to gradually transition away from brown technologies in response to these pressures. Or companies could double-down on brown technologies by seeking to improve their energy or carbon efficiency.

To explore these hypotheses, we look at how the landmark Paris Agreement in 2015 may have changed companies' R&D behavior. This is a commonly used shock to capture changes in climate beliefs and regulatory stance towards brown activities that worsen global overheating. We define an indicator variable *Post2015* that takes the value 1 for the period from 2016 onwards, and 0 for the period before and estimate the following Pseudo Poisson Maximum Likelihood model:

$$\text{Patent Ratio}_{i,t} = a + b*\text{LOGS1TOT}_{i,t-1} + c*\text{LOGS1TOT}_{i,t-1}*\text{Post2015}_t + d*\text{Controls}_{i,t-1} + \text{FEffects} + \varepsilon_{i,t}$$

$$(3)$$

We are primarily interested in the coefficient c, which measures the differential effect of the post-Paris period, relative to the pre-Paris period, on the link between brown activities as reflected in direct carbon emissions and patent ratios. We report the results in Table 15.

In Panel A, we report the results for green patent ratios (for respectively both worldwide and EUPO patent filings). Remarkably, we find that in all our specifications the coefficient c is negative and is statistically significant in 5 out of 6 specifications. This result reveals that the tightening regulatory stance towards brown activities after Paris has amplified the difference in R&D activity between green and brown companies, consistent with the path-dependency view that greener firms were more likely to respond to this major shift by deepening their green innovation investments. In Panel B, we look at how firms' have changed their brown innovation activities. We find a positive and statistically significant effect of the *Paris shock* on brown innovation (measured through worldwide patent filings), which is again consistent with the path-dependency hypothesis of R&D. This estimated coefficient, however, is insignificant when R&D activity is measured from EUPO filings.

In an alternative test, we examine the role of the Paris accord shock on patent citation counts. We report the results in Table A.XII. As for the green patent ratios, we find that the relationship between scope 1 emissions and citation counts of green patents become more negative

21

after the Paris accord. The coefficient of the interaction variable between *Paris* and *LOGSCOPE1* is negative and statistically significant at the 5% level for the worldwide classification and similarly significant for the EUPO classification, except for the specification with industry*year fixed effect where the result is borderline insignificant. The results for brown patent citations are qualitatively similar but statistically insignificant.

Overall, we find supporting evidence that companies responded meaningfully to the Paris shock, but the shift towards greener R&D came mostly from green companies with lower carbon emissions to begin with.

4. Green Innovation and the Jevons Paradox

We have shown that companies with higher emissions, within individual industries, are both less likely to produce green innovation and more likely to generate brown innovation. These results are consistent with the path-dependency hypothesis formulated in the economics literature on innovation (Popp, 2002, Redding, 2002, Aghion et al., 2016). In this section we turn to the effects of green innovation on carbon emission reductions. Much is predicated on the assumption that technological change is the solution to the climate crisis. But does green innovation significantly reduce carbon emissions? The archetypal image of a technological change that drastically reduces carbon emissions is the substitution of a coal-fired power plant by a photovoltaic power station, or the substitution of a combustion-engine car by an electric vehicle. Yet even these obvious examples come with questions about the net effects of green innovation on carbon emissions, since solar panel and electric vehicle production require inputs and energy that cause upstream carbon emissions. Similarly, with brown efficiency-improving innovation the effect on carbon emission reductions may be limited because of rebound effects. Fuel economy innovations for combustion engine cars may be undone by people driving longer distances. Battery life improvements for cell phones may simply result in greater phone usage. It is therefore unclear how much green and brown efficiency-innovation has affected direct and indirect carbon emissions. More generally, another important set of questions is how companies' innovation activities have changed their corporate policies, such as capital expenditures, sales, or cash holdings? These are the questions we explore in this section.

We begin our analysis of the impact of green R&D on carbon emissions by estimating the following regression model linking future corporate policy outcomes such as future carbon emissions to measures of contemporaneous green and brown patenting. Our first model exploits both extensive and intensive margins of patenting. Formally, we estimate the following linear regression model:

$$\text{Corporate Policy}_{i,t+h} = a + b*\text{Patent Ratio}_{i,t} + c*\text{Controls}_{i,t-1} + \text{FEffects} + \varepsilon_{i,t} \qquad (4)$$

where *Corporate Policy* is a generic response variable that includes: i) the total level of emissions; ii) emission intensity; iii) LOGPPE; iv) INVEST/A; v) LOGCAPEX; and vi) LOGCASH, measured *t+h* years ahead. We let h take the value of respectively 1 and 3 years to reflect the possibility that there may be a "time to build" lag in corporate adjustments. The variable *Patent Ratio* is defined as before, and all regressions include country, year, and firm fixed effects. We double cluster standard errors at the firm and year dimensions. Our coefficient of primary interest is *b*, which measures the impact of *Patent Ratio* on future corporate policy outcomes.

To start with we look at the effects of green innovation on future corporate policy outcomes by linking the green innovation ratio to the outcome variables defined above. The results are reported in Table 16. In Panels A and B we measure green innovation activity by looking at worldwide patent filings and by estimating the link between green patent ratios on outcome variables respectively one and three years ahead. Our main finding is that there appears to be no significant impact of green R&D on future carbon emissions and other future outcome variables. Whether we look one year or three years ahead, we do not find any significant effect of green innovation on direct emissions, their levels, and intensities (although we observe a small reduction in indirect emissions with a 10% statistically significant negative coefficient of -0.031 for scope 3 emissions). Further, we do not observe any significant effect of an increase in the green patent ratio on the other corporate policy outcomes we consider. For robustness, we consider the alternative specification with green patent counts, rather than ratios, as our main explanatory variable. We find a stronger positive effect of direct emissions, both levels and their intensities, particularly scope 2, and a strong negative effect on scope 3 emissions, especially their intensities. These results are presented in Table A.XIII. We also look at the impact of green innovation ratios on future changes in emissions. Again, we do not find that the slope of emission changes differs with the degree of green innovation, as reported in Table A.XIV. Overall, the conclusion we draw is that companies' green R&D activities are largely divorced from their other operations. Based on this evidence we conclude that the green industrial revolution has not yet materialized and that green innovation as the solution to the energy transition and the path to net-zero is still more of a promise than a reality.

In Panels C and D, we measure innovation activity through patent filings at the EUPO and obtain results in line with those reported in Panels A and B. We do not find that green

innovation activity leads to a future reduction in corporate carbon emissions, or an increase in capital expenditures. In fact, we find that in the following three years, companies with more green innovation reduce their investment expenditures. One way of interpreting this latter result could be that investment was mostly in brown activities that become less valuable following breakthroughs in green R&D.

In Table 17 we report the results of a similar analysis, but this time exploring the effects of brown R&D on future corporate policy outcomes. In Panels A and B, we again measure innovation activity by looking at worldwide patent filings, whereas in Panels C and D we measure innovation activity through EUPO filings. Again, we do not find any significant effect of brown innovation on future corporate outcomes, including future carbon emissions. We provide additional robustness checks of these findings. First, we explore the impact on emissions of general efficiency patents and OECD patents in Tables A.XV and A.XVI. The results are qualitatively very similar. Second, instead of looking at patent ratios, we look at the citation counts as predictors of future corporate actions. The results (in Tables A.XVII-A.XIX) are not very different. Overall, the results corroborate the view that corporate R&D is largely divorced from other operations. When we focus on intensive margin adjustments only, we again find that R&D is largely separate from other corporate activities. The regressions we estimate follow the model of those in Tables 16 and 17, except that we now focus only on firms with some green/brown patents to begin with. We find that even on the intensive margin, innovation activity does not have much of an impact on direct carbon emissions or other corporate policies. These results are reported in Tables 18 and 19. Interestingly, when we condition future emissions on the level of general efficiency patent ratios for the EUPO, we find a strong negative effect on next-year intensity of scope 1-scope 3 emissions. These results are reported in Table A.XXIII.

The lack of any clear evidence of R&D activity on future carbon emissions and capital expenditure may be due to multiple reasons. One obvious first reason is that filing a patent may only be a first step in a protracted innovation process, with few patents resulting in fundamental changes in technology that make a material difference to carbon emissions. Most patents are about incremental technological improvements that do not have a wide impact. Another related reason is that the innovation that is patented is destined primarily to other companies and therefore would not have a significant impact on the company's carbon emissions or capital expenditures. Also, when a technological breakthrough is significant it can affect multiple margins. For a brown efficiency-improving innovation the effects could be simultaneously to improve carbon efficiency and sales so that the overall effect on the level of emissions is limited. Finally, our analysis is

primarily looking at large listed companies for which we have data on carbon emissions. Many of these companies are conglomerates and their R&D activity is only a small part of their operations. Be that as it may, green R&D is often represented as bringing about fundamental changes to the economy and to overall carbon emissions (see, e.g., IEA, 2020). Yet, we find little evidence of any large-scale effects so far of green R&D on carbon emission reductions.

5. Conclusion

We have attempted the first global firm-level analysis of the determinants of green innovation activity and its impact on future corporate carbon emissions. Our main finding is that at least up to now the promise of a green technological revolution has not materialized in terms of significant decarbonization of economic activity. Specifically, although many companies have increased their green innovation activity around the world the effects in terms of lower future direct or indirect corporate carbon emissions have not been significant.

Another main finding is that within each sector the browner a company's activities in terms of the level of its carbon emissions the less likely the company is to engage in green innovation. This latter finding sheds a somewhat different light on the results of Cohen, Gurun, and Nguyen (2022) for the U.S., who observe that there is greater innovation activity at traditional energy firms than at many companies outside the energy sector. In contrast to their main conclusion, our findings suggests that the exclusionary screening focus of ESG investors on companies with high carbon emissions is well placed. Far from excluding the most active green innovators such exclusionary screening tests, as long as they are sector neutral, tend to exclude those that lag behind in their green innovation efforts.

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1 Tables

TABLE 1: OBSERVATIONS BY COUNTRY

The sample period is 2005-2020 conditional on available financial data. We report the number of firm-year observations by country for the full (public and private), public, private and Trucost sample. The full sample is based on firms from Orbis/ Orbis IP, FactSet, Worldscope and Trucost. We report countries with less than 300 firm-year observations in the full sample aggregated by region under "Others". "Others North America" include ANGUILLA, ANTIGUA & BARBUDA, BAHAMAS, BARBADOS, BELIZE, COSTA RICA, CURACAO, DOMINICA, DOMINICAN REPUBLIC, EL SALVADOR, GRENADA, GREENLAND, GUATEMALA, HONDURAS, MARSHALL ISLANDS, NICARAGUA, SAINT KITTS & NEVIS, SAINT LUCIA , SAINT MARTIN, SAINT PIERRE & MIQUELON, TRINIDAD & TOBAGO; "Others Asia" include ARMENIA, AZERBAIJAN, BAHRAIN, BHUTAN, CAMBODIA, KYRGYZSTAN, LAO PEOPLE'S DEMOCRATIC REPUBLIC, LEBANON, MACAO S.A.R, MYANMAR/BURMA, NEPAL, PALESTINIAN TERRITORIES, SYRIAN ARAB REPUBLIC; "Others Africa" include ALGERIA, BOTSWANA, CAMEROON, CAPE VERDE, COTE D'IVOIRE, ESWATINI, ETHIOPIA, GABON, GAMBIA, GHANA, KENYA, LIBERIA, MALAWI, MALI, MAYOTTE, MOZAMBIQUE, NAMIBIA, SENEGAL, SEYCHELLE, SUDAN, TOGO, TUNISIA, UGANDA, UNITED REPUBLIC OF TANZANIA, ZAMBIA; "Others Europe" include ALBANIA, BELARUS, FAROE ISLANDS, GEORGIA, GIBRALTAR, ISLE OF MAN, LIECHTENSTEIN, MONACO, SAN MARINO, SVALBARD and "Others South America" include FRENCH GUIANA, GUYANA, VENEZUELA. In Panel A, we report observations for the entire sample covering patenting and non-patenting firm-year observations in columns 1 to 4 as well as firm-year observations with at least one granted or purchased patent at any patent office worldwide in columns 5 to 8. In Panel B, we report firm-year observations with at least one granted or purchased green patent at any patent office worldwide in columns 1 to 4 and at the European Patent Office in columns 5 to 8. In Panel C, we report firm-year observations with at least one granted or purchased brown efficiency patent at any patent office worldwide in columns 1 to 4 and at the European Patent Office in columns 5 to 8.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Entire and patent sample	Full sample				Patenting sample			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
ARGENTINA	1254	505	749	130	63	56	7	21
AUSTRALIA	26417	7933	18484	4418	2208	1867	341	1123
AUSTRIA	10515	856	9659	421	613	455	158	249
BANGLADESH	949	407	542	40	8	8	0	0
BELGIUM	222005	1086	220919	595	798	510	288	309
BERMUDA	6235	5472	763	193	902	838	64	26
BOLIVIA	356	0	356	0	0	0	0	0
BOSNIA & HERZEGOVINA	15137	64	15073	1	16	1	15	0
BRAZIL	8068	2999	5069	1628	789	637	152	434
BULGARIA	112719	790	111929	31	101	63	38	8
CANADA	34860	29653	5207	3712	3571	3233	338	1140
CANARY ISLANDS	11532	6	11526	0	0	0	0	0
CAYMAN ISLANDS	7328	3721	3607	88	1111	635	476	35
CHILE	2480	1370	1110	509	211	189	22	108
CHINA	337935	37880	300055	12744	63964	25989	37975	8971
COLOMBIA	1558	357	1201	160	41	24	17	15
CROATIA	20609	410	20199	22	33	21	12	4
CYPRUS	3406	274	3132	27	29	24	5	5
CZECH REP	86553	117	86436	69	211	28	183	20
DENMARK	278801	1360	277441	541	688	513	175	339
ECUADOR	626	0	626	0	0	0	0	0
EGYPT	2480	971	1509	379	61	40	21	12
ESTONIA	57293	111	57182	21	11	3	8	0
FINLAND	84816	1505	83311	606	951	743	208	414
FRANCE	396731	4957	391774	2628	3689	2427	1262	1602
GERMANY	99122	6067	93055	2248	3709	2923	786	1491
GREECE	13171	1017	12154	356	111	101	10	44
GUADELOUPE	628	0	628	0	0	0	0	0
GUERNSEY	373	158	215	35	27	21	6	6
HONG KONG	10209	9237	972	3499	2797	2624	173	1186
HUNGARY	39849	248	39601	69	72	52	20	25
ICELAND	20224	140	20084	13	54	33	21	5
INDIA	74885	14820	60065	4317	2350	2105	245	1178
INDONESIA	4106	3092	1014	1135	36	35	1	12
IRAQ	588	0	588	0	0	0	0	0
IRELAND	9288	570	8718	429	342	252	90	207
ISLAMIC REPUBLIC OF IRAN	3805	0	3805	0	4	0	4	0
ISRAEL	5181	4003	1178	921	1146	998	148	382
ITALY	575505	2967	572538	1307	1576	1126	450	597
JAMAICA	554	160	394	9	0	0	0	0
JAPAN	73643	44867	28776	16199	28109	25206	2903	10868
JERSEY	409	166	243	45	45	28	17	18
JORDAN	1049	600	449	41	28	21	7	0
KAZAKHSTAN	1534	57	1477	33	20	1	19	0
KUWAIT	1129	823	306	129	47	40	7	12
LATVIA	18365	139	18226	0	27	25	2	0
LITHUANIA	6348	184	6164	15	11	7	4	1
LUXEMBOURG	18333	406	17927	245	232	152	80	114
MALAYSIA	78668	6144	72524	1654	626	549	77	236
MALTA	19833	64	19769	15	2	2	0	2
MARTINIQUE	610	0	610	0	0	0	0	0
MAURITIUS	1193	331	862	20	32	27	5	0
MEXICO	1688	1206	482	738	214	184	30	145
MONGOLIA	1216	4	1212	4	1	1	0	1
MONTENEGRO	3235	37	3198	0	0	0	0	0
MOROCCO	927	282	645	174	8	5	3	2
NETHERLANDS	42995	1372	41623	884	907	681	226	533
NEW ZEALAND	1995	770	1225	425	189	162	27	69
NIGERIA	758	457	301	176	7	6	1	2
NORTH MACEDONIA	8768	68	8700	0	2	0	2	0
NORWAY	349501	1992	347509	746	806	575	231	317
OMAN	805	310	495	79	11	8	3	1
PAKISTAN	2996	1508	1488	417	24	15	9	11
PANAMA	333	15	318	9	1	0	1	0
PARAGUAY	518	0	518	0	12	0	12	0
PERU	1838	636	1202	204	63	40	23	21
PHILIPPINES	4205	2685	1520	649	153	140	13	89
POLAND	69197	3815	65382	643	770	645	125	172
PORTUGAL	111040	378	110662	196	120	71	49	43
QATAR	388	340	48	205	15	9	6	5
REPUBLIC OF MOLDOVA	5183	0	5183	0	16	0	16	0
REUNION	1294	0	1294	0	0	0	0	0
ROMANIA	69367	436	68931	53	152	43	109	5
RUSSIA	246487	1803	244684	644	2506	744	1762	401
SAUDI ARABIA	1390	1181	209	390	64	55	9	20
SERBIA	44282	66	44216	16	47	1	46	0
SINGAPORE	17781	4685	13096	1160	1140	912	228	293
SLOVAKIA	42243	82	42161	0	118	21	97	0
SLOVENIA	24463	148	24315	31	94	41	53	10
SOUTH AFRICA	2849	2384	465	1828	513	484	29	428
SOUTH KOREA	47291	18924	28367	7492	16489	12325	4164	5657
SPAIN	354890	1571	353319	972	835	612	223	429
SRI LANKA	1292	1091	201	52	8	8	0	2
SWEDEN	335924	5454	330470	1741	2666	1757	909	874
SWITZERLAND	4783	2564	2219	1899	1499	1268	231	1023
TAIWAN	21673	15789	5884	5551	10914	9179	1735	3817
THAILAND	20458	4344	16114	1404	245	218	27	157
TURKEY	11478	2426	9052	827	284	262	22	166
UKRAINE	201248	81	201167	35	142	16	126	9
UNITED ARAB EMIRATES	662	520	142	260	43	37	6	23
UNITED KINGDOM	182467	10151	172316	7171	5279	3464	1815	2653
UNITED STATES	94986	78202	16784	24913	31696	28844	2852	13657
URUGUAY	481	0	481	0	1	0	1	0
UZBEKISTAN	1486	0	1486	0	0	0	0	0
VIETNAM	18653	2707	15946	143	45	35	10	7
VIRIGIN ISL	1118	814	304	6	100	87	13	0
ZIMBABWE	494	31	463	21	7	0	7	0
Others Africa	1096	380	716	193	12	7	5	1
Others Asia	985	217	768	73	4	4	0	3
Others Australia	284	20	264	9	1	0	1	0
Others Europe	817	137	680	61	30	9	21	4
Others North America	1492	285	1207	21	27	27	0	4
Others South America	512	5	507	0	0	0	0	0
Total	5171577	371437	4800140	124212	199752	137634	62118	62273

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B: Conditioning on at least one green patent existing								
	at any patent office worldwide				at European patent office			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
ARGENTINA	5	5	0	3	3	3	0	1
AUSTRALIA	377	313	64	217	193	156	37	101
AUSTRIA	212	173	39	120	163	136	27	96
BANGLADESH	2	2	0	0	0	0	0	0
BELGIUM	341	224	117	160	283	193	90	140
BERMUDA	146	141	5	9	28	27	1	3
BOLIVIA	0	0	0	0	0	0	0	0
BOSNIA & HERZEGOVINA	0	0	0	0	0	0	0	0
BRAZIL	127	100	27	83	72	57	15	48
BULGARIA	14	10	4	1	8	4	4	1
CANADA	948	870	78	476	430	396	34	204
CANARY ISLANDS	0	0	0	0	0	0	0	0
CAYMAN ISLANDS	134	107	27	8	39	36	3	1
CHILE	51	46	5	22	31	31	0	19
CHINA	10205	6359	3846	3245	721	617	104	449
COLOMBIA	7	7	0	7	3	3	0	3
CROATIA	1	0	1	0	0	0	0	0
CYPRUS	4	3	1	2	1	1	0	1
CZECH REP	23	9	14	9	4	0	4	0
DENMARK	228	193	35	168	173	149	24	130
ECUADOR	0	0	0	0	0	0	0	0
EGYPT	14	9	5	1	6	5	1	0
ESTONIA	0	0	0	0	0	0	0	0
FINLAND	313	282	31	241	252	232	20	208
FRANCE	1342	1037	305	852	1061	841	220	716
GERMANY	1453	1200	253	868	1134	953	181	736
GREECE	7	7	0	3	3	3	0	1
GUADELOUPE	0	0	0	0	0	0	0	0
GUERNSEY	4	4	0	1	3	3	0	1
HONG KONG	581	560	21	348	111	106	5	80
HUNGARY	7	6	1	4	2	2	0	1
ICELAND	4	4	0	2	1	1	0	0
INDIA	414	387	27	287	218	208	10	166
INDONESIA	7	7	0	0	0	0	0	0
IRAQ	0	0	0	0	0	0	0	0
IRELAND	112	95	17	89	61	51	10	46
ISLAMIC REPUBLIC OF IRAN	0	0	0	0	0	0	0	0
ISRAEL	231	210	21	113	130	118	12	68
ITALY	432	351	81	228	349	293	56	202
JAMAICA	0	0	0	0	0	0	0	0
JAPAN	9507	8885	622	5515	4669	4410	259	3333
JERSEY	10	5	5	5	6	4	2	4
JORDAN	11	9	2	0	2	2	0	0
KAZAKHSTAN	8	0	8	0	1	0	1	0
KUWAIT	10	8	2	2	0	0	0	0
LATVIA	4	4	0	0	3	3	0	0
LITHUANIA	0	0	0	0	0	0	0	0
LUXEMBOURG	68	48	20	38	43	31	12	24
MALAYSIA	95	90	5	52	28	27	1	20
MALTA	0	0	0	0	0	0	0	0
MARTINIQUE	0	0	0	0	0	0	0	0
MAURITIUS	0	0	0	0	0	0	0	0
MEXICO	56	51	5	46	37	35	2	33
MONGOLIA	1	1	0	1	0	0	0	0
MONTENEGRO	0	0	0	0	0	0	0	0
MOROCCO	4	2	2	0	3	1	2	0
NETHERLANDS	396	325	71	274	313	255	58	216
NEW ZEALAND	22	18	4	8	6	5	1	3
NIGERIA	1	1	0	0	0	0	0	0
NORTH MACEDONIA	0	0	0	0	0	0	0	0
NORWAY	238	201	37	145	163	137	26	104
OMAN	0	0	0	0	0	0	0	0
PAKISTAN	3	2	1	1	0	0	0	0
PANAMA	0	0	0	0	0	0	0	0
PARAGUAY	1	0	1	0	0	0	0	0
PERU	8	4	4	4	0	0	0	0
PHILIPPINES	21	16	5	13	4	4	0	4
POLAND	76	61	15	30	37	33	4	11
PORTUGAL	15	13	2	10	6	4	2	4
QATAR	0	0	0	0	0	0	0	0
REPUBLIC OF MOLDOVA	0	0	0	0	0	0	0	0
REUNION	0	0	0	0	0	0	0	0
ROMANIA	11	4	7	0	0	0	0	0
RUSSIA	337	163	174	118	26	12	14	10
SAUDI ARABIA	28	22	6	11	20	14	6	9
SERBIA	5	0	5	0	1	0	1	0
SINGAPORE	267	209	58	108	88	77	11	54
SLOVAKIA	11	1	10	0	2	0	2	0
SLOVENIA	10	4	6	1	6	4	2	1
SOUTH AFRICA	80	76	4	73	48	47	1	44
SOUTH KOREA	5282	4403	879	2637	1060	972	88	800
SPAIN	239	194	45	169	133	105	28	93
SRI LANKA	3	3	0	1	1	1	0	1
SWEDEN	654	518	136	376	502	402	100	301
SWITZERLAND	573	531	42	464	415	388	27	346
TAIWAN	2553	2370	183	1468	425	406	19	309
THAILAND	87	79	8	67	41	40	1	39
TURKEY	53	52	1	43	37	37	0	33
UKRAINE	4	0	4	0	0	0	0	0
UNITED ARAB EMIRATES	10	9	1	7	4	4	0	4
UNITED KINGDOM	1513	1094	419	939	975	723	252	618
UNITED STATES	10311	9669	642	6210	5434	5148	286	3585
URUGUAY	0	0	0	0	0	0	0	0
UZBEKISTAN	0	0	0	0	0	0	0	0
VIETNAM	4	3	1	0	0	0	0	0
VIRGIN ISL	23	21	2	0	4	4	0	0
ZIMBABWE	3	0	3	0	1	0	1	0
Others Africa	0	0	0	0	0	0	0	0
Others Asia	2	2	0	1	0	0	0	0
Others Australia	0	0	0	0	0	0	0	0
Others Europe	15	0	15	0	14	0	14	0
Others North America	3	3	0	0	1	1	0	0
Others South America	0	0	0	0	0	0	0	0
Total	50382	41895	8487	26404	20042	17961	2081	13425

28

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel C: Conditioning on at least one brown efficiency patent existing								
	at any patent office worldwide				at European patent office			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
ARGENTINA	12	12	0	6	6	6	0	3
AUSTRALIA	156	149	7	95	83	81	2	52
AUSTRIA	129	112	17	85	86	74	12	61
BANGLADESH	2	2	0	0	0	0	0	0
BELGIUM	152	116	36	84	121	97	24	72
BERMUDA	56	55	1	10	20	20	0	4
BOLIVIA	0	0	0	0	0	0	0	0
BOSNIA & HERZEGOVINA	0	0	0	0	0	0	0	0
BRAZIL	56	52	4	39	20	20	0	17
BULGARIA	2	1	1	0	1	1	0	0
CANADA	437	422	15	275	141	137	4	88
CANARY ISLANDS	0	0	0	0	0	0	0	0
CAYMAN ISLANDS	40	26	14	2	12	11	1	0
CHILE	11	10	1	4	8	8	0	3
CHINA	2894	2189	705	1416	198	177	21	133
COLOMBIA	1	1	0	1	1	1	0	1
CROATIA	0	0	0	0	0	0	0	0
CYPRUS	5	5	0	1	0	0	0	0
CZECH REP	7	1	6	1	0	0	0	0
DENMARK	60	54	6	48	35	30	5	27
ECUADOR	0	0	0	0	0	0	0	0
EGYPT	0	0	0	0	0	0	0	0
ESTONIA	0	0	0	0	0	0	0	0
FINLAND	144	131	13	117	113	103	10	96
FRANCE	663	558	105	497	483	406	77	366
GERMANY	769	658	111	527	593	512	81	431
GREECE	8	7	1	3	5	4	1	3
GUADELOUPE	0	0	0	0	0	0	0	0
GUERNSEY	2	2	0	2	2	2	0	2
HONG KONG	181	180	1	144	30	30	0	28
HUNGARY	2	1	1	0	2	1	1	0
ICELAND	2	2	0	0	0	0	0	0
INDIA	197	187	10	157	108	106	2	94
INDONESIA	0	0	0	0	0	0	0	0
IRAQ	0	0	0	0	0	0	0	0
IRELAND	36	33	3	29	24	21	3	18
ISLAMIC REPUBLIC OF IRAN	0	0	0	0	0	0	0	0
ISRAEL	64	62	2	37	34	33	1	16
ITALY	300	271	29	177	235	219	16	139
JAMAICA	0	0	0	0	0	0	0	0
JAPAN	3879	3690	189	2670	2089	1993	96	1619
JERSEY	3	3	0	3	0	0	0	0
JORDAN	1	1	0	0	0	0	0	0
KAZAKHSTAN	0	0	0	0	0	0	0	0
KUWAIT	0	0	0	0	0	0	0	0
LATVIA	1	1	0	0	0	0	0	0
LITHUANIA	0	0	0	0	0	0	0	0
LUXEMBOURG	37	25	12	23	25	19	6	18
MALAYSIA	40	31	9	22	23	19	4	17
MALTA	0	0	0	0	0	0	0	0
MARTINIQUE	0	0	0	0	0	0	0	0
MAURITIUS	0	0	0	0	0	0	0	0
MEXICO	27	24	3	19	18	17	1	15
MONGOLIA	0	0	0	0	0	0	0	0
MONTENEGRO	0	0	0	0	0	0	0	0
MOROCCO	0	0	0	0	0	0	0	0
NETHERLANDS	202	170	32	153	140	119	21	112
NEW ZEALAND	1	1	0	0	0	0	0	0
NIGERIA	0	0	0	0	0	0	0	0
NORTH MACEDONIA	0	0	0	0	0	0	0	0
NORWAY	135	120	15	90	78	71	7	59
OMAN	0	0	0	0	0	0	0	0
PAKISTAN	0	0	0	0	0	0	0	0
PANAMA	0	0	0	0	0	0	0	0
PARAGUAY	0	0	0	0	0	0	0	0
PERU	0	0	0	0	0	0	0	0
PHILIPPINES	0	0	0	0	0	0	0	0
POLAND	42	41	1	21	20	20	0	7
PORTUGAL	4	2	2	2	3	2	1	2
QATAR	0	0	0	0	0	0	0	0
REPUBLIC OF MOLDOVA	0	0	0	0	0	0	0	0
REUNION	0	0	0	0	0	0	0	0
ROMANIA	5	1	4	0	2	1	1	0
RUSSIA	176	97	79	70	8	5	3	4
SAUDI ARABIA	22	16	6	9	18	12	6	8
SERBIA	2	0	2	0	0	0	0	0
SINGAPORE	96	80	16	54	38	30	8	26
SLOVAKIA	2	0	2	0	1	0	1	0
SLOVENIA	3	1	2	0	1	0	1	0
SOUTH AFRICA	23	23	0	20	15	15	0	12
SOUTH KOREA	1883	1648	235	1143	364	341	23	306
SPAIN	71	61	10	59	30	23	7	22
SRI LANKA	0	0	0	0	0	0	0	0
SWEDEN	354	294	60	247	276	230	46	198
SWITZERLAND	243	232	11	210	142	135	7	125
TAIWAN	382	365	17	270	52	51	1	45
THAILAND	27	25	2	24	16	16	0	16
TURKEY	35	35	0	31	33	33	0	29
UKRAINE	4	0	4	0	0	0	0	0
UNITED ARAB EMIRATES	1	1	0	1	0	0	0	0
UNITED KINGDOM	706	496	210	468	463	323	140	303
UNITED STATES	4035	3854	181	2868	1903	1832	71	1429
URUGUAY	0	0	0	0	0	0	0	0
UZBEKISTAN	0	0	0	0	0	0	0	0
VIETNAM	2	1	1	0	0	0	0	0
VIRIGIN ISL	4	4	0	0	0	0	0	0
ZIMBABWE	0	0	0	0	0	0	0	0
Others Africa	1	0	1	0	0	0	0	0
Others Asia	0	0	0	0	0	0	0	0
Others Australia	0	0	0	0	0	0	0	0
Others Europe	6	0	6	0	4	0	4	0
Others North America	1	1	0	0	1	1	0	0
Others South America	0	0	0	0	0	0	0	0
Total	18844	16643	2201	12234	8124	7408	716	6026

TABLE 2: PATENT RATIO BY COUNTRY

The sample period is 2005-2020 conditional on available financial data. We report average patent ratios by country for the full (public and private), public, private and Trucost sample. Countries with less than 300 firm-year observations in the full sample are aggregated by region under "Others" as in Table 1. In Panel A we report the average *GREENRATIOWW* in columns 1 to 4 and the average *GREENRATIOEP* in columns 5 to 8. *GREENRATIOWW* is the number of green patents over the total number of patents granted or purchased at the firm and year level based on worldwide patents. *GREENRATIOEP* considers patents granted or purchased at the European Patent Office. In Panel B we report the average *BROWNEFFRATIOWW* in columns 1 to 4 and the average *BROWNEFFRATIOEP* in columns 5 to 8. *BROWNEFFRATIOWW* is the number of green patents over the total number of patents granted or purchased at the firm and year level based on worldwide patents. *BROWNEFFRATIOEP* considers patents granted or purchased at the European Patent Office.

Panel A: GREENRATIO	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GREENRATIOWW				GREENRATIOEP			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
ARGENTINA	0.025	0.028	0.000	0.063	0.034	0.036	0.000	0.021
AUSTRALIA	0.084	0.078	0.118	0.066	0.117	0.110	0.153	0.096
AUSTRIA	0.097	0.084	0.134	0.080	0.129	0.116	0.170	0.096
BANGLADESH	0.156	0.156						
BELGIUM	0.112	0.105	0.124	0.119	0.139	0.127	0.162	0.142
BERMUDA	0.056	0.060	0.008	0.130	0.070	0.069	0.091	0.167
BOSNIA & HERZEGOVINA	0.000	0.000	0.000					
BRAZIL	0.060	0.050	0.100	0.065	0.138	0.119	0.223	0.160
BULGARIA	0.115	0.120	0.105	0.125	0.469	0.500	0.444	0.500
CANADA	0.127	0.126	0.137	0.150	0.150	0.151	0.140	0.163
CAYMAN ISLANDS	0.037	0.050	0.020	0.016	0.172	0.243	0.016	0.024
CHILE	0.088	0.077	0.186	0.060	0.086	0.093	0.000	0.119
CHINA	0.034	0.033	0.035	0.038	0.126	0.127	0.122	0.139
COLOMBIA	0.097	0.165	0.000	0.265	0.429	0.429		0.429
CROATIA	0.030	0.000	0.083	0.000	0.000	0.000		
CYPRUS	0.046	0.014	0.200	0.047	0.050	0.063	0.000	0.125
CZECH REP	0.055	0.160	0.039	0.223	0.074	0.000	0.087	0.000
DENMARK	0.116	0.125	0.091	0.150	0.128	0.139	0.094	0.153
EGYPT	0.146	0.106	0.222	0.083	0.110	0.087	0.167	0.000
ESTONIA	0.000	0.000	0.000					
FINLAND	0.087	0.093	0.067	0.123	0.113	0.116	0.095	0.147
FRANCE	0.094	0.098	0.086	0.096	0.107	0.111	0.099	0.116
GERMANY	0.110	0.112	0.103	0.136	0.124	0.126	0.117	0.147
GREECE	0.056	0.061	0.000	0.062	0.046	0.050	0.000	0.045
GUERNSEY	0.036	0.047	0.000	0.056	0.062	0.078	0.000	0.083
HONG KONG	0.047	0.046	0.064	0.049	0.119	0.116	0.175	0.124
HUNGARY	0.060	0.064	0.050	0.088	0.028	0.038	0.000	0.056
ICELAND	0.005	0.008	0.000	0.005	0.004	0.007	0.000	0.000
INDIA	0.054	0.054	0.057	0.060	0.098	0.098	0.102	0.119
INDONESIA	0.021	0.021	0.000	0.000	0.000	0.000		0.000
IRELAND	0.046	0.053	0.028	0.054	0.067	0.079	0.035	0.076
ISLAMIC REPUBLIC OF IRAN	0.000		0.000					
ISRAEL	0.069	0.065	0.095	0.064	0.082	0.078	0.115	0.077
ITALY	0.085	0.083	0.092	0.083	0.108	0.110	0.105	0.116
JAPAN	0.053	0.053	0.053	0.064	0.121	0.120	0.145	0.131
JERSEY	0.099	0.067	0.152	0.105	0.149	0.124	0.214	0.169
JORDAN	0.268	0.278	0.238		0.222	0.222		
KAZAKHSTAN	0.222	0.000	0.233		0.500		0.500	
KUWAIT	0.123	0.130	0.086	0.092	0.000	0.000		0.000
LATVIA	0.030	0.033	0.000		0.071	0.071		
LITHUANIA	0.000	0.000	0.000	0.000	0.000	0.000		
LUXEMBOURG	0.076	0.067	0.095	0.055	0.082	0.079	0.088	0.048
MALAYSIA	0.085	0.091	0.042	0.077	0.109	0.114	0.063	0.121
MALTA	0.000	0.000		0.000	0.000	0.000		0.000
MAURITIUS	0.000	0.000	0.000		0.000	0.000	0.000	
MEXICO	0.092	0.083	0.150	0.100	0.120	0.120	0.125	0.141
MONGOLIA	0.444	0.444		0.444				
MOROCCO	0.500	0.400	0.667	0.000	0.750	0.500	1.000	
NETHERLANDS	0.102	0.111	0.074	0.108	0.119	0.124	0.101	0.122
NEW ZEALAND	0.057	0.058	0.052	0.046	0.031	0.035	0.011	0.053
NIGERIA	0.143	0.167	0.000	0.000				
NORTH MACEDONIA	0.000		0.000		0.000		0.000	
NORWAY	0.110	0.115	0.095	0.117	0.127	0.132	0.115	0.123
OMAN	0.000	0.000	0.000	0.000	0.000		0.000	
PAKISTAN	0.055	0.021	0.111	0.010	0.000		0.000	
PANAMA	0.000		0.000					
PARAGUAY	0.042		0.042		0.000		0.000	
PERU	0.058	0.050	0.072	0.095	0.000	0.000	0.000	0.000
PHILIPPINES	0.074	0.055	0.282	0.070	0.098	0.103	0.000	0.148
POLAND	0.047	0.040	0.086	0.066	0.095	0.089	0.142	0.081
PORTUGAL	0.063	0.085	0.031	0.098	0.089	0.135	0.050	0.219
QATAR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
REPUBLIC OF MOLDOVA	0.000		0.000		0.000		0.000	
ROMANIA	0.056	0.093	0.042	0.000	0.000	0.000	0.000	
RUSSIA	0.050	0.062	0.045	0.062	0.202	0.151	0.277	0.178
SAUDI ARABIA	0.154	0.171	0.051	0.224	0.149	0.166	0.074	0.191
SERBIA	0.058	0.000	0.059		0.333	0.000	0.500	
SINGAPORE	0.094	0.087	0.123	0.123	0.171	0.173	0.162	0.199
SLOVAKIA	0.063	0.048	0.066		0.091	0.000	0.133	
SLOVENIA	0.038	0.016	0.055	0.014	0.039	0.026	0.058	0.019
SOUTH AFRICA	0.074	0.071	0.121	0.075	0.133	0.135	0.100	0.130
SOUTH KOREA	0.096	0.098	0.091	0.103	0.154	0.163	0.102	0.175
SPAIN	0.155	0.166	0.127	0.198	0.182	0.187	0.167	0.238
SRI LANKA	0.375	0.375		0.500	1.000	1.000		1.000
SWEDEN	0.076	0.078	0.072	0.065	0.086	0.089	0.078	0.077
SWITZERLAND	0.088	0.085	0.102	0.082	0.093	0.092	0.097	0.092
TAIWAN	0.046	0.047	0.042	0.057	0.116	0.115	0.122	0.120
THAILAND	0.139	0.137	0.154	0.147	0.132	0.135	0.083	0.156
TURKEY	0.031	0.029	0.045	0.026	0.043	0.044	0.000	0.037
UKRAINE	0.018	0.000	0.021	0.000				
UNITED ARAB EMIRATES	0.139	0.148	0.083	0.195	0.235	0.258	0.000	0.258
UNITED KINGDOM	0.098	0.100	0.094	0.095	0.113	0.116	0.106	0.109
UNITED STATES	0.087	0.086	0.097	0.086	0.100	0.099	0.112	0.100
URUGUAY	0.000		0.000					
VIETNAM	0.074	0.067	0.100	0.000				
VIRIGIN ISL	0.109	0.111	0.096		0.183	0.193	0.000	
ZIMBABWE	0.235		0.235		0.143		0.143	
Others Africa	0.000	0.000	0.000	0.000	0.000		0.000	
Others Asia	0.500	0.500		0.333				
Others Australia	0.000		0.000					
Others Europe	0.018	0.000	0.025	0.000	0.026	0.000	0.028	0.000
Others North America	0.003	0.003		0.000	0.003	0.003		0.000
Total	0.063	0.069	0.052	0.077	0.114	0.114	0.113	0.121

Panel B: BROWNEFFRATIO	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	BROWNEFFRATIOWW				BROWNEFFRATIOEP			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
ARGENTINA	0.088	0.099	0.000	0.100	0.172	0.182	0.000	0.219
AUSTRALIA	0.029	0.032	0.015	0.026	0.055	0.064	0.009	0.064
AUSTRIA	0.042	0.047	0.029	0.050	0.038	0.038	0.038	0.040
BANGLADESH	0.113	0.113						
BELGIUM	0.038	0.046	0.022	0.048	0.041	0.051	0.021	0.054
BERMUDA	0.025	0.027	0.006	0.174	0.075	0.080	0.000	0.139
BOSNIA & HERZEGOVINA	0.000	0.000	0.000					
BRAZIL	0.012	0.013	0.009	0.011	0.018	0.022	0.000	0.023
BULGARIA	0.017	0.011	0.026	0.000	0.031	0.071	0.000	0.000
CANADA	0.044	0.047	0.016	0.058	0.034	0.037	0.013	0.035
CAYMAN ISLANDS	0.007	0.007	0.008	0.001	0.023	0.020	0.029	0.000
CHILE	0.007	0.007	0.003	0.001	0.028	0.030	0.000	0.001
CHINA	0.005	0.005	0.005	0.007	0.026	0.027	0.021	0.027
COLOMBIA	0.024	0.042	0.000	0.067	0.143	0.143		0.143
CROATIA	0.000	0.000	0.000	0.000	0.000	0.000		
CYPRUS	0.016	0.020	0.000	0.013	0.000	0.000	0.000	0.000
CZECH REP	0.011	0.000	0.013	0.001	0.000	0.000	0.000	0.000
DENMARK	0.020	0.020	0.019	0.024	0.023	0.020	0.034	0.023
EGYPT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ESTONIA	0.000	0.000	0.000					
FINLAND	0.030	0.033	0.022	0.048	0.047	0.047	0.046	0.065
FRANCE	0.024	0.028	0.016	0.027	0.026	0.029	0.019	0.030
GERMANY	0.034	0.035	0.032	0.043	0.042	0.042	0.043	0.051
GREECE	0.044	0.038	0.100	0.031	0.065	0.054	0.200	0.102
GUERNSEY	0.062	0.079	0.000	0.278	0.111	0.139	0.000	0.417
HONG KONG	0.007	0.007	0.002	0.011	0.009	0.009	0.000	0.012
HUNGARY	0.028	0.019	0.050	0.000	0.045	0.030	0.091	0.000
ICELAND	0.003	0.005	0.000	0.000	0.000	0.000	0.000	0.000
INDIA	0.021	0.021	0.020	0.027	0.043	0.046	0.015	0.057
INDONESIA	0.000	0.000	0.000	0.000	0.000	0.000		0.000
IRELAND	0.014	0.012	0.021	0.007	0.019	0.012	0.035	0.010
ISLAMIC REPUBLIC OF IRAN	0.000		0.000					
ISRAEL	0.013	0.013	0.014	0.014	0.018	0.019	0.011	0.018
ITALY	0.049	0.055	0.034	0.061	0.067	0.079	0.034	0.079
JAPAN	0.012	0.012	0.008	0.014	0.041	0.042	0.029	0.045
JERSEY	0.005	0.009	0.000	0.013	0.000	0.000	0.000	0.000
JORDAN	0.012	0.016	0.000		0.000	0.000		
KAZAKHSTAN	0.000	0.000	0.000		0.000		0.000	
KUWAIT	0.000	0.000	0.000	0.000	0.000	0.000		0.000
LATVIA	0.002	0.002	0.000		0.000	0.000		
LITHUANIA	0.000	0.000	0.000	0.000	0.000	0.000		
LUXEMBOURG	0.032	0.026	0.045	0.032	0.037	0.032	0.047	0.028
MALAYSIA	0.036	0.028	0.088	0.040	0.078	0.071	0.153	0.095
MALTA	0.000	0.000		0.000	0.000	0.000		0.000
MAURITIUS	0.000	0.000	0.000		0.000	0.000	0.000	
MEXICO	0.025	0.015	0.083	0.016	0.046	0.043	0.063	0.040
MONGOLIA	0.000	0.000		0.000				
MOROCCO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
NETHERLANDS	0.033	0.030	0.040	0.030	0.035	0.030	0.048	0.033
NEW ZEALAND	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
NIGERIA	0.000	0.000	0.000	0.000				
NORTH MACEDONIA	0.000		0.000		0.000		0.000	
NORWAY	0.044	0.054	0.019	0.057	0.045	0.052	0.023	0.055
OMAN	0.000	0.000	0.000	0.000	0.000		0.000	
PAKISTAN	0.000	0.000	0.000	0.000	0.000		0.000	
PANAMA	0.000		0.000					
PARAGUAY	0.000		0.000		0.000		0.000	
PERU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PHILIPPINES	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
POLAND	0.020	0.022	0.008	0.025	0.037	0.042	0.000	0.027
PORTUGAL	0.021	0.017	0.027	0.028	0.054	0.077	0.033	0.125
QATAR	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
REPUBLIC OF MOLDOVA	0.000		0.000		0.000		0.000	
ROMANIA	0.024	0.012	0.028	0.000	0.167	0.500	0.125	
RUSSIA	0.020	0.024	0.018	0.028	0.029	0.018	0.045	0.015
SAUDI ARABIA	0.071	0.080	0.018	0.084	0.041	0.045	0.022	0.043
SERBIA	0.004	0.000	0.004		0.000	0.000	0.000	
SINGAPORE	0.022	0.019	0.031	0.036	0.060	0.053	0.098	0.070
SLOVAKIA	0.017	0.000	0.021		0.045	0.000	0.067	
SLOVENIA	0.002	0.001	0.002	0.000	0.003	0.000	0.008	0.000
SOUTH AFRICA	0.013	0.014	0.000	0.009	0.043	0.046	0.000	0.030
SOUTH KOREA	0.020	0.021	0.016	0.021	0.027	0.029	0.015	0.031
SPAIN	0.019	0.017	0.026	0.024	0.023	0.018	0.039	0.027
SRI LANKA	0.000	0.000		0.000	0.000	0.000		0.000
SWEDEN	0.031	0.033	0.026	0.047	0.036	0.038	0.033	0.053
SWITZERLAND	0.019	0.019	0.015	0.018	0.018	0.019	0.013	0.020
TAIWAN	0.003	0.003	0.002	0.003	0.009	0.009	0.007	0.010
THAILAND	0.022	0.021	0.026	0.026	0.019	0.021	0.000	0.024
TURKEY	0.012	0.014	0.000	0.019	0.024	0.025	0.000	0.030
UKRAINE	0.012	0.000	0.013	0.000				
UNITED ARAB EMIRATES	0.023	0.027	0.000	0.043	0.000	0.000	0.000	0.000
UNITED KINGDOM	0.037	0.032	0.046	0.035	0.045	0.039	0.060	0.044
UNITED STATES	0.023	0.024	0.016	0.030	0.026	0.027	0.013	0.032
URUGUAY	0.000		0.000					
VIETNAM	0.044	0.029	0.100	0.000				
VIRIGIN ISL	0.008	0.009	0.000		0.000	0.000	0.000	
ZIMBABWE	0.000		0.000		0.000		0.000	
Others Africa	0.008	0.000	0.020		0.000		0.000	
Others Asia	0.000	0.000		0.000				
Others Australia	0.000		0.000					
Others Europe	0.018	0.000	0.026	0.000	0.003	0.000	0.003	0.000
Others North America	0.002	0.002		0.000	0.006	0.006		0.000
Total	0.015	0.018	0.010	0.022	0.033	0.034	0.028	0.037

TABLE 3: PATENT RATIO BY GICS6-INDUSTRY

The sample period is 2005-2020. We report average patent ratios by GICS 6-Industry for the full (public and private), public, private and Trucost sample. In Panel A we report the average $GREENRATIOWW$ in columns 1 to 4 and the average $GREENRATIOEP$ in columns 5 to 8. In Panel B we report the average $BROWNEFFRATIOWW$ in columns 1 to 4 and the average $BROWNEFFRATIOEP$ in columns 5 to 8. All variables are defined in Table 2.

Panel A: GREENRATIO	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GREENRATIOWW				GREENRATIOEP			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
Aerospace & Defense	0.057	0.068	0.025	0.067	0.095	0.099	0.032	0.091
Air Freight & Logistics	0.054	0.050	0.079	0.057	0.093	0.075	0.400	0.066
Airlines	0.030	0.032	0.006	0.028	0.040	0.044	0.000	0.035
Auto Components	0.048	0.054	0.036	0.076	0.093	0.090	0.113	0.101
Automobiles	0.117	0.118	0.106	0.115	0.265	0.251	0.529	0.242
Banks	0.055	0.053	0.061	0.052	0.082	0.079	0.089	0.076
Beverages	0.036	0.032	0.046	0.040	0.115	0.115	0.118	0.122
Biotechnology	0.129	0.135	0.112	0.153	0.159	0.160	0.156	0.175
Building Products	0.058	0.065	0.041	0.082	0.116	0.129	0.065	0.126
Capital Markets	0.058	0.058	0.056	0.054	0.089	0.090	0.085	0.090
Chemicals	0.071	0.083	0.048	0.100	0.147	0.148	0.136	0.145
Commercial Services & Supplies	0.059	0.074	0.043	0.086	0.091	0.096	0.072	0.099
Communications Equipment	0.031	0.032	0.028	0.032	0.050	0.050	0.050	0.048
Construction Materials	0.099	0.115	0.070	0.145	0.231	0.218	0.288	0.240
Construction & Engineering	0.075	0.083	0.060	0.105	0.204	0.225	0.116	0.252
Consumer Finance	0.034	0.031	0.064	0.023	0.056	0.061	0.000	0.072
Containers & Packaging	0.036	0.034	0.044	0.033	0.039	0.036	0.052	0.038
Distributors	0.025	0.026	0.020	0.021	0.035	0.039	0.007	0.048
Diversified Consumer Services	0.022	0.019	0.032	0.028	0.001	0.001	0.000	0.004
Diversified Financial Services	0.045	0.055	0.030	0.055	0.085	0.084	0.125	0.087
Diversified Telecommunication Services	0.029	0.029	0.028	0.022	0.033	0.034	0.031	0.021
Electric Utilities	0.285	0.278	0.301	0.291	0.499	0.470	0.640	0.442
Electrical Equipment	0.146	0.170	0.119	0.212	0.302	0.314	0.245	0.325
Electronic Equipment, Instruments & Components	0.061	0.075	0.039	0.075	0.116	0.114	0.147	0.113
Energy Equipment & Services	0.102	0.101	0.107	0.107	0.157	0.139	0.302	0.140
Entertainment	0.023	0.018	0.028	0.010	0.038	0.025	0.087	0.018
Equity Real Estate Investment Trusts (REITs)	0.091	0.094	0.084	0.143	0.111	0.110	0.113	0.255
Food Products	0.055	0.059	0.045	0.057	0.125	0.119	0.162	0.118
Food & Staples Retailing	0.036	0.040	0.025	0.045	0.067	0.066	0.071	0.071
Gas Utilities	0.114	0.119	0.074	0.119	0.368	0.370	0.333	0.407
Health Care Equipment & Supplies	0.036	0.036	0.036	0.034	0.039	0.037	0.050	0.040
Health Care Providers & Services	0.036	0.047	0.028	0.042	0.080	0.087	0.064	0.073
Health Care Technology	0.036	0.036	0.018	0.030	0.087	0.087	0.044	0.083
Hotels, Restaurants & Leisure	0.033	0.037	0.050	0.042	0.020	0.016	0.073	0.025
Household Durables	0.034	0.031	0.005	0.039	0.058	0.056	0.131	0.071
Household Products	0.035	0.036	0.041	0.033	0.054	0.054	0.926	0.051
IT Services	0.037	0.036	0.213	0.027	0.059	0.053	0.000	0.045
Independent Power and Renewable Electricity Producers	0.201	0.197	0.000	0.197	0.536	0.479	0.000	0.494
Industrial Conglomerates	0.080	0.081	0.099	0.076	0.130	0.130	0.000	0.130
Insurance	0.034	0.030	0.038	0.028	0.083	0.083	0.036	0.076
Interactive Media & Services	0.030	0.020	0.000	0.006	0.035	0.037	0.000	0.031
Internet Software & Services (discont. 2018)	0.012	0.012	0.008	0.007	0.005	0.005	0.090	0.007
Internet & Direct Marketing Retail	0.019	0.021	0.029	0.010	0.028	0.031	0.145	0.037
Leisure Products	0.041	0.043	0.000	0.067	0.090	0.097	0.000	0.129
Life Sciences Tools & Services	0.090	0.092	0.041	0.093	0.113	0.114	0.000	0.112
Machinery	0.046	0.049	0.104	0.056	0.083	0.081	0.119	0.088
Marine	0.079	0.074	0.031	0.056	0.123	0.120	0.000	0.128
Media	0.019	0.017	0.021	0.020	0.035	0.041	0.270	0.040
Media (discont. 2018)	0.034	0.038	0.049	0.047	0.050	0.054	0.021	0.059
Metals & Mining	0.057	0.060	0.000	0.063	0.128	0.129	0.012	0.122
Multi-Utilities	0.294	0.298	0.040	0.310	0.367	0.367	0.087	0.373
Multiline Retail	0.056	0.060	0.102	0.067	0.087	0.092	0.056	0.102
Oil, Gas & Consumable Fuels	0.197	0.215	0.019	0.235	0.358	0.367	0.166	0.385
Paper & Forest Products	0.060	0.072	0.047	0.087	0.088	0.096	0.167	0.118
Personal Products	0.027	0.024	0.046	0.016	0.042	0.044	0.162	0.029
Pharmaceuticals	0.049	0.051	0.052	0.039	0.074	0.071	0.045	0.060
Professional Services	0.072	0.079	0.084	0.075	0.117	0.130	0.101	0.088
Real Estate Management & Development	0.066	0.060	0.078	0.053	0.189	0.197	0.047	0.178
Road & Rail	0.072	0.070	0.069	0.057	0.166	0.166	0.063	0.145
Semiconductors & Semiconductor Equipment	0.095	0.103	0.023	0.137	0.176	0.179	0.129	0.201
Software	0.023	0.023	0.029	0.016	0.035	0.032	0.079	0.019
Specialty Retail	0.039	0.043	0.022	0.037	0.066	0.059	0.096	0.057
Technology Hardware, Storage & Peripherals	0.029	0.030	0.021	0.036	0.048	0.048	0.250	0.048
Textiles, Apparel & Luxury Goods	0.024	0.025	0.137	0.020	0.049	0.048		0.036
Tobacco	0.110	0.105	0.046	0.093	0.114	0.112		0.103
Trading Companies & Distributors	0.046	0.046	0.040	0.052	0.096	0.102		0.109
Transportation Infrastructure	0.027	0.022	0.035	0.026	0.060	0.034		0.023
Water Utilities	0.050	0.064		0.073	0.207	0.195		0.292
Wireless Telecommunication Services	0.019	0.019		0.020	0.022	0.022		0.020
Total	0.063	0.069	0.052	0.077	0.114	0.114	0.113	0.121

Panel B: BROWNEFFRATIO	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	BROWNEFFRATIOWW				BROWNEFFRATIOEP			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
Aerospace & Defense	0.031	0.040	0.007	0.048	0.056	0.059	0.007	0.061
Air Freight & Logistics	0.003	0.004	0.000	0.002	0.002	0.002	0.000	0.002
Airlines	0.008	0.009	0.000	0.006	0.014	0.015	0.000	0.017
Auto Components	0.035	0.043	0.018	0.048	0.084	0.087	0.061	0.071
Automobiles	0.051	0.057	0.010	0.072	0.145	0.149	0.071	0.159
Banks	0.024	0.020	0.039	0.019	0.045	0.031	0.077	0.029
Beverages	0.007	0.007	0.010	0.006	0.005	0.005	0.000	0.006
Biotechnology	0.003	0.001	0.006	0.001	0.001	0.001	0.003	0.000
Building Products	0.023	0.024	0.020	0.023	0.064	0.065	0.058	0.046
Capital Markets	0.017	0.016	0.023	0.015	0.028	0.025	0.042	0.025
Chemicals	0.016	0.018	0.011	0.023	0.037	0.037	0.044	0.036
Commercial Services & Supplies	0.018	0.024	0.013	0.028	0.047	0.051	0.034	0.050
Communications Equipment	0.002	0.002	0.001	0.002	0.005	0.005	0.003	0.002
Construction Materials	0.021	0.024	0.017	0.030	0.094	0.095	0.091	0.087
Construction & Engineering	0.032	0.038	0.021	0.047	0.108	0.112	0.093	0.114
Consumer Finance	0.018	0.020	0.000	0.019	0.075	0.081	0.000	0.097
Containers & Packaging	0.003	0.003	0.003	0.004	0.003	0.004	0.000	0.005
Distributors	0.011	0.007	0.027	0.010	0.033	0.013	0.200	0.015
Diversified Consumer Services	0.019	0.017	0.026	0.007	0.003	0.003	0.000	0.010
Diversified Financial Services	0.022	0.028	0.011	0.026	0.055	0.053	0.250	0.049
Diversified Telecommunication Services	0.003	0.004	0.002	0.001	0.002	0.002	0.001	0.001
Electric Utilities	0.049	0.055	0.032	0.064	0.113	0.121	0.076	0.141
Electrical Equipment	0.011	0.014	0.007	0.018	0.035	0.036	0.030	0.038
Electronic Equipment, Instruments & Components	0.006	0.007	0.004	0.007	0.013	0.013	0.020	0.014
Energy Equipment & Services	0.164	0.188	0.075	0.208	0.202	0.208	0.159	0.206
Entertainment	0.004	0.002	0.006	0.001	0.000	0.000	0.000	0.000
Equity Real Estate Investment Trusts (REITs)	0.013	0.010	0.020	0.018	0.007	0.001	0.026	0.000
Food Products	0.004	0.005	0.002	0.005	0.007	0.008	0.002	0.010
Food & Staples Retailing	0.020	0.025	0.010	0.010	0.047	0.047	0.048	0.000
Gas Utilities	0.039	0.041	0.022	0.042	0.062	0.066	0.000	0.074
Health Care Equipment & Supplies	0.004	0.004	0.003	0.004	0.004	0.004	0.005	0.003
Health Care Providers & Services	0.004	0.004	0.004	0.001	0.004	0.006	0.000	0.001
Health Care Technology	0.008	0.008	0.011	0.010	0.000	0.000	0.000	0.000
Hotels, Restaurants & Leisure	0.006	0.004	0.005	0.003	0.006	0.006	0.014	0.000
Household Durables	0.009	0.010	0.000	0.015	0.024	0.025	0.000	0.032
Household Products	0.003	0.003	0.001	0.003	0.013	0.013	0.074	0.006
IT Services	0.010	0.013	0.025	0.009	0.021	0.022	0.000	0.014
Independent Power and Renewable Electricity Producers	0.045	0.051	0.000	0.048	0.173	0.188	0.000	0.213
Industrial Conglomerates	0.029	0.029	0.000	0.028	0.051	0.051	0.000	0.051
Insurance	0.011	0.012	0.000	0.009	0.034	0.034	0.000	0.030
Interactive Media & Services	0.003	0.006	0.000	0.000	0.001	0.001	0.000	0.001
Internet Software & Services (discont. 2018)	0.005	0.005	0.019	0.008	0.000	0.000	0.057	0.000
Internet & Direct Marketing Retail	0.005	0.003	0.001	0.001	0.002	0.003	0.000	0.003
Leisure Products	0.003	0.004	0.000	0.008	0.013	0.015	0.000	0.019
Life Sciences Tools & Services	0.003	0.003	0.016	0.003	0.004	0.004	0.000	0.005
Machinery	0.026	0.033	0.000	0.043	0.071	0.074	0.075	0.083
Marine	0.051	0.062	0.001	0.072	0.054	0.062	0.000	0.066
Media	0.008	0.010	0.001	0.002	0.009	0.011	0.064	0.000
Media (discont. 2018)	0.008	0.010	0.021	0.007	0.015	0.016	0.000	0.006
Metals & Mining	0.024	0.024	0.000	0.031	0.069	0.068	0.000	0.069
Multi-Utilities	0.085	0.086	0.000	0.091	0.118	0.118	0.001	0.120
Multiline Retail	0.007	0.009	0.039	0.004	0.000	0.000	0.041	0.000
Oil, Gas & Consumable Fuels	0.063	0.068	0.000	0.075	0.096	0.099	0.000	0.097
Paper & Forest Products	0.009	0.011	0.000	0.011	0.007	0.008	0.001	0.012
Personal Products	0.002	0.002	0.002	0.001	0.002	0.002	0.011	Trucost
Pharmaceuticals	0.002	0.002	0.012	0.003	0.001	0.001	0.014	0.001
Professional Services	0.022	0.025	0.006	0.032	0.046	0.047	0.000	0.070
Real Estate Management & Development	0.010	0.011	0.008	0.010	0.015	0.020	0.008	0.018
Road & Rail	0.010	0.010	0.003	0.004	0.000	0.000	0.022	0.004
Semiconductors & Semiconductor Equipment	0.004	0.004	0.004	0.004	0.007	0.006	0.000	0.007
Software	0.004	0.004	0.007	0.002	0.009	0.008	0.056	0.002
Specialty Retail	0.010	0.011	0.001	0.010	0.010	0.012	0.000	0.005
Technology Hardware, Storage & Peripherals	0.003	0.004	0.007	0.005	0.005	0.005	0.094	0.005
Textiles, Apparel & Luxury Goods	0.004	0.003	0.000	0.001	0.005	0.003		0.002
Tobacco	0.011	0.013	0.012	0.015	0.020	0.023		0.024
Trading Companies & Distributors	0.013	0.014	0.014	0.017	0.046	0.043		0.033
Transportation Infrastructure	0.012	0.011	0.007	0.007	0.000	0.000		0.000
Water Utilities	0.015	0.022		0.008	0.043	0.028		0.011
Wireless Telecommunication Services	0.001	0.001		0.001	0.002	0.002		0.002
Total	0.015	0.018	0.010	0.022	0.033	0.034	0.028	0.037

TABLE 4: PATENT RATIO BY YEAR

The sample period is 2005-2020. We report average patent ratios by year for the full (public and private), public, private and Trucost sample. In Panel A we report the average *GREENRATIOWW* in columns 1 to 4 and the average *GREENRATIOEP* in columns 5 to 8. In Panel B we report the average *BROWNEFFRATIOWW* in columns 1 to 4 and the average *BROWNEFFRATIOEP* in columns 5 to 8. All variables are defined in Table 2.

Panel A: GREENRATIO

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GREENRATIOWW				GREENRATIOEP			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
2005	0.057	0.055	0.060	0.065	0.087	0.084	0.096	0.091
2006	0.058	0.058	0.058	0.065	0.088	0.088	0.087	0.091
2007	0.057	0.057	0.053	0.068	0.095	0.097	0.085	0.097
2008	0.060	0.061	0.055	0.071	0.093	0.097	0.073	0.106
2009	0.060	0.060	0.060	0.071	0.100	0.102	0.090	0.108
2010	0.067	0.068	0.063	0.080	0.103	0.105	0.092	0.111
2011	0.064	0.065	0.060	0.078	0.105	0.106	0.101	0.114
2012	0.065	0.068	0.056	0.082	0.113	0.113	0.117	0.130
2013	0.065	0.069	0.055	0.084	0.121	0.119	0.134	0.126
2014	0.062	0.068	0.051	0.084	0.124	0.122	0.134	0.137
2015	0.058	0.069	0.041	0.083	0.120	0.121	0.113	0.132
2016	0.062	0.074	0.044	0.078	0.128	0.128	0.128	0.130
2017	0.064	0.071	0.051	0.073	0.124	0.121	0.144	0.120
2018	0.066	0.075	0.049	0.078	0.124	0.122	0.135	0.121
2019	0.070	0.077	0.055	0.080	0.136	0.135	0.143	0.134
2020	0.069	0.074	0.055	0.079	0.134	0.131	0.158	0.132
Total	0.063	0.069	0.052	0.077	0.114	0.114	0.113	0.121

Panel B: BROWNEFFRATIO

	Full	Public	Private	Trucost	Full	Public	Private	Trucost
	BROWNEFFRATIOWW				BROWNEFFRATIOEP			
	Full	Public	Private	Trucost	Full	Public	Private	Trucost
2005	0.020	0.020	0.019	0.024	0.030	0.031	0.025	0.034
2006	0.020	0.020	0.018	0.029	0.033	0.034	0.026	0.045
2007	0.017	0.019	0.011	0.026	0.033	0.036	0.020	0.037
2008	0.017	0.019	0.012	0.030	0.034	0.033	0.035	0.041
2009	0.015	0.017	0.010	0.024	0.031	0.033	0.021	0.038
2010	0.016	0.017	0.011	0.028	0.031	0.033	0.022	0.040
2011	0.017	0.019	0.012	0.028	0.032	0.034	0.022	0.043
2012	0.017	0.019	0.011	0.029	0.035	0.038	0.023	0.048
2013	0.014	0.017	0.009	0.023	0.035	0.036	0.027	0.042
2014	0.015	0.017	0.010	0.026	0.033	0.033	0.034	0.037
2015	0.012	0.016	0.005	0.025	0.034	0.034	0.032	0.042
2016	0.012	0.016	0.006	0.018	0.032	0.032	0.031	0.035
2017	0.015	0.017	0.010	0.019	0.035	0.034	0.041	0.034
2018	0.015	0.018	0.011	0.020	0.036	0.035	0.039	0.038
2019	0.016	0.018	0.013	0.019	0.032	0.032	0.034	0.033
2020	0.013	0.016	0.007	0.017	0.030	0.030	0.031	0.030
Total	0.015	0.018	0.010	0.022	0.033	0.034	0.028	0.037

TABLE 5: SUMMARY STATISTICS QUANTITATIVE VARIABLES

The table reports sample averages, medians, and standard deviations of various firm-level characteristics for the period 2005 to 2020. Panel A's column splits are based on firms' patenting at worldwide patent offices and Panel B's column splits on patenting at the European Patent Office. Panel A.1 and B.1 report summary statistics for the entire sample (public and private) firms, while Panel A.2 and B.2 are based on the Trucost sample. Column 1 to 3 aggregate all firm-years with at least one patent. Column 4 to 6 aggregate firm-years without patenting. Column 7 to 9 aggregate firm-years in the bottom decile based on a firm's average $GREENRATIOWW$ across the whole period. This covers only firms with 0 green patents in Panel A and represents about about 35% of firm-year observations here. Column 10 to 12 aggregate firm-years in the top decile based on a firm's average $GREENRATIOWW$ across the whole period. $GREENRATIOWW$ is the green patent ratio based on patenting at any patent office worldwide, calculated as the number of granted or purchased green patents over the total number of granted or purchased patents. $GREENRATIOEP$ is the green patent ratio based on patenting at the European Patent Office. $BROWNEFFRATIOWW$, $BROWNEFFRATIOEP$, $GENERALEFFRATIOWW$, $GENERALEFFRATIOEP$, $OECDRATIOWW$ and $OECDRATIOEP$ are similarly defined patent ratios where the numerator count is based on the brown efficiency classification, general efficiency classsification or the OECD green Env-tech classification. $GREENCITATIONRATIOWW$, as well as the other citation ratios ([...]$CITRATIO$[...]), are patent citation ratios based on forward citations, i.e. how often a patent has been cited in future work. Similarly to the patent ratio variables, we divide the number of forward citations of green, brown efficiency, general efficiency, or OECD classified patents by the total number of citations of all patents. $LOGS1TOT$ ($LOGS2TOT$ and $LOGS3TOT$) is the natural logarithm of firm-level scope 1 (2 and 3) emissions; $S1CHG$ ($S2CHG$ and $S3CHG$) is the annual percentage change in total scope 1 (2 and 3) emissions; $S1INT$ ($S2INT$ and $S3INT$) is the the firm-level scope 1 (2 and 3) emission intensity defined as the level of emission divided by the firm sales; $LOGSIZE$ is the natural logarithm of market capitalization (in \$ million); $LOGPPE$ is the natural logarithm of plant, property & equipment (in \$ million); $LEVERAGE$ is the book value of leverage defined as the book value of debt divided by the book value of assets; ROE is the return on equity; M/B is the market value of equity divided by the book value of equity; $BETA$ is the firm-level market beta estimated over the one-year period; $VOLAT$ is the monthly stock return volatility calculated over the one year period; MOM is the cumulative stock return over the one-year period; RET is the monthly stock return in December; $INVEST/A$ is CAPEX divided by the book value of assets; $MSCI$ is an indicator variable equal to one if a stock is part of the MSCI ACWI in a given year and zero otherwise; LOGCAPEX is the natural logarithm of capital expenditures; LOGCASH is the natural logarithm of cash and short-term equivalents.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Patenting Sample			Non-patenting observations			Bottom decile green ratio			Top decile green ratio		

Panel A: Conditioning on patenting at any patent office worldwide

Panel A.1: All public and private firms

	mean	p50	sd	mean	p50	sd	mean	p50	sd	mean	p50	sd
GREENRATIOWW	0.063	0.000	0.184	.	.	.	0.000	0.000	0.000	0.422	0.333	0.376
GREENRATIOEP	0.114	0.000	0.257	.	.	.	0.000	0.000	0.000	0.481	0.444	0.411
BROWNEFFRATIOWW	0.015	0.000	0.088	.	.	.	0.009	0.000	0.081	0.030	0.000	0.120
BROWNEFFRATIOEP	0.033	0.000	0.138	.	.	.	0.018	0.000	0.127	0.050	0.000	0.163
LOGASSETS	5.210	5.075	2.504	1.618	1.095	1.648	4.639	4.515	2.283	5.383	5.190	2.704
LOGPPE	4.101	3.870	3.002	0.722	0.074	1.366	3.521	3.028	2.834	4.286	3.955	3.238
LEVERAGE	16.394	9.216	19.121	10.202	0.000	18.553	14.929	5.758	19.294	19.122	13.332	20.207
ROE	4.270	7.990	33.447	10.242	5.860	35.831	3.870	7.850	34.701	−0.309	6.640	39.704
INVEST/A	5.115	2.944	6.620	4.088	0.265	8.341	5.108	2.693	6.898	5.682	3.419	7.092
LOGCAPEX	2.351	1.926	2.064	0.366	0.006	0.900	1.870	1.414	1.765	2.618	2.090	2.362
LOGCASH	3.146	2.987	2.214	0.494	0.071	0.970	2.648	2.426	1.976	3.241	3.044	2.304

Panel A.2: Public firms with emission data

	mean	p50	sd	mean	p50	sd	mean	p50	sd	mean	p50	sd
GREENRATIOWW	0.077	0.000	0.181	.	.	.	0.000	0.000	0.000	0.438	0.383	0.344
GREENRATIOEP	0.121	0.000	0.242	.	.	.	0.000	0.000	0.000	0.500	0.500	0.381
BROWNEFFRATIOWW	0.022	0.000	0.093	.	.	.	0.010	0.000	0.086	0.047	0.000	0.138
BROWNEFFRATIOEP	0.037	0.000	0.133	.	.	.	0.018	0.000	0.126	0.065	0.000	0.179
GENERALEFFRATIOWW	0.089	0.000	0.201	.	.	.	0.115	0.000	0.277	0.067	0.000	0.161
GENERALEFFRATIOEP	0.098	0.000	0.216	.	.	.	0.123	0.000	0.300	0.065	0.000	0.183
OECDRATIOWW	0.088	0.000	0.188	.	.	.	0.031	0.000	0.139	0.330	0.226	0.346
OECDRATIOEP	0.124	0.000	0.242	.	.	.	0.042	0.000	0.177	0.371	0.250	0.391
GREENCITRATIOWW	0.097	0.000	0.218	.	.	.	0.000	0.000	0.002	0.495	0.477	0.381
GREENCITRATIOEP	0.131	0.000	0.265	.	.	.	0.000	0.000	0.005	0.537	0.550	0.403
BROWNEFFCITRATIOWW	0.026	0.000	0.110	.	.	.	0.012	0.000	0.099	0.050	0.000	0.159
BROWNEFFCITRATIOEP	0.037	0.000	0.142	.	.	.	0.017	0.000	0.125	0.064	0.000	0.189
GENERALEFFCITRATIOWW	0.106	0.000	0.231	.	.	.	0.137	0.000	0.313	0.070	0.000	0.186
GENERALEFFCITRATIOEP	0.107	0.000	0.238	.	.	.	0.127	0.000	0.314	0.061	0.000	0.188
OECDCITRATIOWW	0.107	0.000	0.225	.	.	.	0.035	0.000	0.160	0.376	0.241	0.388
OECDCITRATIOEP	0.137	0.000	0.267	.	.	.	0.043	0.000	0.186	0.402	0.242	0.416
LOGS1TOT	5.852	5.609	2.784	4.347	3.998	2.706	4.992	4.729	2.599	6.718	6.251	3.467
LOGS2TOT	5.725	5.738	2.190	4.347	4.382	1.980	5.012	4.992	2.043	5.706	5.723	2.533
LOGS3TOT	7.548	7.648	2.229	5.738	5.758	1.953	6.685	6.779	2.059	7.588	7.839	2.621
S1CHG	0.089	0.023	0.432	0.094	0.020	0.468	0.096	0.029	0.443	0.091	0.012	0.462
S2CHG	0.127	0.028	0.496	0.123	0.026	0.525	0.127	0.031	0.499	0.148	0.022	0.582
S3CHG	0.064	0.030	0.259	0.066	0.031	0.290	0.070	0.034	0.270	0.060	0.023	0.292
S1INT	1.890	0.194	5.444	2.182	0.136	6.103	1.594	0.161	5.036	3.792	0.402	7.630
S2INT	0.408	0.209	0.565	0.418	0.189	0.582	0.368	0.174	0.536	0.493	0.242	0.655
S3INT	1.958	1.461	1.752	1.242	0.599	1.568	1.629	0.894	1.754	2.161	1.670	1.690
LOGSIZE	7.589	7.631	1.728	6.726	6.759	1.499	7.126	7.198	1.602	7.510	7.553	1.880
LOGPPE	5.923	5.995	2.223	4.617	4.893	2.367	5.195	5.276	2.161	6.345	6.300	2.578
LEVERAGE	23.274	21.507	17.794	25.654	23.055	20.521	22.687	19.859	19.047	25.412	24.126	17.925
ROE	8.293	9.894	25.245	8.774	9.422	25.247	7.373	9.789	27.141	4.554	8.596	29.797
M/B	2.644	1.738	2.957	2.399	1.442	2.962	2.818	1.799	3.228	2.475	1.656	2.850
BETA	0.650	0.693	0.350	0.703	0.721	0.262	0.629	0.661	0.303	0.663	0.700	0.379
VOLAT	0.105	0.089	0.071	0.109	0.087	0.089	0.110	0.092	0.077	0.115	0.092	0.088
MOM	0.005	0.005	0.036	0.003	0.004	0.039	0.004	0.005	0.037	0.004	0.005	0.040
RET	0.016	0.010	0.118	0.014	0.006	0.127	0.016	0.007	0.123	0.017	0.007	0.133
INVEST/A	4.632	3.408	4.635	4.545	2.097	6.393	4.486	3.025	4.980	5.622	4.408	5.119
MSCI	0.341	0.000	0.474	0.146	0.000	0.353	0.241	0.000	0.428	0.332	0.000	0.471
LOGCAPEX	4.284	4.296	2.007	3.112	3.123	1.889	3.635	3.630	1.860	4.589	4.534	2.298
LOGCASH	5.514	5.495	1.776	4.292	4.316	1.685	4.984	4.994	1.652	5.375	5.397	1.875

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Panel B: Conditioning on patenting at the European Patent Office											

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Patenting Sample			Non-patenting observations			Bottom decile green ratio			Top decile green ratio		

Panel B: Conditioning on patenting at the European Patent Office

Panel B.1: All public and private firms

	mean	p50	sd	mean	p50	sd	mean	p50	sd	mean	p50	sd
GREENRATIOWW	0.081	0.000	0.200	0.044	0.000	0.164	0.021	0.000	0.098	0.418	0.333	0.386
GREENRATIOEP	0.114	0.000	0.257	.	.	.	0.000	0.000	0.000	0.729	1.000	0.364
BROWNEFFRATIOWW	0.021	0.000	0.099	0.008	0.000	0.073	0.016	0.000	0.100	0.024	0.000	0.107
BROWNEFFRATIOEP	0.033	0.000	0.138	.	.	.	0.024	0.000	0.142	0.028	0.000	0.126
LOGASSETS	5.986	5.971	2.618	1.745	1.175	1.785	5.413	5.410	2.435	5.798	5.800	2.742
LOGPPE	4.643	4.750	3.076	0.846	0.095	1.578	4.080	4.006	2.960	4.666	4.627	3.189
LEVERAGE	19.041	14.520	19.276	10.382	0.000	18.583	18.172	12.036	19.873	20.121	14.958	20.279
ROE	1.050	7.480	38.460	10.088	6.009	35.588	−0.590	6.967	40.657	−2.451	6.193	41.876
INVEST/A	4.869	3.126	5.972	4.169	0.410	8.270	4.878	2.924	6.234	5.626	3.498	6.858
LOGCAPEX	2.887	2.650	2.255	0.470	0.011	1.057	2.368	2.087	1.974	2.893	2.530	2.393
LOGCASH	3.897	3.891	2.295	0.587	0.083	1.125	3.401	3.399	2.072	3.730	3.659	2.298

Panel B.2: Public firms with emission data

	Patenting Sample			Non-patenting observations			Bottom decile green ratio			Top decile green ratio		
	mean	p50	sd	mean	p50	sd	mean	p50	sd	mean	p50	sd
GREENRATIOWW	0.086	0.003	0.184	0.052	0.000	0.170	0.026	0.000	0.103	0.396	0.333	0.354
GREENRATIOEP	0.121	0.000	0.242	.	.	.	0.000	0.000	0.000	0.673	0.750	0.356
BROWNEFFRATIOWW	0.025	0.000	0.096	0.012	0.000	0.081	0.017	0.000	0.099	0.035	0.000	0.115
BROWNEFFRATIOEP	0.037	0.000	0.133	.	.	.	0.024	0.000	0.142	0.044	0.000	0.148
GENERALEFFRATIOWW	0.090	0.013	0.189	0.088	0.000	0.233	0.110	0.000	0.242	0.059	0.000	0.143
GENERALEFFRATIOEP	0.098	0.000	0.216	.	.	.	0.130	0.000	0.299	0.048	0.000	0.159
OECDRATIOWW	0.094	0.013	0.186	0.073	0.000	0.193	0.051	0.000	0.155	0.299	0.175	0.333
OECDRATIOEP	0.124	0.000	0.242	.	.	.	0.047	0.000	0.186	0.462	0.444	0.416
GREENCITRATIOWW	0.106	0.000	0.222	0.064	0.000	0.202	0.028	0.000	0.122	0.472	0.432	0.386
GREENCITRATIOEP	0.131	0.000	0.265	.	.	.	0.000	0.000	0.004	0.692	0.900	0.374
BROWNEFFCITRATIOWW	0.029	0.000	0.116	0.013	0.000	0.090	0.019	0.000	0.114	0.037	0.000	0.135
BROWNEFFCITRATIOEP	0.037	0.000	0.142	.	.	.	0.024	0.000	0.144	0.043	0.000	0.157
GENERALEFFCITRATIOWW	0.107	0.003	0.222	0.102	0.000	0.259	0.129	0.000	0.278	0.064	0.000	0.166
GENERALEFFCITRATIOEP	0.107	0.000	0.238	.	.	.	0.137	0.000	0.318	0.048	0.000	0.169
OECDCITRATIOWW	0.113	0.002	0.224	0.088	0.000	0.227	0.057	0.000	0.182	0.354	0.198	0.377
OECDCITRATIOEP	0.137	0.000	0.267	.	.	.	0.049	0.000	0.198	0.486	0.480	0.433
LOGS1TOT	6.130	5.921	2.765	4.853	4.535	2.780	5.276	5.047	2.560	6.691	6.259	3.462
LOGS2TOT	6.054	6.099	2.241	4.752	4.770	2.029	5.317	5.357	2.101	5.887	5.971	2.501
LOGS3TOT	7.945	8.136	2.325	6.298	6.344	2.010	7.115	7.302	2.210	7.814	8.073	2.638
S1CHG	0.084	0.018	0.431	0.097	0.026	0.452	0.094	0.028	0.441	0.104	0.016	0.479
S2CHG	0.122	0.024	0.495	0.128	0.031	0.512	0.125	0.026	0.500	0.166	0.028	0.591
S3CHG	0.059	0.027	0.252	0.069	0.034	0.281	0.067	0.033	0.262	0.073	0.029	0.303
S1INT	1.606	0.189	4.710	2.264	0.160	6.267	1.362	0.161	4.462	3.285	0.375	6.993
S2INT	0.407	0.211	0.561	0.414	0.195	0.577	0.353	0.176	0.521	0.503	0.245	0.661
S3INT	2.086	1.609	1.716	1.486	0.764	1.697	1.791	1.091	1.741	2.281	1.804	1.645
LOGSIZE	7.857	7.894	1.760	6.931	6.983	1.553	7.372	7.389	1.713	7.589	7.659	1.881
LOGPPE	6.200	6.275	2.219	5.028	5.208	2.306	5.493	5.563	2.178	6.426	6.363	2.535
LEVERAGE	23.142	21.705	17.164	24.613	22.119	19.729	22.611	20.147	18.444	24.738	23.591	17.609
ROE	8.202	10.122	26.957	8.614	9.484	23.818	6.833	9.709	29.142	3.940	8.717	30.944
M/B	2.781	1.843	3.083	2.409	1.508	2.850	2.915	1.897	3.340	2.538	1.626	2.947
BETA	0.637	0.693	0.381	0.687	0.700	0.278	0.617	0.658	0.331	0.709	0.732	0.385
VOLAT	0.103	0.087	0.070	0.109	0.090	0.081	0.107	0.089	0.075	0.118	0.096	0.088
MOM	0.006	0.007	0.036	0.003	0.004	0.038	0.005	0.006	0.036	0.005	0.005	0.042
RET	0.018	0.013	0.118	0.014	0.005	0.123	0.019	0.011	0.124	0.017	0.007	0.136
INVEST/A	4.704	3.621	4.364	4.530	2.572	5.783	4.602	3.312	4.703	5.649	4.351	5.245
MSCI	0.406	0.000	0.491	0.189	0.000	0.392	0.294	0.000	0.456	0.369	0.000	0.483
LOGCAPEX	4.596	4.620	2.018	3.431	3.436	1.914	3.968	3.948	1.934	4.665	4.624	2.293
LOGCASH	5.746	5.731	1.798	4.706	4.731	1.726	5.216	5.186	1.716	5.577	5.620	1.834

TABLE 6: GREEN PATENT RATIO AND SCOPE 1 EMISSIONS

The unit of observation is firm-year. The dependent variable is *GREENRATIOWW* in Panel A and *GREENRATIOEP* in Panel B. The sample period is 2005-2020. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: *GREENRATIOWW* as dependent variable						
LOGS1TOT	0.094***	−0.009	−0.007	0.100***	−0.021**	−0.023**
	(0.004)	(0.006)	(0.006)	(0.006)	(0.009)	(0.009)
LOGSIZE				−0.134***	−0.058***	−0.061***
				(0.013)	(0.014)	(0.014)
LOGPPE				0.078***	0.086***	0.091***
				(0.012)	(0.013)	(0.013)
LEVERAGE				−0.005***	−0.003***	−0.003***
				(0.001)	(0.001)	(0.001)
ROE				−0.004***	−0.001***	−0.001***
				(0.000)	(0.000)	(0.000)
M/B				0.014***	0.014***	0.013***
				(0.005)	(0.005)	(0.005)
INVEST/A				0.018***	0.008***	0.008***
				(0.002)	(0.002)	(0.003)
BETA				0.186***	0.044	0.052
				(0.031)	(0.031)	(0.032)
VOLAT				1.594***	1.244***	1.346***
				(0.221)	(0.172)	(0.175)
MOM				−0.022	−0.567*	−0.746**
				(0.385)	(0.341)	(0.359)
RET				0.021	0.033	−0.005
				(0.098)	(0.087)	(0.092)
MSCI				0.025	0.026	0.022
				(0.028)	(0.027)	(0.027)
Constant	−3.083***	−2.079***	−1.986***	−2.852***	−2.264***	−2.177***
	(0.031)	(0.042)	(0.042)	(0.077)	(0.076)	(0.076)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	53399	53191	50178	53399	53191	50178
Pseudo R2	0.0311	0.123	0.144	0.0418	0.126	0.146
Std dev dep. var.	0.180	0.180	0.183	0.180	0.180	0.183
Std dev LOGS1TOT	2.703	2.705	2.728	2.703	2.705	2.728
Eco sig LOGS1TOT	1.419	0.129	0.107	1.502	0.313	0.337

	(1)	(2)	(3)	(4)	(5)	(6)
			Panel B: *GREENRATIOEP* as dependent variable			
LOGS1TOT	0.084***	−0.027***	−0.029***	0.087***	−0.042***	−0.054***
	(0.005)	(0.007)	(0.007)	(0.008)	(0.011)	(0.011)
LOGSIZE				−0.164***	−0.094***	−0.097***
				(0.016)	(0.018)	(0.018)
LOGPPE				0.112***	0.118***	0.134***
				(0.016)	(0.017)	(0.018)
LEVERAGE				−0.006***	−0.004***	−0.004***
				(0.001)	(0.001)	(0.001)
ROE				−0.004***	−0.002***	−0.002***
				(0.001)	(0.001)	(0.001)
M/B				0.020***	0.020***	0.021***
				(0.006)	(0.005)	(0.006)
INVEST/A				0.014***	0.010***	0.009***
				(0.003)	(0.003)	(0.003)
BETA				0.207***	0.079**	0.093**
				(0.035)	(0.035)	(0.037)
VOLAT				2.065***	1.395***	1.399***
				(0.221)	(0.217)	(0.232)
MOM				0.327	−0.092	−0.109
				(0.461)	(0.418)	(0.454)
RET				−0.145	−0.101	−0.252**
				(0.123)	(0.111)	(0.116)
MSCI				0.063*	0.044	0.035
				(0.032)	(0.031)	(0.032)
Constant	−2.643***	−1.573***	−1.424***	−2.404***	−1.713***	−1.572***
	(0.039)	(0.052)	(0.051)	(0.091)	(0.093)	(0.093)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	28086	27817	25032	28086	27817	25032
Pseudo R2	0.0197	0.113	0.142	0.0331	0.117	0.146
Std dev dep. var.	0.240	0.241	0.246	0.240	0.241	0.246
Std dev LOGS1TOT	2.674	2.679	2.701	2.674	2.679	2.701
Eco sig LOGS1TOT	0.942	0.302	0.314	0.973	0.467	0.598

The unit of observation is firm-year. The dependent variable is *BROWNEFFRATIOWW* in Panel A and *BROWNEFFRATIOEP* in Panel B. The sample period is 2005-2020. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	Panel A: *BROWNEFFRATIOWW* as dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
LOGS1TOT	0.158***	0.050***	0.051***	0.090***	0.052***	0.043***
	(0.006)	(0.010)	(0.010)	(0.010)	(0.016)	(0.016)
LOGSIZE				−0.266***	−0.084***	−0.072***
				(0.026)	(0.027)	(0.028)
LOGPPE				0.246***	0.052**	0.053**
				(0.025)	(0.025)	(0.025)
LEVERAGE				−0.006***	−0.001	−0.001
				(0.001)	(0.001)	(0.001)
ROE				0.004***	0.001	0.002**
				(0.001)	(0.001)	(0.001)
M/B				−0.030***	−0.007	−0.011
				(0.009)	(0.010)	(0.010)
INVEST/A				0.013***	0.005	0.007
				(0.005)	(0.005)	(0.005)
BETA				0.273***	−0.034	−0.013
				(0.054)	(0.049)	(0.050)
VOLAT				−0.102	−0.473	−0.595
				(0.387)	(0.394)	(0.421)
MOM				0.467	−0.050	−0.156
				(0.667)	(0.623)	(0.654)
RET				−0.071	0.229	0.192
				(0.180)	(0.167)	(0.177)
MSCI				−0.051	0.055	0.059
				(0.050)	(0.048)	(0.047)
Constant	−4.662***	−3.191***	−2.976***	−3.730***	−2.844***	−2.691***
	(0.051)	(0.079)	(0.080)	(0.144)	(0.149)	(0.151)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	53166	51787	43813	53166	51787	43813
Pseudo R2	0.0624	0.208	0.234	0.0749	0.209	0.235
Std dev dep. var.	0.0946	0.0958	0.102	0.0946	0.0958	0.102
Std dev LOGS1TOT	2.701	2.717	2.779	2.701	2.717	2.779
Eco sig LOGS1TOT	4.502	1.405	1.387	2.564	1.472	1.163

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel B: *BROWNEFFRATIOEP* as dependent variable					
LOGS1TOT	0.150***	0.060***	0.066***	0.056***	0.044**	0.052**
	(0.008)	(0.012)	(0.012)	(0.013)	(0.021)	(0.021)
LOGSIZE				−0.280***	−0.079**	−0.067**
				(0.031)	(0.032)	(0.031)
LOGPPE				0.300***	0.071**	0.057*
				(0.032)	(0.033)	(0.032)
LEVERAGE				−0.005***	−0.001	−0.001
				(0.002)	(0.002)	(0.002)
ROE				0.005***	0.001	0.002
				(0.001)	(0.001)	(0.001)
M/B				−0.026**	−0.007	−0.014
				(0.011)	(0.011)	(0.011)
INVEST/A				−0.002	0.005	0.003
				(0.007)	(0.006)	(0.007)
BETA				0.340***	−0.008	−0.017
				(0.062)	(0.054)	(0.058)
VOLAT				0.259	0.159	0.127
				(0.466)	(0.488)	(0.530)
MOM				1.294	0.332	0.635
				(0.895)	(0.804)	(0.855)
RET				−0.360	−0.043	0.012
				(0.231)	(0.216)	(0.237)
MSCI				0.009	0.106*	0.108**
				(0.057)	(0.054)	(0.053)
Constant	−4.258***	−2.822***	−2.599***	−3.490***	−2.623***	−2.383***
	(0.064)	(0.099)	(0.100)	(0.166)	(0.177)	(0.179)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	27993	26261	20338	27993	26261	20338
Pseudo R2	0.0376	0.212	0.240	0.0507	0.212	0.241
Std dev dep. var.	0.134	0.137	0.150	0.134	0.137	0.150
Std dev LOGS1TOT	2.673	2.706	2.764	2.673	2.706	2.764
Eco sig LOGS1TOT	3.007	1.181	1.215	1.125	0.864	0.955

TABLE 8: GREEN PATENT RATIO AND SCOPE 1 EMISSIONS - INTENSIVE MARGIN

The unit of observation is firm-year. The dependent variable is *GREENRATIOWW* in Panel A and *GREENRATIOEP* in Panel B. The sample period is 2005-2020 and the sample restricts inclusion to firm-years with with *at least one* green patent at the European Office in Panel A and one green patent at some patent office worldwide. All variables are defined in Table 5. The model is estimated using pooled regression model. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: *GREENRATIOWW* as dependent variable			
LOGS1TOT	−0.002***	−0.028***	−0.028***	0.011***	−0.009***	−0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LOGSIZE				−0.040***	−0.030***	−0.028***
				(0.002)	(0.002)	(0.002)
LOGPPE				0.001	−0.002	−0.003
				(0.002)	(0.002)	(0.002)
LEVERAGE				−0.000***	−0.001***	−0.001***
				(0.000)	(0.000)	(0.000)
ROE				−0.001***	−0.000***	−0.000***
				(0.000)	(0.000)	(0.000)
M/B				0.004***	0.004***	0.004***
				(0.001)	(0.001)	(0.001)
INVEST/A				0.005***	0.004***	0.004***
				(0.000)	(0.000)	(0.000)
BETA				0.006	0.001	0.002
				(0.004)	(0.004)	(0.005)
VOLAT				0.278***	0.254***	0.265***
				(0.042)	(0.039)	(0.045)
MOM				0.002	−0.029	−0.061
				(0.064)	(0.056)	(0.067)
RET				−0.002	−0.000	−0.008
				(0.017)	(0.015)	(0.018)
MSCI				0.001	0.005	0.002
				(0.004)	(0.004)	(0.004)
Constant	0.191***	0.373***	0.371***	0.376***	0.464***	0.449***
	(0.005)	(0.007)	(0.007)	(0.012)	(0.012)	(0.014)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	23515	23497	22312	23515	23497	22312
R2	0.0978	0.359	0.417	0.173	0.385	0.440
Std dev dep. var.	0.236	0.236	0.235	0.236	0.236	0.235
Std dev LOGS1TOT	2.678	2.678	2.698	2.678	2.678	2.698
Eco sig LOGS1TOT	0.0212	0.319	0.321	0.130	0.0978	0.0981

	Panel B: *GREENRATIOEP* as dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
LOGS1TOT	−0.009***	−0.047***	−0.047***	0.014***	−0.015***	−0.016***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
LOGSIZE				−0.064***	−0.050***	−0.050***
				(0.003)	(0.004)	(0.004)
LOGPPE				0.005	−0.000	0.002
				(0.003)	(0.003)	(0.004)
LEVERAGE				−0.001***	−0.001***	−0.001***
				(0.000)	(0.000)	(0.000)
ROE				−0.001***	−0.000**	−0.000**
				(0.000)	(0.000)	(0.000)
M/B				0.005***	0.005***	0.005***
				(0.001)	(0.001)	(0.001)
INVEST/A				0.005***	0.004***	0.004***
				(0.001)	(0.001)	(0.001)
BETA				0.013*	0.014**	0.011
				(0.007)	(0.007)	(0.008)
VOLAT				0.413***	0.319***	0.343***
				(0.075)	(0.069)	(0.083)
MOM				0.145	−0.005	−0.009
				(0.115)	(0.099)	(0.124)
RET				−0.027	−0.007	−0.033
				(0.031)	(0.026)	(0.033)
MSCI				−0.010	−0.007	−0.007
				(0.007)	(0.006)	(0.007)
Constant	0.350***	0.623***	0.623***	0.641***	0.784***	0.786***
	(0.010)	(0.012)	(0.013)	(0.022)	(0.023)	(0.026)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	12219	12187	10991	12219	12187	10991
R2	0.103	0.430	0.496	0.209	0.465	0.528
Std dev dep. var.	0.296	0.295	0.295	0.296	0.295	0.295
Std dev LOGS1TOT	2.646	2.646	2.676	2.646	2.646	2.676
Eco sig LOGS1TOT	0.0839	0.417	0.424	0.125	0.138	0.141

TABLE 9: BROWN EFFICIENCY PATENT RATIO AND SCOPE 1 EMISSIONS - INTENSIVE MARGIN

The unit of observation is firm-year. The dependent variable is *BROWNEFFRATIOWW* in Panel A and *BROWNEFFRATIOEP* in Panel B. The sample period is 2005-2020 and the sample restricts inclusion to firm-years with with *at least one* green patent at the European Office in Panel A and one green patent at some patent office worldwide. All variables are defined in Table 5. The model is estimated using pooled regression model. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	Panel A: *BROWNEFFRATIOWW* as dependent variable					
	(1)	(2)	(3)	(4)	(5)	(6)
LOGS1TOT	−0.003***	−0.021***	−0.020***	0.005***	−0.005***	−0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
LOGSIZE				−0.036***	−0.020***	−0.019***
				(0.002)	(0.003)	(0.003)
LOGPPE				0.004	−0.008***	−0.009***
				(0.002)	(0.003)	(0.003)
LEVERAGE				−0.000***	−0.001***	−0.001***
				(0.000)	(0.000)	(0.000)
ROE				−0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)
M/B				0.000	0.001	−0.000
				(0.001)	(0.001)	(0.001)
INVEST/A				0.005***	0.004***	0.004***
				(0.001)	(0.001)	(0.001)
BETA				0.001	−0.009*	−0.004
				(0.005)	(0.005)	(0.006)
VOLAT				0.028	−0.011	−0.009
				(0.052)	(0.048)	(0.055)
MOM				0.025	0.022	−0.002
				(0.074)	(0.068)	(0.086)
RET				−0.003	0.025	0.009
				(0.019)	(0.017)	(0.022)
MSCI				−0.012***	−0.008*	−0.007
				(0.004)	(0.004)	(0.005)
Constant	0.131***	0.268***	0.262***	0.347***	0.381***	0.370***
	(0.006)	(0.009)	(0.010)	(0.015)	(0.016)	(0.017)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	11184	11141	10046	11184	11141	10046
R2	0.107	0.356	0.433	0.189	0.379	0.452
Std dev dep. var.	0.181	0.181	0.181	0.181	0.181	0.181
Std dev LOGS1TOT	2.669	2.671	2.698	2.669	2.671	2.698
Eco sig LOGS1TOT	0.0421	0.305	0.294	0.0673	0.0664	0.0526

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel B: *BROWNEFFRATIOEP* as dependent variable					
LOGS1TOT	−0.013***	−0.036***	−0.036***	0.002	−0.005	−0.003
	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
LOGSIZE				−0.054***	−0.038***	−0.039***
				(0.004)	(0.005)	(0.006)
LOGPPE				0.002	−0.021***	−0.022***
				(0.004)	(0.004)	(0.005)
LEVERAGE				0.000	−0.001**	−0.001***
				(0.000)	(0.000)	(0.000)
ROE				0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)
M/B				0.001	0.003	0.000
				(0.002)	(0.002)	(0.002)
INVEST/A				0.005***	0.004***	0.003*
				(0.001)	(0.001)	(0.002)
BETA				0.007	−0.003	−0.000
				(0.009)	(0.009)	(0.011)
VOLAT				−0.006	−0.154	−0.125
				(0.105)	(0.100)	(0.130)
MOM				0.039	0.047	0.126
				(0.160)	(0.145)	(0.198)
RET				−0.048	0.019	0.022
				(0.040)	(0.036)	(0.050)
MSCI				−0.011	0.004	0.012
				(0.008)	(0.008)	(0.010)
Constant	0.299***	0.484***	0.487***	0.615***	0.730***	0.753***
	(0.013)	(0.019)	(0.022)	(0.029)	(0.033)	(0.040)
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	5558	5518	4558	5558	5518	4558
R2	0.0928	0.401	0.492	0.176	0.432	0.520
Std dev dep. var.	0.244	0.243	0.243	0.244	0.243	0.243
Std dev LOGS1TOT	2.557	2.560	2.589	2.557	2.560	2.589
Eco sig LOGS1TOT	0.137	0.379	0.379	0.0180	0.0475	0.0336

TABLE 10: GREEN PATENT RATIO AND EXTERNAL GOVERNANCE

The unit of observation is firm-year. The dependent variable is $GREENRATIOWW$ in Panel A and $GREENRATIOEP$ in Panel B. The sample period is 2005-2020. $ANALYST$ is the natural logarithm of the number of equity analysts providing earnings forecast for a firm in a given year. $NOOWN$ is the natural logarithm of the number of institutional owners. $HERF$ is the Herfindahl index for ownership concentration. ESS is the fraction of positive media news by Dow Jones newswires over the previous one-year period. The regressions include the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All other variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regressions include country and year fixed effects. Column 1, 3, 5, and 7 additionally include Trucost sector industry and industry-year fixed effects and column 2, 4, 6, and 8 additionally include firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT. *** 1% significance, ** 5% significance * 10% significance.

Panel A: $GREENRATIOWW$ as dependent variable								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	−0.027***	−0.003	−0.053***	0.037	−0.021**	−0.017	−0.013	−0.009
	(0.009)	(0.012)	(0.015)	(0.028)	(0.009)	(0.012)	(0.029)	(0.026)
ANALYST	−0.031	0.037						
	(0.026)	(0.033)						
LOGS1TOT X ANALYST	0.006**	−0.006						
	(0.003)	(0.004)						
NOOWN			−0.050**	0.052				
			(0.020)	(0.040)				
LOGS1TOT X NOOWN			0.006***	−0.010*				
			(0.002)	(0.005)				
HERF					0.204	−0.246		
					(0.127)	(0.195)		
LOGS1TOT X HERF					−0.010	0.049		
					(0.023)	(0.032)		
ESS (/ 100)							0.152	0.251
							(0.364)	(0.305)
LOGS1TOT X ESS (/ 100)							0.007	−0.028
							(0.052)	(0.042)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes
Observations	50178	37347	49404	36883	49404	36883	35682	27890
Pseudo R2	0.147	0.235	0.147	0.235	0.147	0.235	0.150	0.228
Std dev dep. var.	0.183	0.201	0.182	0.200	0.182	0.200	0.182	0.197
Std dev LOGS1TOT	2.728	2.641	2.720	2.634	2.720	2.634	2.748	2.643

Panel B: $GREENRATIOEP$ as dependent variable								
LOGS1TOT	−0.054***	0.015	−0.073***	0.001	−0.057***	0.011	−0.004	−0.035
	(0.011)	(0.016)	(0.021)	(0.040)	(0.012)	(0.016)	(0.040)	(0.036)
ANALYST	0.017	0.029						
	(0.032)	(0.039)						
LOGS1TOT X ANALYST	0.000	−0.003						
	(0.003)	(0.004)						
NOOWN			−0.007	−0.063				
			(0.031)	(0.057)				
LOGS1TOT X NOOWN			0.003	0.002				
			(0.003)	(0.007)				
HERF					0.037	0.076		
					(0.198)	(0.296)		
LOGS1TOT X HERF					0.007	0.010		
					(0.033)	(0.046)		
ESS (/ 100)							0.771	−0.702
							(0.517)	(0.449)
LOGS1TOT X ESS (/ 100)							−0.075	0.075
							(0.071)	(0.059)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes
Observations	25032	20173	24720	19915	24720	19915	20059	16636
Pseudo R2	0.146	0.214	0.146	0.213	0.146	0.213	0.150	0.205
Std dev dep. var.	0.246	0.259	0.245	0.258	0.245	0.258	0.237	0.248
Std dev LOGS1TOT	2.701	2.584	2.693	2.577	2.693	2.577	2.702	2.574

TABLE 11: GREEN PATENT RATIO AND INTERNAL GOVERNANCE

The unit of observation is firm-year. The dependent variable is *GREENRATIOWW* in Panel A and *GREENRATIOEP* in Panel B. The sample period is 2005-2020. The regressions include various internal governance variables defined in the table and the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regressions include country and year fixed effects. Column 1, 3, 5, and 7 additionally include industry and industry-year fixed effects and column 2, 4, 6, and 8 additionally include firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT. *** 1% significance, ** 5% significance * 10% significance.

Panel A: *GREENRATIOWW* as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
LOGS1TOT	−0.014	−0.024	−0.034***	−0.035**	−0.014	−0.043***	−0.027**	−0.034*	−0.025**	−0.006	−0.026**	−0.014	−0.032	−0.031	0.015	−0.039**	−0.022*	−0.022	−0.009	−0.008
	(0.013)	(0.016)	(0.012)	(0.015)	(0.012)	(0.015)	(0.013)	(0.018)	(0.012)	(0.017)	(0.012)	(0.017)	(0.021)	(0.023)	(0.013)	(0.020)	(0.013)	(0.017)	(0.033)	(0.026)
Board Size	0.096	0.009																		
	(0.142)	(0.163)																		
LOGS1TOT X Board size	0.000	−0.003																		
	(0.015)	(0.018)																		
Perc female on board			−0.159	−0.199																
			(0.123)	(0.144)																
LOGS1TOT X Perc female on board			0.039***	0.021																
			(0.014)	(0.016)																
Perc with finance background					−0.173	−0.387***														
					(0.113)	(0.119)														
LOGS1TOT X Perc with finance background					−0.001	0.036***														
					(0.013)	(0.014)														
Avg number of years on board							−0.238	−0.343*												
							(0.146)	(0.203)												
LOGS1TOT X Avg number of years on board							0.024	0.027												
							(0.018)	(0.024)												
Perc of nonexecutive members									0.060	0.414**										
									(0.133)	(0.177)										
LOGS1TOT X Perc of nonexecutive members									0.020	−0.029										
									(0.014)	(0.020)										
Perc of indep. board members											−0.169	0.206								
											(0.128)	(0.171)								
LOGS1TOT X Perc of indep. board members											0.026*	−0.021								
											(0.013)	(0.020)								
Perc of strictly indep board members													−0.228	0.102						
													(0.164)	(0.179)						
LOGS1TOT X Perc of strictly indep board members													0.026	0.003						
													(0.020)	(0.022)						
Equal voting rights															0.481***	−0.195				
															(0.144)	(0.217)				
LOGS1TOT X Equal voting rights															−0.051***	0.025				
															(0.015)	(0.024)				
Number of antitakeover devices																	−0.174	0.076		
																	(0.126)	(0.179)		
LOGS1TOT X Number of antitakeover devices																	0.015	−0.006		
																	(0.014)	(0.020)		
Is company controversial																			−0.133	0.256
																			(0.546)	(0.402)
LOGS1TOT X Is company controversial																			−0.010	−0.033
																			(0.059)	(0.044)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Observations	28419	23866	27960	23450	26345	22029	26300	22094	27701	23169	27024	22531	12864	11289	28419	23866	28419	23866	28419	23866
Pseudo R2	0.153	0.226	0.154	0.227	0.155	0.228	0.157	0.229	0.154	0.227	0.155	0.228	0.163	0.233	0.153	0.226	0.153	0.226	0.153	0.226
Std Dev Dep. Var.	0.180	0.190	0.181	0.190	0.182	0.192	0.183	0.193	0.181	0.191	0.182	0.192	0.190	0.199	0.180	0.190	0.180	0.190	0.180	0.190
Std Dev LogS1	2.771	2.655	2.774	2.659	2.778	2.672	2.781	2.666	2.775	2.657	2.782	2.667	2.699	2.582	2.771	2.655	2.771	2.655	2.771	2.655
Eco significance LogS1	0.214	0.330	0.522	0.483	0.212	0.594	0.418	0.467	0.381	0.0805	0.402	0.195	0.449	0.397	0.227	0.549	0.342	0.304	0.132	0.108

Panel B: *GREENRATIOEP* as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
LOGS1TOT	−0.061***	0.019	−0.074***	0.019	−0.055***	0.011	−0.063***	0.014	−0.047***	0.015	−0.051***	0.027	−0.085***	0.020	−0.033**	0.003	−0.062***	0.023	−0.059	−0.022
	(0.015)	(0.020)	(0.014)	(0.020)	(0.014)	(0.019)	(0.015)	(0.022)	(0.015)	(0.022)	(0.014)	(0.021)	(0.023)	(0.027)	(0.014)	(0.022)	(0.016)	(0.020)	(0.037)	(0.030)
Board Size	−0.044	0.091		0.091																
	(0.160)	(0.185)		(0.185)																
LOGS1TOT X Board size	0.019	−0.018		−0.018																
	(0.017)	(0.021)		(0.021)																
Perc female on board			−0.245*																	
			(0.146)																	
LOGS1TOT X Perc female on board			0.032*																	
			(0.016)																	
Perc with finance background					0.074	0.043														
					(0.135)	(0.149)														
LOGS1TOT X Perc with finance background					−0.004	−0.002														
					(0.015)	(0.017)														
Avg number of years on board							−0.278*	−0.015												
							(0.167)	(0.242)												
LOGS1TOT X Avg number of years on board							0.011	0.006												
							(0.020)	(0.028)												
Perc of nonexecutive members									0.263*	0.076										
									(0.154)	(0.220)										
LOGS1TOT X Perc of nonexecutive members									−0.014	−0.000										
									(0.016)	(0.025)										
Perc of indep. board members											0.087	0.217								
											(0.149)	(0.191)								
LOGS1TOT X Perc of indep. board members											−0.006	−0.022								
											(0.015)	(0.022)								
Perc of strictly indep board members													−0.051	0.239						
													(0.200)	(0.210)						
LOGS1TOT X Perc of strictly indep board members													0.013	−0.025						
													(0.025)	(0.024)						
Equal voting rights															0.387***	−0.002				
															(0.149)	(0.214)				
LOGS1TOT X Equal voting rights															−0.037**	0.013				
															(0.016)	(0.025)				
Number of antitakeover devices																	−0.138	0.370*		
																	(0.147)	(0.198)		
LOGS1TOT X Number of antitakeover devices																	0.018	−0.024		
																	(0.017)	(0.022)		
Is company controversial																			−0.172	−0.453
																			(0.627)	(0.471)
LOGS1TOT X Is company controversial																			0.013	0.060
																			(0.066)	(0.050)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Observations	17836	15708	17528	15708	16427	14371	16541	14549	17317	15222	16805	14724	8215	7563	17836	15708	17836	15708	17836	15708
Pseudo R2	0.154	0.204	0.155	0.204	0.154	0.207	0.156	0.208	0.155	0.206	0.156	0.207	0.165	0.214	0.154	0.204	0.154	0.204	0.154	0.204
Std dev dep. var.	0.231	0.238	0.231	0.238	0.232	0.240	0.230	0.239	0.231	0.240	0.232	0.241	0.222	0.232	0.231	0.238	0.231	0.238	0.231	0.238
Std dev LOGS1TOT	2.655	2.536	2.656	2.536	2.661	2.549	2.665	2.548	2.659	2.541	2.665	2.545	2.579	2.461	2.655	2.536	2.655	2.536	2.655	2.536

TABLE 12: BROWN EFFICIENCY PATENT RATIO AND EXTERNAL GOVERNANCE

The unit of observation is firm-year. The dependent variable is *BROWNEFFRATIOWW* in Panel A and *BROWNEFFRATIOEP* in Panel B. The sample period is 2005-2020. The regressions include the exteneral governance variables ANALYST, NOOWN, HERF and ESS defined in Table 10 as well as the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regressions include country and year fixed effects. Column 1, 3, 5, and 7 additionally include industry and industry-year fixed effects and column 2, 4, 6, and 8 additionally include firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT. *** 1% significance, ** 5% significance * 10% significance.

Panel A: BROWNEFFRATIOWW as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.043***	−0.001	0.027	0.047	0.041**	−0.001	−0.007	−0.098*
	(0.017)	(0.028)	(0.030)	(0.071)	(0.017)	(0.028)	(0.061)	(0.052)
ANALYST	0.008	−0.039						
	(0.045)	(0.067)						
LOGS1TOT X ANALYST	−0.000	0.001						
	(0.005)	(0.008)						
NOOWN			−0.022	−0.025				
			(0.046)	(0.101)				
LOGS1TOT X NOOWN			0.002	−0.009				
			(0.005)	(0.013)				
HERF					0.170	−0.039		
					(0.332)	(0.528)		
LOGS1TOT X HERF					−0.020	0.016		
					(0.052)	(0.081)		
ESS (/ 100)							−0.572	−0.861
							(0.748)	(0.565)
LOGS1TOT X ESS (/ 100)							0.058	0.112
							(0.108)	(0.081)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes
Observations	43813	23565	43150	23281	43150	23281	30588	17988
Pseudo R2	0.235	0.267	0.233	0.266	0.233	0.266	0.241	0.273
Std dev dep. var.	0.102	0.133	0.102	0.133	0.102	0.133	0.109	0.136
Std dev LOGS1TOT	2.779	2.614	2.770	2.607	2.770	2.607	2.813	2.601

Panel B: BROWNEFFRATIOEP as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOGS1TOT	0.042**	−0.085**	0.005	−0.082	0.033	−0.062*	0.018	−0.015
	(0.021)	(0.033)	(0.044)	(0.105)	(0.022)	(0.034)	(0.078)	(0.070)
ANALYST	−0.105*	−0.234***						
	(0.062)	(0.082)						
LOGS1TOT X ANALYST	0.013**	0.022**						
	(0.006)	(0.009)						
NOOWN			0.029	0.011				
			(0.065)	(0.154)				
LOGS1TOT X NOOWN			0.006	0.003				
			(0.007)	(0.019)				
HERF					−0.661	0.164		
					(0.652)	(0.872)		
LOGS1TOT X HERF					0.024	−0.048		
					(0.096)	(0.120)		
ESS (/ 100)							0.136	0.502
							(1.029)	(0.856)
LOGS1TOT X ESS (/ 100)							0.005	−0.122
							(0.139)	(0.116)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes
Observations	20338	12189	20016	12058	20016	12058	15985	10047
Pseudo R2	0.241	0.250	0.240	0.250	0.240	0.250	0.246	0.250
Std dev dep. var.	0.150	0.184	0.151	0.184	0.151	0.184	0.154	0.185
Std dev LOGS1TOT	2.764	2.495	2.758	2.491	2.758	2.491	2.773	2.497

TABLE 13: BROWN EFFICIENCY PATENT RATIO AND INTERNAL GOVERNANCE

The unit of observation is firm-year. The dependent variable is *BROWNEFFRATIOWW* in Panel A and *BROWNEFFRATIOEP* in Panel B. The sample period is 2005-2020. The regressions include various internal governance variables defined in the table and the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regressions include country and year fixed effects. Column 1, 3, 5, and 7 additionally include industry and industry-year fixed effects and column 2, 4, 6, and 8 additionally include firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
							Panel A: *BROWNEFFRATIOWW* as dependent variable													
LOGS1TOT	0.067***	0.009	0.050**	−0.013	0.073***	0.022	0.046**	−0.013	0.035	−0.092**	0.026	−0.035	−0.011	−0.042	0.076***	−0.027	0.062***	−0.005	0.055	−0.081
	(0.021)	(0.034)	(0.021)	(0.035)	(0.022)	(0.034)	(0.021)	(0.043)	(0.022)	(0.045)	(0.020)	(0.038)	(0.036)	(0.053)	(0.026)	(0.039)	(0.023)	(0.040)	(0.060)	(0.056)
Board Size	0.627***	0.491																		
	(0.230)	(0.331)																		
LOGS1TOT X Board size	−0.057**	−0.065*																		
	(0.025)	(0.037)																		
Perc female on board			0.287	0.150																
			(0.212)	(0.327)																
LOGS1TOT X Perc female on board			−0.036	−0.033																
			(0.024)	(0.036)																
Perc with finance background					0.461**	0.536*														
					(0.224)	(0.279)														
LOGS1TOT X Perc with finance background					−0.070***	−0.056*														
					(0.026)	(0.032)														
Avg number of years on board							0.214	0.491												
							(0.226)	(0.464)												
LOGS1TOT X Avg number of years on board							−0.013	−0.038												
							(0.028)	(0.053)												
Perc of nonexecutive members									−0.171	−1.324***										
									(0.241)	(0.481)										
LOGS1TOT X Perc of nonexecutive members									−0.002	0.117**										
									(0.026)	(0.055)										
Perc of indep. board members											−0.176	−0.059								
											(0.230)	(0.416)								
LOGS1TOT X Perc of indep. board members											0.020	0.018								
											(0.025)	(0.047)								
Perc of strictly indep board members													−0.225	0.158						
													(0.283)	(0.432)						
LOGS1TOT X Perc of strictly indep board members													0.016	−0.016						
													(0.036)	(0.051)						
Equal voting rights															0.857***	−0.038				
															(0.308)	(0.370)				
LOGS1TOT X Equal voting rights															−0.064*	0.004				
															(0.033)	(0.042)				
Number of antitakeover devices																	0.391*	0.168		
																	(0.220)	(0.382)		
LOGS1TOT X Number of antitakeover devices																	−0.042*	−0.038		
																	(0.025)	(0.044)		
Is company controversial																			0.220	−0.966
																			(0.916)	(0.703)
LOGS1TOT X Is company controversial																			−0.032	0.109
																			(0.113)	(0.091)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Observations	25109	16885	24670	16559	23365	15494	23241	15523	24469	16308	23880	15822	10518	7528	25109	16885	25109	16885	25109	16885
Pseudo R2	0.240	0.268	0.241	0.268	0.241	0.268	0.244	0.269	0.242	0.269	0.243	0.269	0.289	0.288	0.240	0.268	0.240	0.268	0.240	0.268
Std dev dep. var.	0.111	0.130	0.111	0.131	0.111	0.132	0.113	0.133	0.112	0.132	0.112	0.133	0.135	0.154	0.111	0.130	0.111	0.130	0.111	0.130
Std dev LOGS1TOT	2.833	2.596	2.835	2.598	2.838	2.615	2.842	2.610	2.836	2.603	2.839	2.610	2.766	2.523	2.833	2.596	2.833	2.596	2.833	2.596

Panel B: *BROWNEFFRATIOEP* as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
LOGS1TOT	0.060**	−0.067*	0.035	−0.046	0.039	−0.035	0.028	−0.118**	0.033	−0.150***	0.016	−0.083*	0.050	−0.051	0.053*	−0.112**	0.059**	−0.075	0.090	−0.038
	(0.025)	(0.040)	(0.026)	(0.043)	(0.026)	(0.041)	(0.027)	(0.050)	(0.028)	(0.049)	(0.025)	(0.045)	(0.046)	(0.058)	(0.028)	(0.045)	(0.028)	(0.049)	(0.081)	(0.056)
Board Size	0.399	0.089																		
	(0.279)	(0.361)																		
LOGS1TOT X Board size	−0.034	0.002																		
	(0.030)	(0.041)																		
Perc female on board			0.056	0.322																
			(0.290)	(0.349)																
LOGS1TOT X Perc female on board			−0.004	−0.047																
			(0.033)	(0.039)																
Perc with finance background					−0.206	0.371														
					(0.266)	(0.301)														
LOGS1TOT X Perc with finance background					0.012	−0.031														
					(0.031)	(0.034)														
Avg number of years on board							−0.222	−0.589												
							(0.330)	(0.522)												
LOGS1TOT X Avg number of years on board							0.037	0.068												
							(0.037)	(0.058)												
Perc of nonexecutive members									0.097	−1.504***										
									(0.278)	(0.558)										
LOGS1TOT X Perc of nonexecutive members									−0.001	0.157**										
									(0.030)	(0.065)										
Perc of indep. board members											−0.348	−0.180								
											(0.268)	(0.496)								
LOGS1TOT X Perc of indep. board members											0.039	0.034								
											(0.028)	(0.058)								
Perc of strictly indep board members													0.005	−0.215						
													(0.363)	(0.437)						
LOGS1TOT X Perc of strictly indep board members													−0.017	0.007						
													(0.044)	(0.048)						
Equal voting rights															0.456	−0.703*				
															(0.317)	(0.409)				
LOGS1TOT X Equal voting rights															−0.015	0.085*				
															(0.035)	(0.049)				
Number of antitakeover devices																	0.317	−0.120		
																	(0.271)	(0.431)		
LOGS1TOT X Number of antitakeover devices																	−0.025	0.016		
																	(0.031)	(0.049)		
Is company controversial																			0.774	0.652
																			(1.521)	(0.749)
LOGS1TOT X Is company controversial																			−0.089	−0.054
																			(0.154)	(0.083)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Industry X Year F.E.	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Firm F.E.	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
Observations	14328	10070	14061	9858	13156	9059	13215	9197	13867	9598	13486	9279	5736	4248	14328	10070	14328	10070	14328	10070
Pseudo R2	0.236	0.252	0.238	0.253	0.237	0.250	0.238	0.253	0.238	0.252	0.240	0.254	0.284	0.270	0.236	0.252	0.236	0.252	0.236	0.252
Std dev dep. var.	0.148	0.172	0.148	0.173	0.148	0.173	0.148	0.173	0.148	0.174	0.149	0.174	0.159	0.182	0.148	0.172	0.148	0.172	0.148	0.172
Std dev LOGS1TOT	2.727	2.454	2.729	2.456	2.738	2.475	2.747	2.477	2.735	2.467	2.740	2.470	2.694	2.381	2.727	2.454	2.727	2.454	2.727	2.454

The unit of observation is firm-year. The dependent variable is GREENRATIOWW or GREENRATIOEP in Panel A and BROWNEFFRATIOWW or BROWNEFFRATIOEP in Panel B. The sample period is 2005 to 2020. The regressions include the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in 5. Column 1 and 5 report the results for the sample of firms in North America, column 2 and 6 in Europe, column 3 and 7 in Asia, and column 4 and 8 in all remaining countries. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country, year, Trucost sector industry and industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

Panel A: Green innovation

	GREENRATIOWW				GREENRATIOEP			
	(1) N. America	(2) Europe	(3) Asia	(4) Others	(5) N. America	(6) Europe	(7) Asia	(8) Others
LOGS1TOT	−0.131***	−0.001	−0.004	−0.019	−0.162***	−0.046**	−0.017	−0.100
	(0.021)	(0.013)	(0.018)	(0.070)	(0.026)	(0.018)	(0.021)	(0.093)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry X Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Observations	10146	24735	8292	597	6067	8399	5935	190
Pseudo R2	0.188	0.140	0.168	0.207	0.185	0.135	0.175	0.248
Std dev dep. var.	0.212	0.154	0.216	0.288	0.236	0.263	0.244	0.338
Std dev LOGS1TOT	2.644	2.618	3.076	3.500	2.543	2.514	2.987	3.764
Eco sig LOGS1TOT	1.635	0.0223	0.0576	0.235	1.747	0.442	0.214	1.118

Panel B: Brown efficiency innovation

	BROWNEFFRATIOWW				BROWNEFFRATIOEP			
	(1) N. America	(2) Europe	(3) Asia	(4) Others	(5) N. America	(6) Europe	(7) Asia	(8) Others
LOGS1TOT	0.004	0.102***	0.065**	−0.032	0.051	0.013	0.061*	−1.227
	(0.036)	(0.029)	(0.030)	(0.098)	(0.044)	(0.040)	(0.033)	(2.110)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry-Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Observations	8000	20348	6627	259	3777	6032	4385	62
Pseudo R2	0.310	0.202	0.214	0.249	0.296	0.234	0.229	0.273
Std dev dep. var.	0.143	0.0721	0.132	0.198	0.159	0.159	0.159	0.258
Std dev LOGS1TOT	2.707	2.666	3.134	3.628	2.649	2.535	3.012	3.816
Eco sig LOGS1TOT	0.0678	3.777	1.543	0.592	0.853	0.210	1.151	18.16

TABLE 15: PATENT RATIO AND SCOPE 1 EMISSIONS - PRE AND POST 2015

The unit of observation is firm-year. The dependent variable is GREENRATIOWW and GREENRATIOEP in Panel A and BROWNEFFRATIOWW and BROWNEFFRATIOEP in Panel B. Post2015 is a dummy that is equal to 1 for all years after 2015 and zero otherwise. We interact this variable with all control variables and report the coefficient on the LOGS1TOT and Post2015 interaction. The regressions also include the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT. *** 1% significance, ** 5% significance * 10% significance.

Panel A: Green innovation	(1)	(2)	(3)	(4)	(5)	(6)
	GREENRATIOWW			GREENRATIOEP		
LOGS1TOT	0.122***	−0.005	0.008	0.108***	−0.023*	−0.032**
	(0.009)	(0.011)	(0.014)	(0.010)	(0.013)	(0.015)
LOGS1TOT X POST2015	−0.044***	−0.025**	−0.048***	−0.046***	−0.032**	−0.038*
	(0.012)	(0.011)	(0.018)	(0.015)	(0.014)	(0.022)
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	53399	53191	50178	28086	27817	25032
Pseudo R2	0.043	0.126	0.147	0.034	0.117	0.146
Std dev dep. var.	0.180	0.180	0.183	0.240	0.241	0.246
Std dev LOGS1TOT	2.703	2.705	2.728	2.674	2.679	2.701

Panel B: Brown efficiency innovation						
	BROWNEFFRATIOWW			BROWNEFFRATIOEP		
LOGS1TOT	0.079***	0.017	−0.003	0.068***	0.033	0.054*
	(0.014)	(0.018)	(0.023)	(0.018)	(0.024)	(0.029)
LOGS1TOT X POST2015	0.016	0.065***	0.082**	−0.032	0.017	−0.007
	(0.019)	(0.019)	(0.032)	(0.025)	(0.025)	(0.040)
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	53166	51787	43813	27993	26261	20338
Pseudo R2	0.077	0.209	0.235	0.055	0.214	0.242
Std dev dep. var.	0.095	0.096	0.102	0.134	0.137	0.150
Std dev LOGS1TOT	2.701	2.717	2.779	2.673	2.706	2.764

TABLE 16: JEVONS PARADOX - GREEN INNOVATION

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is *GREENRATIOWW* in Panel A and B and *GREENRATIOEP* in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are *LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI*. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Ratio WW	−0.017	0.012	−0.033**	−0.117	0.018	−0.012	−0.017	−0.129	−0.007	−0.031
	(0.024)	(0.028)	(0.016)	(0.083)	(0.012)	(0.017)	(0.012)	(0.114)	(0.020)	(0.024)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. dev. dep var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. dev. patent ratio	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.177
Eco sig patent ratio	0.00109	0.000989	0.00262	0.00411	0.00578	0.00125	0.00137	0.00539	0.000636	0.00322
Panel B: Worldwide Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Ratio WW	0.021	0.011	−0.022	0.088	0.017	0.006	−0.004	−0.171	−0.017	−0.014
	(0.026)	(0.030)	(0.018)	(0.085)	(0.013)	(0.017)	(0.018)	(0.119)	(0.024)	(0.025)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.945	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. dev. dep var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. dev. patent ratio	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.172	0.174
Eco sig patent ratio	0.00133	0.000895	0.00173	0.00309	0.00517	0.000582	0.000330	0.00732	0.00146	0.00135
Panel C: European Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Ratio EP	0.021	−0.019	0.004	0.019	−0.006	−0.009	0.007	−0.047	0.005	−0.027
	(0.026)	(0.025)	(0.016)	(0.070)	(0.010)	(0.018)	(0.011)	(0.100)	(0.018)	(0.022)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. dev. dep var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. dev. patent ratio	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.236
Eco sig patent ratio	0.00182	0.00203	0.000420	0.00112	0.00263	0.00123	0.000765	0.00296	0.000640	0.00370
Panel D: European Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Ratio EP	0.030	−0.005	0.019	0.075	0.007	0.018	0.017	−0.397***	−0.042*	−0.026
	(0.027)	(0.028)	(0.018)	(0.072)	(0.012)	(0.018)	(0.017)	(0.114)	(0.022)	(0.023)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. dev. dep var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. dev. patent ratio	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.232
Eco sig patent ratio	0.00265	0.000553	0.00191	0.00443	0.00277	0.00260	0.00180	0.0254	0.00487	0.00339
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE 17: JEVONS PARADOX - BROWN EFFICIENCY INNOVATION

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $BROWNEFFRATIOWW$ in Panel A and B and $BROWNEFFRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Ratio WW	0.025	−0.077	−0.029	0.101	−0.016	−0.030	−0.029	−0.179	−0.028	0.063
	(0.039)	(0.053)	(0.022)	(0.136)	(0.018)	(0.026)	(0.023)	(0.184)	(0.037)	(0.046)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. dev. dep var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. dev. patent ratio	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0924
Eco sig patent ratio	0.000854	0.00329	0.00123	0.00186	0.00261	0.00161	0.00126	0.00392	0.00128	0.00333
Panel B: Worldwide Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Ratio WW	0.002	−0.043	−0.031	0.087	−0.004	−0.017	−0.047*	0.090	0.004	0.017
	(0.041)	(0.054)	(0.026)	(0.144)	(0.020)	(0.025)	(0.028)	(0.213)	(0.039)	(0.045)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.946	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. dev. dep var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. dev. patent ratio	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0914
Eco sig patent ratio	0.0000584	0.00182	0.00131	0.00161	0.000647	0.000936	0.00201	0.00204	0.000204	0.000883
Panel C: European Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Ratio EP	0.031	−0.045	−0.014	0.045	0.008	0.017	0.005	−0.073	−0.014	0.001
	(0.043)	(0.041)	(0.020)	(0.144)	(0.015)	(0.025)	(0.018)	(0.147)	(0.030)	(0.041)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. dev. dep var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. dev. patent ratio	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.131
Eco sig patent ratio	0.00153	0.00265	0.000790	0.00146	0.00176	0.00137	0.000290	0.00253	0.000919	0.0000413
Panel D: European Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Ratio EP	0.080**	0.015	−0.003	0.028	−0.008	−0.015	0.003	−0.099	−0.009	0.030
	(0.040)	(0.042)	(0.022)	(0.139)	(0.014)	(0.026)	(0.024)	(0.162)	(0.036)	(0.039)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. dev. dep var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. dev. patent ratio	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
Eco sig patent ratio	0.00394	0.000900	0.000154	0.000941	0.00174	0.00122	0.000214	0.00359	0.000614	0.00222
Controls F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE 18: JEVONS PARADOX - GREEN INNOVATION (INTENSIVE MARGIN)

The unit of observation is firm-year. All firm-year observations with *at least one* green patent are included. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $GREENRATIOWW$ in Panel A and B and $GREENRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA,$ $VOLAT, MOM, RET, MSCI$. All variables are defined in Table 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Ratio WW	−0.039	0.024	−0.042**	−0.155	0.025*	−0.008	−0.031**	−0.200	−0.023	−0.039
	(0.031)	(0.040)	(0.022)	(0.111)	(0.015)	(0.024)	(0.016)	(0.151)	(0.025)	(0.031)
Observations	28230	28230	28228	28230	28230	28230	28230	28222	28222	27235
R2	0.956	0.937	0.976	0.940	0.841	0.954	0.986	0.741	0.949	0.929
Std. dev. dep var	2.721	2.146	2.120	5.386	0.597	1.627	2.075	4.156	1.973	1.750
Std. dev. patent ratio	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.215
Eco sig patent ratio	0.00302	0.00241	0.00427	0.00614	0.00906	0.00105	0.00320	0.0103	0.00251	0.00477
Panel B: Worldwide Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Ratio WW	0.008	−0.021	−0.033	0.087	0.016	0.010	−0.019	−0.006	0.003	−0.014
	(0.034)	(0.041)	(0.025)	(0.114)	(0.017)	(0.023)	(0.025)	(0.163)	(0.031)	(0.034)
Observations	25300	25300	25298	25300	25300	25300	25300	25296	25296	24412
R2	0.960	0.945	0.976	0.948	0.862	0.962	0.975	0.711	0.943	0.935
Std. dev. dep var	2.737	2.176	2.146	5.247	0.605	1.603	2.114	3.984	2.014	1.782
Std. dev. patent ratio	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.207
Eco sig patent ratio	0.000595	0.00199	0.00315	0.00339	0.00543	0.00129	0.00187	0.000306	0.000286	0.00165
Panel C: European Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Ratio EP	−0.014	−0.011	−0.011	−0.050	−0.005	0.021	0.005	−0.120	−0.005	−0.021
	(0.035)	(0.034)	(0.022)	(0.105)	(0.015)	(0.025)	(0.016)	(0.159)	(0.026)	(0.031)
Observations	13226	13226	13224	13226	13226	13226	13226	13226	13226	13060
R2	0.957	0.942	0.975	0.940	0.847	0.951	0.987	0.727	0.961	0.931
Std. dev. dep var	2.672	2.115	2.113	4.701	0.611	1.558	2.007	3.637	1.898	1.718
Std. dev. patent ratio	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.277
Eco sig patent ratio	0.00141	0.00146	0.00147	0.00296	0.00245	0.00378	0.000633	0.00909	0.000735	0.00345
Panel D: European Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Ratio EP	0.035	−0.019	0.031	0.131	0.005	0.042	0.015	−0.455***	−0.044	−0.058*
	(0.037)	(0.040)	(0.025)	(0.113)	(0.016)	(0.028)	(0.024)	(0.165)	(0.031)	(0.032)
Observations	11741	11741	11741	11741	11741	11741	11741	11741	11741	11605
R2	0.962	0.945	0.975	0.950	0.869	0.958	0.979	0.701	0.953	0.935
Std. dev. dep var	2.690	2.138	2.136	4.734	0.621	1.521	2.041	3.518	1.919	1.736
Std. dev. patent ratio	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.268	0.269
Eco sig patent ratio	0.00345	0.00243	0.00387	0.00742	0.00222	0.00738	0.00203	0.0347	0.00609	0.00892
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE 19: JEVONS PARADOX - BROWN EFFICIENCY INNOVATION (INTENSIVE MARGIN)

The unit of observation is firm-year. All firm-year observations with *at least one* brown efficiency patent are included. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $BROWNEFFRATIOWW$ in Panel A and B and $BROWNEFFRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE$, $LOGPPE$, $LEVERAGE$, ROE, M/B, $INVEST/A$, $BETA$, $VOLAT$, MOM, RET, $MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Ratio WW	0.025	−0.077	−0.029	0.101	−0.016	−0.030	−0.029	−0.179	−0.028	0.063
	(0.039)	(0.053)	(0.022)	(0.136)	(0.018)	(0.026)	(0.023)	(0.184)	(0.037)	(0.046)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. dev. dep var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. dev. patent ratio	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0921	0.0924
Eco sig patent ratio	0.000854	0.00329	0.00123	0.00186	0.00261	0.00161	0.00126	0.00392	0.00128	0.00333
Panel B: Worldwide Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Ratio WW	0.002	−0.043	−0.031	0.087	−0.004	−0.017	−0.047*	0.090	0.004	0.017
	(0.041)	(0.054)	(0.026)	(0.144)	(0.020)	(0.025)	(0.028)	(0.213)	(0.039)	(0.045)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.946	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. dev. dep var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. dev. patent ratio	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0912	0.0914
Eco sig patent ratio	0.0000584	0.00182	0.00131	0.00161	0.000647	0.000936	0.00201	0.00204	0.000204	0.000883
Panel C: European Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Ratio EP	0.031	−0.045	−0.014	0.045	0.008	0.017	0.005	−0.073	−0.014	0.001
	(0.043)	(0.041)	(0.020)	(0.144)	(0.015)	(0.025)	(0.018)	(0.147)	(0.030)	(0.041)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. dev. dep var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. dev. patent ratio	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.131
Eco sig patent ratio	0.00153	0.00265	0.000790	0.00146	0.00176	0.00137	0.000290	0.00253	0.000919	0.0000413
Panel D: European Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Ratio EP	0.080**	0.015	−0.003	0.028	−0.008	−0.015	0.003	−0.099	−0.009	0.030
	(0.040)	(0.042)	(0.022)	(0.139)	(0.014)	(0.026)	(0.024)	(0.162)	(0.036)	(0.039)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. dev. dep var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. dev. patent ratio	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
Eco sig patent ratio	0.00394	0.000900	0.000154	0.000941	0.00174	0.00122	0.000214	0.00359	0.000614	0.00222
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

2 Figures

Each graph presents the annual number of firms from the whole Trucost sample that exist in the full sample (full sample - grey bars), that have a patent granted or purchased at any patent office world wide (Any WW - dark blue bars), that have a green patent granted or purchased at any patent office world wide (Green WW - light blue bars), that have a patent granted or purchased at the European Patent Office wide (Any EP - dark purple bars), that have a patent granted or purchased at the European Patent Office (Green EP - light purple bars). Panel A covers the full sample. Panel B is restricted to firms with emission data from Trucost prior to 2016. Panel C is restricted to firms with emission data from Trucost in 2006.

(A) FULL SAMPLE
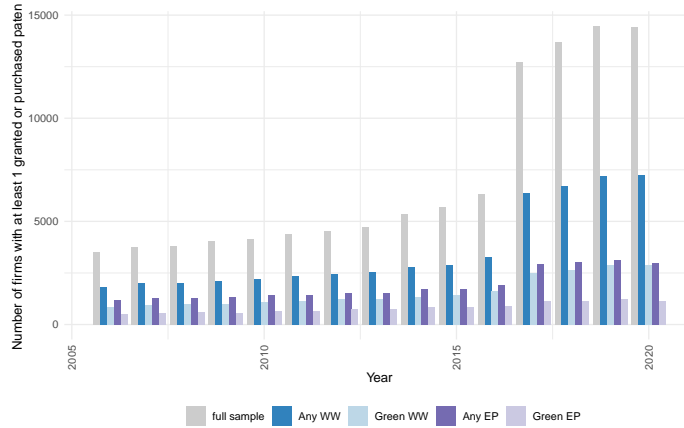
(B) PRE 2016 LEGACY SAMPLE
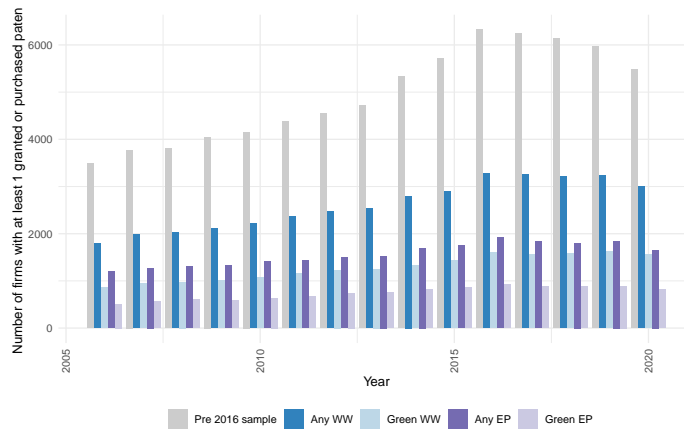
(C) PRE 2006 LEGACY SAMPLE
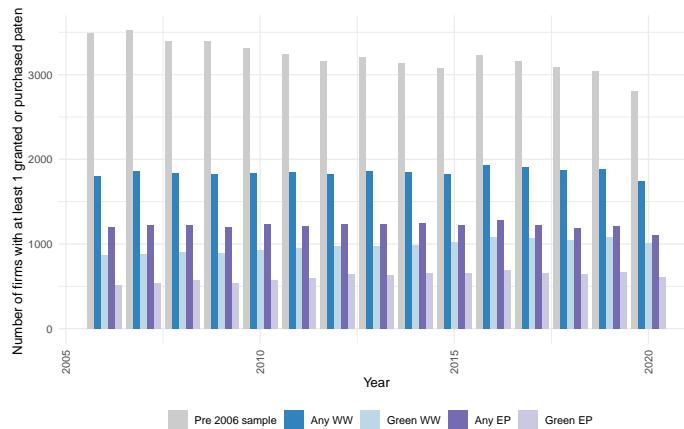
FIGURE 2: FIRM COUNT BY FIRST YEAR WITH A GRANTED/PURCHASED PATENT

Each graph covers the Trucost sample and documents a firm's first year with a granted or purchased patent. The bars represent the number of firms with their first patent in the given year. The dark blue bars cover any patent from any patent office world wide (Any WW). The light blue bars cover any patents from any patent office world wide (Green WW). The dark purple bars cover any patent from the European Patent Office (Any EP) and the light purple bars cover green patents from the European Patent Office (Green EP). Panel A covers the full sample. Panel B is restricted to firms with emission data from Trucost prior to 2016. Panel C is restricted to firms with emission data from Trucost in 2006.

(A) FULL SAMPLE
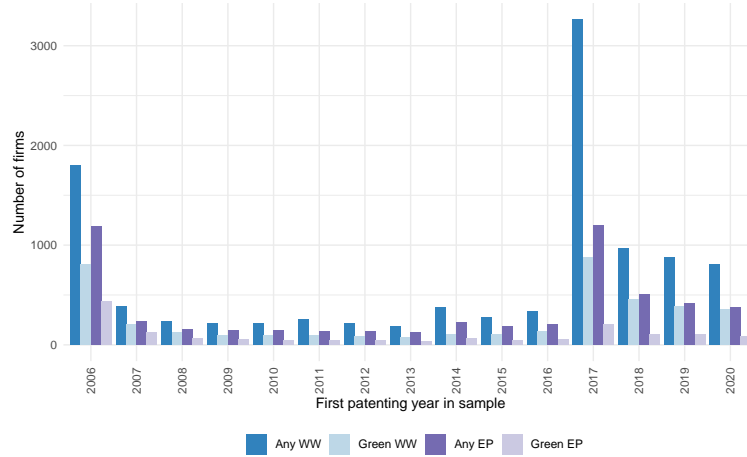
(B) PRE 2016 LEGACY SAMPLE
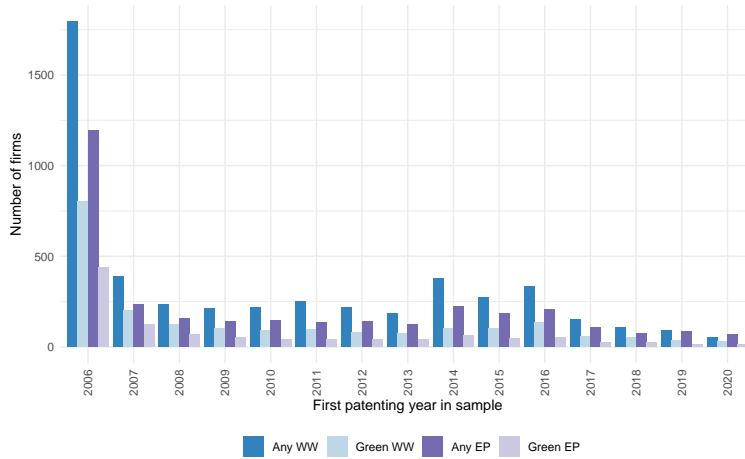
(C) PRE 2006 LEGACY SAMPLE
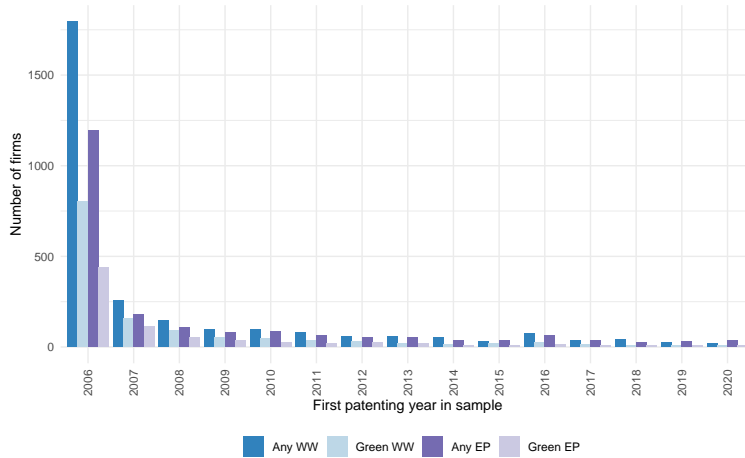
FIGURE 3: HISTOGRAMS OF PATENT COUNTS FOR FIRM-YEAR OBSERVATIONS

The histograms plot the proportion of firm-year observations in bins based on the number of granted/purchased patents for the Trucost sample between 2005 and 2020. In Panel A, the patent count is based on patents granted or purchased at any patent office worldwide and the binwidth is 5 patents. The last bin is an overflow bin with 499 patents and more. In Panel B, the patnet count is based on patents granted or purchased by the European Patent Office and the binwidth is 2 patents. The last bin is an overflow bin with 149 patents and more.

(A) WORLDWIDE PATENT OFFICE
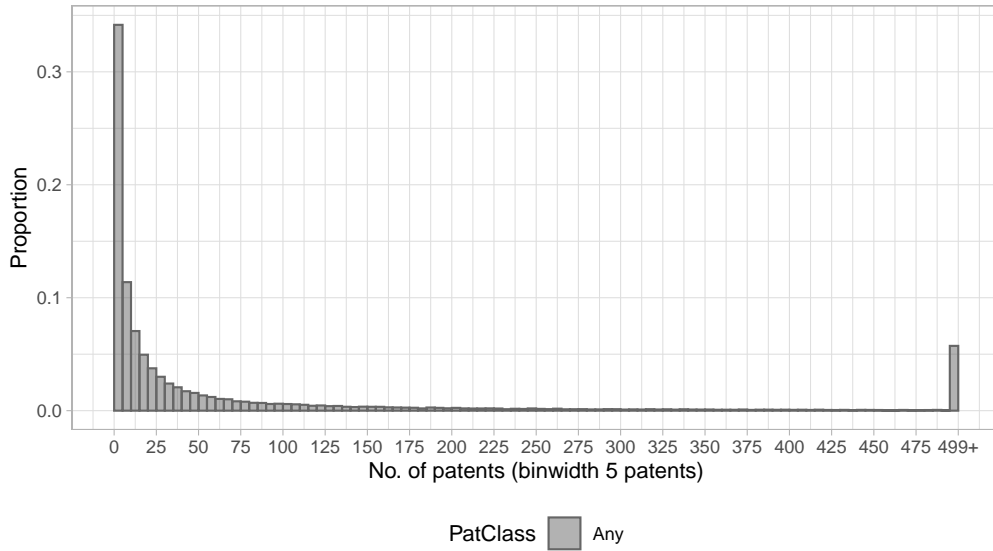
(B) EUROPEAN PATENT OFFICE
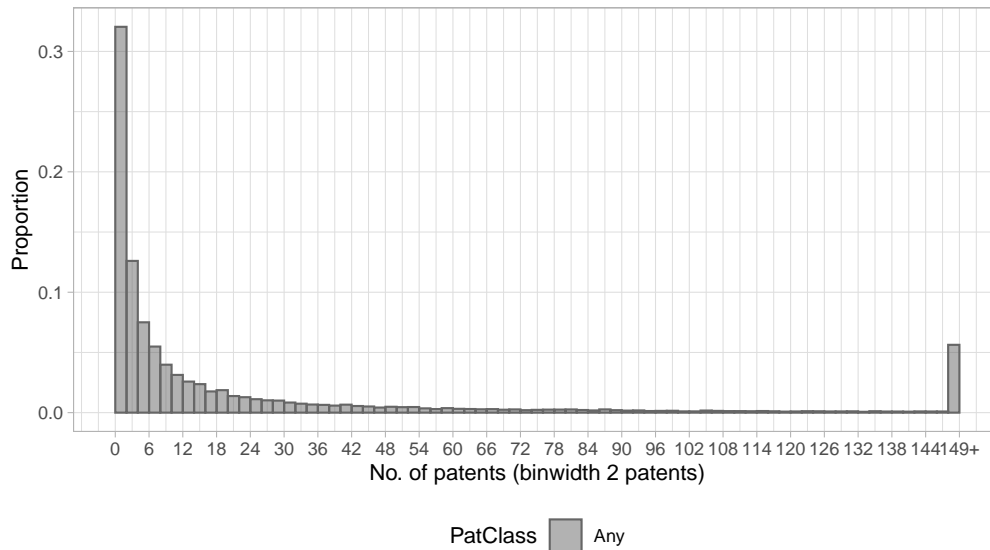
A Appendix Tables

TABLE A.I: TOP 50 FIRMS

We report average firm statistics for the Top 50 firms by average annual total scope 1 emissions in Panel A and by average annual number of worldwide granted/purchased patents in Panel B. The sample period is 2005 to 2020. Column 2 "Mkt Cap" reports the average annual market capitalization in million US Dollar; column 3 "Scope 1" reports average annual total scope 1 emissions and column 4 the average annual number of patents granted or purchased at any patent office worldwide. In columns 4 to 8 we report the GREENRATIOWW, BROWNEFFRATIOWW, GENERALEFFRATIOWW and OECDRATIOWW. Column 9 reports the average annual number of patents granted or purchased at the European Patent Office. Column 10 and 11 report the GREENRATIOEP, respectively the BROWNEEFRATIOEP. All patent ratios are defined in Table 5. Column 12 reports from which sample the firm is, i.e. private, public or Trucost. Column 13 reports the firm's GICS-6 Industry and column 14 the headquarter country.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Panel A: Top 50 firms by scope 1 emissions														
Firm name	Sort Variable: SCOPE1	Mkt Cap	SCOPE1	Patents WW	GREENRATIOWW	BROWNEFFRATIOWW	GENERALEFFRATIOWW	OECDRATIOWW	Patents EP	GREENRATIOEP	BROWNEFFRATIOEP	Sample	GICS-6 Industry	Country
HUANENG POWER INTERNATIONAL INC	2,595,592	14,407	2,595,592	62.0	0.037	0.027	0.026	0.088	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	CHINA
KOREA ELECTRIC POWER CORP	2,194,066	20,607	2,194,066	681.0	0.382	0.085	0.077	0.307	11.0	0.593	0.102	Trucost	Electric Utilities	KOREA, REP
CHINA SHENHUA ENERGY CO LTD	2,130,613	86,781	2,130,613	340.0	0.013	0.015	0.023	0.062	0.0	0.500	0.000	Trucost	Oil, Gas & Consumable Fuels	CHINA
NTPC LTD	2,069,448	23,158	2,069,448	1.0	0.048	0.000	0.000	0.048	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	INDIA
GAZPROM PJSC	1,972,973	116,327	1,972,973	179.0	0.044	0.044	0.026	0.048	1.0	0.357	0.048	Trucost	Oil, Gas & Consumable Fuels	RUSSIA
DATANG INTERNATIONAL POWER GENERATION CO LTD	1,912,462	12,331	1,912,462	121.0	0.036	0.016	0.016	0.066	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	CHINA
ARCELORMITTAL SA	1,741,032	36,060	1,741,032	149.0	0.086	0.035	0.079	0.088	31.0	0.114	0.037	Trucost	Metals & Mining	LUXEMBOURG
GD POWER DEVELOPMENT CO LTD	1,498,981	7,712	1,498,981	22.0	0.188	0.022	0.002	0.208	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	CHINA
RWE AG	1,472,329	30,911	1,472,329	17.0	0.420	0.186	0.071	0.407	10.0	0.640	0.062	Trucost	Multi-Utilities	GERMANY
HUADIAN POWER INTERNATIONAL CORP LTD	1,365,913	5,388	1,365,913	32.0	0.018	0.062	0.019	0.098	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	CHINA
SHANXI COKING COAL ENERGY GROUP CO LTD	1,327,571	3,915	1,327,571	4.0	0.000	0.000	0.000	0.000	0.0	NaN	NaN	Trucost	Oil, Gas & Consumable Fuels	CHINA
CHINA RESOURCES POWER HOLDINGS CO LTD	1,304,952	8,768	1,304,952	35.0	0.021	0.026	0.024	0.068	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	HONG KONG
EXXON MOBIL CORP	1,256,098	362,570	1,256,098	243.0	0.450	0.117	0.043	0.282	101.0	0.425	0.134	Trucost	Oil, Gas & Consumable Fuels	UNITED STATES
SOUTHERN CO	1,167,426	40,727	1,167,426	4.0	0.191	0.237	0.172	0.468	0.0	0.000	1.000	Trucost	Electric Utilities	UNITED STATES
AMERICAN ELECTRIC POWER CO INC	1,162,163	25,804	1,162,163	1.0	0.643	0.000	0.000	0.286	0.0	0.500	0.000	Trucost	Electric Utilities	UNITED STATES
HOLCIM LTD	1,134,424	25,495	1,134,424	32.0	0.232	0.068	0.113	0.345	11.0	0.445	0.117	Trucost	Construction Materials	SWITZERLAND
SAUDI ELECTRICITY CO	1,131,955	21,468	1,131,955	0.0	0.000	0.500	0.000	0.500	0.0	NaN	NaN	Trucost	Electric Utilities	SAUDI ARABIA
ENGIE SA	1,076,220	55,331	1,076,220	49.0	0.215	0.124	0.094	0.267	26.0	0.217	0.172	Trucost	Multi-Utilities	FRANCE
DUKE ENERGY CORP	1,004,712	43,899	1,004,712	2.0	0.462	0.238	0.000	0.544	0.0	0.000	1.000	Trucost	Electric Utilities	UNITED STATES
ZHEJIANG ZHENENG ELECTRIC POWER CO LTD	994,129	11,201	994,129	20.0	0.018	0.077	0.016	0.115	0.0	NaN	NaN	Trucost	Commercial Services & Supplies	CHINA
ENEL SPA	986,721	54,755	986,721	14.0	0.545	0.129	0.071	0.564	3.0	0.681	0.125	Trucost	Electric Utilities	ITALY
LAFARGE SA	958,362	19,649	958,362	15.0	0.206	0.042	0.100	0.260	8.0	0.308	0.028	Trucost	Construction Materials	FRANCE
TOKYO ELECTRIC POWER CO HOLDINGS INC	945,501	18,195	945,501	122.0	0.212	0.020	0.042	0.244	3.0	0.383	0.112	Trucost	Electric Utilities	JAPAN
SUEZ SA /OLD/	908,885	61,388	908,885	26.0	0.116	0.063	0.129	0.498	0.0	0.075	0.000	Trucost	Multi-Utilities	FRANCE
CHINA NATIONAL BUILDING MATERIAL CO LTD	883,418	5,512	883,418	571.0	0.024	0.004	0.049	0.075	3.0	0.094	0.020	Trucost	Construction Materials	CHINA
E.ON SE	869,911	49,046	869,911	26.0	0.446	0.090	0.104	0.389	9.0	0.360	0.275	Trucost	Multi-Utilities	GERMANY
VISTRA CORP	866,790	9,319	866,790	2.0	0.188	0.062	0.656	0.219	0.0	NaN	NaN	Trucost	Independent Power and Renewable Electricity Producers	UNITED STATES
VATTENFALL EUROPE AKTIENGESELLSCHAFT	819,172	10,305	819,172	0.0	NaN	NaN	NaN	NaN	0.0	NaN	NaN	Trucost	Electric Utilities	SWEDEN
NIPPON STEEL CORP	802,317	22,356	802,317	1,493.0	0.047	0.018	0.065	0.102	202.0	0.096	0.057	Trucost	Metals & Mining	JAPAN
INTER RAO UES PJSC	773,006	4,260	773,006	2.0	0.196	0.143	0.010	0.207	0.0	NaN	NaN	Trucost	Electric Utilities	RUSSIA
POSCO	768,764	24,231	768,764	1,551.0	0.075	0.118	0.078	0.129	57.0	0.100	0.110	Trucost	Metals & Mining	KOREA, REP
ROYAL DUTCH SHELL PLC	766,940	212,044	766,940	238.0	0.421	0.193	0.042	0.250	127.0	0.403	0.209	Trucost	Oil, Gas & Consumable Fuels	UNITED KINGDOM
AES CORP	726,126	10,009	726,126	2.0	0.815	0.000	0.037	0.704	1.0	1.000	0.000	Trucost	Independent Power and Renewable Electricity Producers	UNITED STATES
SAUDI ARABIAN OIL CO	725,847	1,864,966	725,847	768.0	0.261	0.156	0.076	0.196	475.0	0.229	0.133	Trucost	Oil, Gas & Consumable Fuels	SAUDI ARABIA
INTERNATIONAL POWER LTD	712,262	11,546	712,262	1.0	0.333	0.000	0.000	0.250	0.0	0.667	0.000	Trucost	Independent Power and Renewable Electricity Producers	UNITED KINGDOM
ELECTRICITE DE FRANCE SA	678,866	70,197	678,866	97.0	0.605	0.069	0.053	0.550	56.0	0.656	0.058	Trucost	Electric Utilities	FRANCE
ANHUI CONCH CEMENT CO LTD	627,864	17,314	627,864	15.0	0.005	0.012	0.093	0.102	0.0	0.500	0.500	Trucost	Construction Materials	CHINA
SASOL LTD	627,037	21,079	627,037	18.0	0.379	0.101	0.049	0.183	9.0	0.350	0.087	Trucost	Oil, Gas & Consumable Fuels	SOUTH AFRICA
NRG ENERGY INC	616,563	7,125	616,563	4.0	0.492	0.100	0.056	0.411	0.0	0.000	0.500	Trucost	Independent Power and Renewable Electricity Producers	UNITED STATES
PETROLEO BRASILEIRO SA	615,974	58,271	615,974	60.0	0.156	0.028	0.018	0.086	10.0	0.328	0.058	Trucost	Oil, Gas & Consumable Fuels	BRAZIL
CHEVRON CORP	606,958	191,564	606,958	143.0	0.397	0.144	0.051	0.201	46.0	0.324	0.168	Trucost	Oil, Gas & Consumable Fuels	UNITED STATES
JFE HOLDINGS INC	605,920	15,168	605,920	1,158.0	0.044	0.019	0.060	0.117	118.0	0.073	0.056	Trucost	Metals & Mining	JAPAN
PETROCHINA CO LTD	592,462	137,737	592,462	1,384.0	0.028	0.020	0.026	0.040	13.0	0.238	0.064	Trucost	Oil, Gas & Consumable Fuels	CHINA
UNIPER SE	590,110	10,140	590,110	2.0	0.167	0.118	0.020	0.225	1.0	0.000	0.074	Trucost	Independent Power and Renewable Electricity Producers	GERMANY
PGE POLSKA GRUPA ENERGETYCZNA SA	576,518	8,432	576,518	1.0	0.000	0.000	0.000	0.071	0.0	NaN	NaN	Trucost	Electric Utilities	POLAND
BP PLC	563,825	145,910	563,825	62.0	0.477	0.123	0.050	0.373	34.0	0.466	0.144	Trucost	Oil, Gas & Consumable Fuels	UNITED KINGDOM
HEIDELBERGCEMENT AG	563,201	14,533	563,201	13.0	0.253	0.067	0.097	0.338	6.0	0.403	0.053	Trucost	Construction Materials	GERMANY
CHUBU ELECTRIC POWER CO INC	558,132	14,704	558,132	87.0	0.147	0.020	0.058	0.205	2.0	0.117	0.116	Trucost	Electric Utilities	JAPAN
XCEL ENERGY INC	543,035	17,020	543,035	0.0	0.000	0.000	0.000	0.500	0.0	NaN	NaN	Trucost	Electric Utilities	UNITED STATES
ABU DHABI NATIONAL ENERGY CO PJSC	536,613	1,094	536,613	0.0	NaN	NaN	NaN	NaN	0.0	NaN	NaN	Trucost	Multi-Utilities	UNITED ARAB EMIRATES
Panel B: Top 50 firms by worldwide patents														
Firm name	Sort Variable: PatentsWW	Mkt Cap	SCOPE1	Patents WW	GREENRATIOWW	BROWNEFFRATIOWW	GENERALEFFRATIOWW	OECDRATIOWW	Patents EP	GREENRATIOEP	BROWNEFFRATIOEP	Sample	GICS-6 Industry	Country
SAMSUNG ELECTRONICS CO LTD	12,711.0	190,812	41,560	12,711.0	0.067	0.003	0.111	0.053	1,991.0	0.063	0.004	Trucost	Semiconductors & Semiconductor Equipment	KOREA, REP
LG CORP	10,947.0	10,388	15,049	10,947.0	0.130	0.006	0.129	0.131	1,542.0	0.202	0.011	Trucost	Industrial Conglomerates	KOREA, REP
TOYOTA MOTOR CORP	10,546.0	159,434	27,377	10,546.0	0.140	0.087	0.045	0.230	1,214.0	0.220	0.177	Trucost	Automobiles	JAPAN
LG ELECTRONICS INC	8,756.0	12,952	5,863	8,756.0	0.072	0.006	0.139	0.074	1,132.0	0.093	0.012	Trucost	Household Durables	KOREA, REP
JPMORGAN CHASE & CO	7,928.0	231,150	837	7,928.0	0.049	0.036	0.103	0.045	33.0	0.057	0.080	Trucost	Diversified Financial Services	UNITED STATES
HONG KONG EXCHANGES & CLEARING LTD	7,680.0	26,666	3	7,680.0	0.050	0.016	0.041	0.089	140.0	0.294	0.018	Trucost	Diversified Financial Services	HONG KONG
BANK OF AMERICA CORP	7,314.0	186,884	971	7,314.0	0.061	0.023	0.116	0.056	5.0	0.008	0.000	Trucost	Diversified Financial Services	UNITED STATES
PANASONIC CORP	6,835.0	28,718	8,891	6,835.0	0.114	0.024	0.063	0.130	918.0	0.187	0.011	Trucost	Household Durables	JAPAN
MIDEA GROUP CO LTD	6,007.0	37,822	7,719	6,007.0	0.011	0.002	0.032	0.034	111.0	0.051	0.011	Trucost	Household Durables	CHINA
HON HAI PRECISION INDUSTRY CO LTD	5,282.0	57,049	27,882	5,282.0	0.049	0.003	0.039	0.039	257.0	0.079	0.009	Trucost	Electronic Equipment, Instruments & Components	TAIWAN
HITACHI LTD	5,175.0	25,325	15,932	5,175.0	0.086	0.025	0.053	0.104	581.0	0.165	0.079	Trucost	Electronic Equipment, Instruments & Components	JAPAN
CANON INC	4,969.0	43,202	1,608	4,969.0	0.024	0.001	0.027	0.018	616.0	0.034	0.001	Trucost	Technology Hardware, Storage & Peripherals	JAPAN
TOSHIBA CORP	4,677.0	16,382	9,720	4,677.0	0.095	0.003	0.138	0.033	389.0	0.200	0.013	Trucost	Technology Hardware, Storage & Peripherals	JAPAN
INTERNATIONAL BUSINESS MACHINES CORP	4,656.0	152,358	4,031	4,656.0	0.036	0.003	0.138	0.033	166.0	0.059	0.003	Trucost	IT Services	UNITED STATES
HYUNDAI MOBIS CO LTD	4,520.0	17,884	728	4,520.0	0.174	0.098	0.089	0.211	44.0	0.169	0.251	Trucost	Auto Components	KOREA, REP
MITSUBISHI ELECTRIC CORP	4,040.0	22,087	3,949	4,040.0	0.071	0.019	0.056	0.084	449.0	0.151	0.028	Trucost	Electrical Equipment	JAPAN
UFJ HOLDINGS INC	3,998.0	78,006	219	3,998.0	0.048	0.040	0.102	0.057	14.0	0.032	0.023	Trucost	Banks	JAPAN
M&T BANK CORP	3,928.0	15,074	46	3,928.0	0.075	0.035	0.060	0.080	0.0	0.089	0.0	Trucost	Banks	UNITED STATES
MORGAN STANLEY	3,856.0	62,584	201	3,856.0	0.049	0.040	0.110	0.057	13.0	0.027	0.009	Trucost	Capital Markets	UNITED STATES
HYUNDAI MOTOR CO LTD	3,842.0	34,996	9,240	3,842.0	0.185	0.114	0.085	0.237	41.0	0.167	0.284	Trucost	Automobiles	KOREA, REP
GREE ELECTRIC APPLIANCES INC OF ZHUHAI	3,824.0	30,341	2,911	3,824.0	0.023	0.002	0.041	0.028	28.0	0.187	0.008	Trucost	Household Durables	CHINA
SK HOLDINGS CO.,LTD	3,783.0	NaN	NaN	3,783.0	0.026	0.005	0.074	0.022	19.0	0.105	0.000	Private	Software	KOREA, REP
WELLS FARGO & CO	3,516.0	188,020	874	3,516.0	0.059	0.031	0.118	0.059	4.0	0.000	0.002	Trucost	Banks	UNITED STATES
RAYTHEON TECHNOLOGIES CORPORATION	3,441.0	108,655	NaN	3,441.0	0.038	0.034	0.334	0.126	332.0	0.173	0.371	Public	Electrical Equipment	UNITED STATES
JEFFERIES FINANCIAL GROUP INCORPORATED	3,348.0	6,719	NaN	3,348.0	0.035	0.001	0.137	0.036	0.0	NaN	NaN	Public	Food Products	UNITED STATES
FUJIFILM HOLDINGS CORP	3,305.0	16,281	7,507	3,305.0	0.030	0.001	0.027	0.027	429.0	0.067	0.003	Trucost	Electronic Equipment, Instruments & Components	JAPAN
CITIGROUP INC	3,288.0	148,641	450	3,288.0	0.093	0.032	0.093	0.080	5.0	0.121	0.088	Trucost	Diversified Financial Services	UNITED STATES
GENERAL ELECTRIC CO	3,193.0	189,258	14,625	3,193.0	0.193	0.244	0.106	0.286	1,366.0	0.234	0.264	Trucost	Industrial Conglomerates	UNITED STATES
MICROSOFT CORP	3,181.0	447,020	664	3,181.0	0.008	0.001	0.146	0.021	640.0	0.021	0.001	Trucost	Software	UNITED STATES
SONY GROUP CORP	3,173.0	39,487	3,934	3,173.0	0.061	0.001	0.060	0.058	862.0	0.052	0.001	Trucost	Household Durables	JAPAN
SK INC	3,146.0	8,498	95,876	3,146.0	0.079	0.003	0.122	0.057	73.0	0.267	0.019	Trucost	IT Services	KOREA, REP
FUJITSU LTD	3,054.0	12,687	3,539	3,054.0	0.037	0.004	0.056	0.048	454.0	0.050	0.007	Trucost	Technology Hardware, Storage & Peripherals	JAPAN
HONDA MOTOR CO LTD	3,046.0	56,957	14,518	3,046.0	0.176	0.071	0.042	0.204	383.0	0.294	0.130	Trucost	Automobiles	JAPAN
SK TELECOM CO LTD	2,885.0	14,326	99	2,885.0	0.035	0.001	0.125	0.038	25.0	0.030	0.000	Trucost	Wireless Telecommunication Services	KOREA, REP
DENSO CORP	2,869.0	29,921	6,140	2,869.0	0.089	0.104	0.055	0.171	101.0	0.127	0.238	Trucost	Auto Components	JAPAN
RICOH CO LTD	2,744.0	9,210	1,792	2,744.0	0.013	0.001	0.026	0.022	319.0	0.023	0.002	Trucost	Technology Hardware, Storage & Peripherals	JAPAN
RENAULT SA	2,743.0	20,834	6,759	2,743.0	0.182	0.104	0.038	0.280	512.0	0.335	0.155	Trucost	Automobiles	FRANCE
SEB SA	2,684.0	NaN	NaN	2,684.0	0.003	0.000	0.004	0.007	94.0	0.000	0.011	Public	Household Durables	FRANCE
SIEMENS AG	2,656.0	91,336	12,161	2,656.0	0.187	0.076	0.100	0.158	1,171.0	0.191	0.095	Trucost	Industrial Conglomerates	GERMANY
CREDIT SUISSE GROUP AG	2,601.0	43,039	193	2,601.0	0.061	0.045	0.045	0.143	0.0	0.000	0.001	Trucost	Capital Markets	SWITZERLAND
INTEL CORP	2,549.0	154,135	11,662	2,549.0	0.047	0.003	0.118	0.094	526.0	0.035	0.001	Trucost	Semiconductors & Semiconductor Equipment	UNITED STATES
ALPHABET INC	2,534.0	424,508	607	2,534.0	0.024	0.001	0.028	0.042	363.0	0.021	0.001	Trucost	Internet Software & Services (discont. 2018)	UNITED STATES
SEIKO EPSON CORP	2,482.0	4,828	1,652	2,482.0	0.022	0.003	0.034	0.021	240.0	0.040	0.002	Trucost	Technology Hardware, Storage & Peripherals	JAPAN
BANK OF NEW YORK MELLON CORP	2,421.0	39,401	91	2,421.0	0.040	0.022	0.077	0.056	7.0	0.021	0.000	Trucost	Capital Markets	UNITED STATES
NIPPON TELEGRAPH & TELEPHONE CORP	2,404.0	68,057	2,504	2,404.0	0.021	0.000	0.055	0.053	293.0	0.011	0.000	Trucost	Diversified Telecommunication Services	JAPAN
SHARP CORP	2,385.0	11,850	3,002	2,385.0	0.062	0.003	0.055	0.072	294.0	0.083	0.009	Trucost	Household Durables	JAPAN
CANADIAN GENERAL INVESTMENTS LIMITED	2,364.0	376	NaN	2,364.0	0.041	0.003	0.111	0.062	325.0	0.059	0.001	Public	Capital Markets	CANADA
NEC CORP	2,233.0	8,092	4,818	2,233.0	0.045	0.002	0.029	0.060	361.0	0.054	0.003	Trucost	Technology Hardware, Storage & Peripherals	JAPAN
METALLURGICAL CORP OF CHINA LTD	2,224.0	11,330	49,188	2,224.0	0.013	0.010	0.029	0.046	0.0	0.018	0.399	Trucost	Construction & Engineering	CHINA
DELL TECHNOLOGIES INC	2,220.0	42,996	578	2,220.0	0.020	0.001	0.086	0.045	49.0	0.040	0.000	Trucost	Software	UNITED STATES

TABLE A.II: PATENT RATIO AND SCOPE 1 EMISSIONS - ALTERNATIVE INDUSTRY SPECIFICATIONS

The unit of observation is firm-year. In Panel A, the dependent variable is a green patent ratio, specifically the *GREENRATIOWW* in column 1 to 4 and *GREENRATIOEP* in column 5 to 8. In Panel B, the dependent variable is a brown efficiency dependent ratio, specifically the *BROWNEFFRATIOWW* in column 1 to 4 and *BROWNEFFRATIOEP* in column 5 to 8. The sample period is 2005 to 2020. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regressions include country and year fixed effects. Column 1 and 5 additionally include year fixed effects and industry fixed effects based on the 6-digit level GICS Industry, while column 3 and 7 add industry as well as the industry-year interaction. Column 2 and 6 additionally include year fixed effects and industry fixed effects based on the 8-digit level GICS Subindustry, while column 4 and 8 also include the industry-year interaction. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

Panel A: Green innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		GREENRATIOWW				GREENRATIOEP		
LOGS1TOT	−0.016**	−0.018**	−0.016**	−0.018**	−0.033***	−0.038***	−0.035***	−0.036***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.010)	(0.009)	(0.010)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	GICS Ind	GICS Sub Ind	GICS Ind	GICS Sub Ind	GICS Ind	GICS Sub Ind	GICS Ind	GICS Sub Ind
Industry-Year F.E.	no	no	GICS Ind	GICS Sub Ind	no	no	GICS Ind	GICS Sub Ind
Observations	53399	53382	53068	52034	28086	27916	27643	26703
Pseudo R2	0.0966	0.108	0.106	0.123	0.0917	0.101	0.104	0.119
Std dev dep. var.	0.180	0.180	0.180	0.182	0.240	0.240	0.241	0.243
Std dev LOGS1TOT	2.703	2.703	2.703	2.714	2.674	2.675	2.667	2.675
Eco sig LOGS1TOT	0.233	0.274	0.239	0.274	0.373	0.422	0.383	0.400

Panel B: Brown efficiency innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		BROWNEFFRATIOWW				BROWNEFFRATIOEP		
LOGS1TOT	0.018	0.019	0.020	0.019	−0.007	0.018	−0.006	0.014
	(0.013)	(0.014)	(0.013)	(0.014)	(0.018)	(0.018)	(0.017)	(0.017)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	GICS Ind	GICS Sub Ind	GICS Ind	GICS Sub Ind	GICS Ind	GICS Sub Ind	GICS Ind	GICS Sub Ind
Industry-Year F.E.	no	no	GICS Ind	GICS Sub Ind	no	no	GICS Ind	GICS Sub Ind
Observations	53162	52742	50765	46783	27535	26622	23843	22363
Pseudo R2	0.168	0.183	0.182	0.199	0.159	0.171	0.160	0.181
Std dev dep. var.	0.0946	0.0950	0.0967	0.100	0.135	0.137	0.144	0.147
Std dev LOGS1TOT	2.701	2.704	2.695	2.734	2.676	2.697	2.606	2.608
Eco sig LOGS1TOT	0.517	0.532	0.557	0.521	0.130	0.347	0.112	0.244

The unit of observation is firm-year. The dependent variable is $GREENRATIOWW$ in Panel A and $GREENRATIOEP$ in Panel B. The sample period is 2005-2020. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. We include country, year, industry and industry-year fixed effects and cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the respective emission variable and the economic significance of a one standard deviation change in the emission variable (Eco sig Emission), calculated as $|Coef_{Emission} * StdDev_{Emission} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Panel A: GREENRATIOWW					
LOGS2TOT	−0.038*** (0.009)							
LOGS3TOT		−0.102*** (0.013)						
S1CHG			0.044* (0.025)					
S2CHG				0.052*** (0.019)				
S3CHG					0.061 (0.045)			
S1INT						0.003 (0.003)		
S2INT							0.077*** (0.021)	
S3INT								−0.031* (0.016)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry-Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Observations	50178	50178	43370	43384	43395	50178	50178	50178
Pseudo R2	0.147	0.147	0.148	0.148	0.148	0.146	0.146	0.146
Std dev dep. var.	0.183	0.183	0.184	0.184	0.184	0.183	0.183	0.183
Std dev Emission	2.171	2.201	0.424	0.489	0.250	5.166	0.553	1.721
Eco sig Emission	0.453	1.230	0.101	0.139	0.0831	0.0850	0.232	0.289
			Panel B: GREENRATIOEP					
LOGS2TOT	−0.054*** (0.012)							
LOGS3TOT		−0.108*** (0.016)						
S1CHG			0.047 (0.029)					
S2CHG				0.065*** (0.023)				
S3CHG					0.148*** (0.054)			
S1INT						−0.000 (0.003)		
S2INT							0.026 (0.026)	
S3INT								−0.040** (0.018)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry-Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Observations	25032	25032	22333	22342	22343	25032	25032	25032
Pseudo R2	0.145	0.146	0.147	0.147	0.147	0.145	0.145	0.145
Std dev dep. var.	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
Std dev Emission	2.243	2.316	0.418	0.481	0.241	4.111	0.550	1.607
Eco sig Emission	0.489	1.018	0.0798	0.126	0.146	0.00683	0.0582	0.261

TABLE A.IV: BROWN EFFICIENCY PATENTING AND ALTERNATIVE EMISSIONS

The unit of observation is firm-year. The dependent variable is *BROWNEFFRATIOWW* in Panel A and *BROWNEFFRATIOEP* in Panel B. The sample period is 2005-2020. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. We include country, year, industry and industry-year fixed effects and cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the respective emission variable and the economic significance of a one standard deviation change in the emission variable (Eco sig Emission), calculated as $|Coef_{Emission} * StdDev_{Emission} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: BROWNEFFRATIOWW				
LOGS2TOT	−0.027							
	(0.018)							
LOGS3TOT		0.052**						
		(0.026)						
S1CHG			−0.088*					
			(0.047)					
S2CHG				−0.062				
				(0.041)				
S3CHG					−0.073			
					(0.091)			
S1INT						0.016***		
						(0.005)		
S2INT							−0.019	
							(0.046)	
S3INT								0.071***
								(0.026)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry-Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Observations	43813	43813	37882	37899	37907	43813	43813	43813
Poisson R2	0.235	0.235	0.235	0.235	0.235	0.235	0.235	0.235
Std dev dep. var.	0.102	0.102	0.104	0.104	0.104	0.102	0.102	0.102
Std dev Emission	2.200	2.236	0.428	0.492	0.253	5.353	0.561	1.664
Eco sig Emission	0.577	1.128	0.362	0.297	0.178	0.854	0.103	1.148
				Panel B: BROWNEFFRATIOEP				
LOGS2TOT	−0.026							
	(0.023)							
LOGS3TOT		0.154***						
		(0.032)						
S1CHG			0.012					
			(0.055)					
S2CHG				−0.039				
				(0.048)				
S3CHG					−0.005			
					(0.111)			
S1INT						0.016***		
						(0.006)		
S2INT							−0.135**	
							(0.053)	
S3INT								0.136***
								(0.028)
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Industry-Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes
Observations	20338	20338	18123	18131	18132	20338	20338	20338
Poisson R2	0.241	0.241	0.238	0.238	0.238	0.241	0.241	0.241
Std dev dep. var.	0.150	0.150	0.151	0.150	0.150	0.150	0.150	0.150
Std dev Emission	2.277	2.367	0.423	0.482	0.246	4.303	0.559	1.560
Eco sig Emission	0.389	2.428	0.0337	0.125	0.00856	0.471	0.502	1.409

TABLE A.V: Green (European Patent Office) patent ratio and Scope 1 Emissions - Industry by Industry

The unit of observation is firm-year. The sample period is 2005-2020. The dependent variable is *GREENRATIOEP* and independent variables are as in Table 6 with controls. All variables are defined in Table 5. We run the regression individually for each 6-digit GICS Industry with a Poisson pseudo-maximum likelihood regression and include country and year fixed effects. We cluster standard errors at the firm and year dimension. We report the coefficient for *LOGS1TOT* in column 1 with *** representing 1% significance, ** 5% significance * 10% significance. Column 2 reports the corresponding standard error. Column 3 reports the Pseudo R2, column 4 the number of observations in the regression, column 5 and 6 the standard deviation of *LOGS1TOT*, respectively *GREENRATIOEP*, in the given regression sample and column 7 the industry average absolute scope 1 emissions by which we rank the table.

Industry	(1) coef for LOGS1TOT	(2) std. err	(3) Pseudo R2	(4) N	(5) Std. dev. LOGS1TOT	(6) Std. dev. GREENRATIOEP	(7) Industry Scope 1
Electric Utilities	-0.130**	0.060	0.076	254	2.037	0.405	21966773
Oil, Gas & Consumable Fuels	0.012	0.060	0.053	562	2.030	0.342	20973912
Independent Power and Renewable Electricity Producers	-0.780***	0.260	0.185	36	3.627	0.421	18641614
Metals & Mining	-0.175***	0.066	0.088	830	2.384	0.241	16138911
Construction Materials	0.283	0.200	0.148	236	2.440	0.317	9916635
Multi-Utilities	0.034	0.070	0.116	116	1.666	0.378	7344608
Chemicals	-0.012	0.031	0.035	2128	2.203	0.208	4744375
Industrial Conglomerates	0.064*	0.035	0.149	448	2.050	0.212	1538727
Food Products	0.312***	0.062	0.091	720	1.665	0.244	1141156
Construction & Engineering	0.176***	0.066	0.084	512	1.796	0.361	845274
Paper & Forest Products	0.486*	0.267	0.174	223	1.714	0.246	805302
Diversified Financial Services	-0.017	0.042	0.153	249	3.323	0.181	729626
Commercial Services & Supplies	-0.287**	0.135	0.135	370	1.745	0.244	696769
Gas Utilities	-0.346	0.238	0.153	55	1.459	0.423	617602
Trading Companies & Distributors	-0.085	0.090	0.164	185	2.443	0.223	591652
Air Freight & Logistics	0.326	0.275	0.238	39	1.836	0.150	448489
Hotels, Restaurants & Leisure	7.278***	0.000	0.083	6	2.138	0.280	426348
Building Products	-0.220***	0.077	0.082	480	1.970	0.209	380646
Food & Staples Retailing	63.905***	0.000	0.217	6	2.156	0.455	351823
Machinery	0.038	0.057	0.043	2422	1.456	0.168	350582
Energy Equipment & Services	0.117**	0.057	0.091	414	2.030	0.237	342478
Containers & Packaging	-0.260	0.246	0.232	313	1.732	0.134	319053
Automobiles	0.041	0.092	0.099	418	1.525	0.252	264498
Electronic Equipment, Instruments & Components	-0.070	0.051	0.044	1440	1.832	0.223	255883
Specialty Retail	12.702***	0.000	0.187	6	1.352	0.427	248423
Beverages	0.572**	0.283	0.243	171	1.647	0.233	224142
Semiconductors & Semiconductor Equipment	-0.110***	0.031	0.080	1300	1.873	0.307	204997
Insurance	0.265	0.319	0.300	140	2.134	0.228	199957
Auto Components	-0.139	0.091	0.054	1013	1.611	0.203	198076
Real Estate Management & Development	5.382***	0.000	0.059	14	1.420	0.222	174526
Pharmaceuticals	-0.060	0.076	0.064	1443	2.163	0.141	168450
Household Durables	0.087	0.093	0.080	626	1.827	0.157	126895
Entertainment	1.041***	0.279	0.354	41	1.679	0.070	126049
Textiles, Apparel & Luxury Goods	0.030	0.193	0.198	369	1.284	0.143	125082
Household Products	-0.095	0.099	0.203	177	1.648	0.106	111966
Health Care Providers & Services	-0.192	0.148	0.222	223	1.664	0.217	109853
Electrical Equipment	-0.125***	0.036	0.122	837	1.761	0.377	109565
Technology Hardware, Storage & Peripherals	-0.002	0.082	0.088	674	1.982	0.126	101589
Aerospace & Defense	0.263***	0.081	0.090	569	1.605	0.148	89730
Wireless Telecommunication Services	-0.589***	0.177	0.325	124	1.904	0.061	88311
Tobacco	-0.709**	0.316	0.234	108	1.415	0.220	74380
Diversified Telecommunication Services	-1.591***	0.300	0.341	277	1.846	0.100	55247
Equity Real Estate Investment Trusts (REITs)	-0.048***	0.000	0.091	6	2.445	0.344	47687
Personal Products	0.341*	0.181	0.238	192	1.618	0.104	45429
Banks	0.094	0.186	0.111	302	1.341	0.213	36212
Internet & Direct Marketing Retail	-0.317	0.520	0.361	50	2.077	0.153	30579
Health Care Equipment & Supplies	0.165	0.135	0.129	1030	1.627	0.135	29296
Media (discont. 2018)	0.991***	0.217	0.258	209	1.520	0.219	27369
Media	1.951**	0.867	0.558	72	1.916	0.173	26301
IT Services	0.224	0.163	0.205	365	1.546	0.155	20489
Capital Markets	-0.043	0.112	0.150	404	1.892	0.202	17109
Life Sciences Tools & Services	0.029	0.105	0.083	291	1.977	0.188	16775
Communications Equipment	-0.335*	0.177	0.208	401	1.483	0.177	15302
Leisure Products	0.433***	0.127	0.272	240	1.440	0.272	15171
Biotechnology	-0.360***	0.052	0.087	1016	2.131	0.309	13626
Professional Services	1.987***	0.599	0.511	74	1.229	0.295	9864
Software	-0.783***	0.300	0.229	571	1.482	0.110	9776
Interactive Media & Services	-0.770***	0.174	0.214	33	1.236	0.079	4414
Internet Software & Services (discont. 2018)	0.484	1.115	0.359	68	1.358	0.045	2517
Health Care Technology	-0.507***	0.000	0.263	7	2.510	0.428	1291

TABLE A.VI: BROWN EFFICIENCY (EUROPEAN PATENT OFFICE) RATIO AND SCOPE 1 EMISSIONS - INDUSTRY BY INDUSTRY

The unit of observation is firm-year. The sample period is 2005-2020. The dependent variable is $BROWNEFFRATIOEP$ and independent variables are as in Table 6 with controls. All variables are defined in Table 5. We run the regression individually for each 6-digit GICS Industry with a Poisson pseudo-maximum likelihood regression and include country and year fixed effects. We cluster standard errors at the firm and year dimension. We report the coefficient for $LOGS1TOT$ in column 1 with *** representing 1% significance, ** 5% significance * 10% significance. Column 2 reports the corresponding standard error. Column 3 reports the Pseudo R2, column 4 the number of observations in the regression, column 5 and 6 the standard deviation of $LOGS1TOT$, respectively $BROWNEFFRATIOEP$, in the given regression sample and column 7 the industry average absolute scope 1 emissions by which we rank the table.

Industry	(1) coef for LOGS1TOT	(2) std. err	(3) Pseudo R2	(4) N	(5) Std. dev. LOGS1TOT	(6) Std. dev. BROWNEFFRATIOEP	(7) Industry Scope 1
Electric Utilities	0.712***	0.133	0.226	232	1.760	0.296	21966773
Oil, Gas & Consumable Fuels	0.126	0.129	0.096	548	2.047	0.190	20973912
Independent Power and Renewable Electricity Producers	0.351***	0.000	0.054	8	4.865	0.263	18641614
Metals & Mining	-0.132**	0.064	0.086	825	2.365	0.163	16138911
Construction Materials	-0.056	0.221	0.165	218	2.285	0.206	9916635
Multi-Utilities	-0.045	0.232	0.275	108	1.617	0.249	7344608
Chemicals	0.024	0.103	0.096	2034	2.203	0.112	4744375
Industrial Conglomerates	-0.217***	0.062	0.178	385	2.153	0.130	1538727
Food Products	0.370	0.243	0.320	472	1.587	0.090	1141156
Construction & Engineering	-0.141	0.091	0.101	523	1.791	0.235	845274
Paper & Forest Products	2.156	1.342	0.567	94	1.417	0.147	805302
Diversified Financial Services	0.107*	0.057	0.258	231	3.262	0.150	729626
Commercial Services & Supplies	0.263	0.196	0.290	273	1.768	0.232	696769
Gas Utilities	12.952***	0.000	0.126	12	0.679	0.196	617602
Trading Companies & Distributors	-0.555***	0.172	0.238	94	1.500	0.111	591652
Building Products	-0.326**	0.144	0.128	479	1.962	0.167	380646
Machinery	-0.088*	0.050	0.069	2394	1.450	0.181	350582
Energy Equipment & Services	-0.106*	0.056	0.100	437	2.011	0.303	342478
Containers & Packaging	0.347	0.381	0.421	173	1.378	0.078	319053
Automobiles	-0.121	0.138	0.075	415	1.500	0.204	264498
Electronic Equipment, Instruments & Components	0.044	0.105	0.095	1278	1.810	0.070	255883
Beverages	0.000	0.000	0.000	2	5.277	0.000	224142
Semiconductors & Semiconductor Equipment	0.286	0.222	0.264	1236	1.803	0.068	204997
Insurance	1.732***	0.556	0.374	125	2.217	0.121	199957
Auto Components	-0.189**	0.079	0.040	995	1.613	0.169	198076
Pharmaceuticals	0.561*	0.297	0.227	811	2.391	0.019	168450
Household Durables	0.123	0.159	0.281	572	1.752	0.145	126895
Household Products	-0.968***	0.273	0.610	129	1.598	0.088	111966
Health Care Providers & Services	1.620**	0.782	0.401	55	1.750	0.023	109853
Electrical Equipment	-0.103	0.108	0.122	809	1.743	0.132	109565
Technology Hardware, Storage & Peripherals	-0.200	0.159	0.486	627	1.841	0.064	101589
Aerospace & Defense	0.016	0.119	0.114	547	1.600	0.126	89730
Tobacco	-0.342	0.910	0.298	87	1.187	0.098	74380
Banks	-2.660**	1.257	0.314	207	1.169	0.166	36212
Health Care Equipment & Supplies	0.516*	0.281	0.160	780	1.559	0.047	29296
Media (discont. 2018)	457.830***	0.000	0.588	124	1.566	0.058	27369
IT Services	1.193*	0.629	0.602	327	1.557	0.085	20489
Capital Markets	-0.196	0.376	0.358	279	1.836	0.147	17109
Life Sciences Tools & Services	0.510	0.421	0.269	198	1.883	0.034	16775
Communications Equipment	0.796*	0.451	0.245	265	1.409	0.004	15302
Leisure Products	0.456	0.373	0.408	169	1.261	0.101	15171
Professional Services	-4.634***	1.789	0.436	51	1.623	0.294	9864
Software	-4.101***	1.081	0.562	198	1.378	0.038	9776
Interactive Media & Services	4.662***	0.000	0.103	6	1.111	0.015	4414

TABLE A.VII: PATENT RATIOS AND SCOPE 1 EMISSIONS

The unit of observation is firm-year. The sample period is 2005-2020. The dependent variable is GENERALEF-FRATIOWW and GENERALEFFRATIOEP in Panel A as well as OECDRATIOWW and OECDRATIOEP in Panel B. The regression includes the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: General efficiency innovation						
	GENERALNEFFRATIOWW			GENERALNEFFRATIOEP		
LOGS1TOT	−0.062***	0.001	−0.001	−0.037***	0.001	0.004
	(0.006)	(0.007)	(0.008)	(0.009)	(0.010)	(0.010)
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry-Year F.E.	no	no	yes	no	no	yes
Observations	53398	53193	50920	28082	27790	24939
Pseudo R2	0.0575	0.136	0.158	0.0151	0.108	0.139
Std dev dep. var.	0.203	0.203	0.204	0.216	0.217	0.220
Std dev LOGS1TOT	2.703	2.706	2.722	2.674	2.678	2.697
Eco sig LOGS1TOT	0.833	0.0176	0.0104	0.459	0.0166	0.0481

	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: OECD env-tech innovation						
	OECDRATIOWW			OECDRATIOEP		
LOGS1TOT	0.114***	0.014*	0.013	0.094***	−0.004	−0.017
	(0.005)	(0.008)	(0.008)	(0.007)	(0.010)	(0.010)
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry-Year F.E.	no	no	yes	no	no	yes
Observations	53394	53169	50649	28080	27738	25044
Pseudo R2	0.0365	0.110	0.133	0.0422	0.132	0.157
Std dev dep. var.	0.188	0.188	0.190	0.241	0.242	0.246
Std dev LOGS1TOT	2.703	2.705	2.729	2.674	2.682	2.717
Eco sig LOGS1TOT	1.647	0.198	0.180	1.046	0.0439	0.183

The unit of observation is firm-year. The sample period is 2005-2020. The dependent variable is GREENCI-TRATIOWW and GREENCITRATIOEP in Panel A, BROWNEFFCITRATIOWW and BROWNEFFCITRATIOEP in Panel B, GENERALEFFCITRATIOWW and GENERALEFFCITRATIOEP in Panel C as well as OECDCITRATIOWW and OECDCITRATIOEP in Panel D. In addition to LOGS1TOT, we include the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

Panel A: Green innovation	(1)	(2)	(3)	(4)	(5)	(6)
	GREENCITRATIOWW			GREENCITRATIOEP		
LOGS1TOT	0.103***	−0.011	−0.017*	0.087***	−0.032***	−0.041***
	(0.006)	(0.009)	(0.009)	(0.008)	(0.011)	(0.012)
Observations	47043	46692	43571	26308	26004	23238
Pseudo R2	0.0392	0.125	0.151	0.0350	0.120	0.152
Std dev dep. var.	0.218	0.218	0.222	0.264	0.265	0.272
Std dev LOGS1TOT	2.684	2.688	2.712	2.662	2.668	2.694
Eco sig LOGS1TOT	1.274	0.130	0.202	0.880	0.319	0.403

Panel B: Brown efficiency innovation						
	BROWNEFFCITRATIOWW			BROWNEFFCITRATIOEP		
LOGS1TOT	0.073***	0.037**	0.036*	0.043***	0.033	0.048**
	(0.011)	(0.019)	(0.019)	(0.014)	(0.023)	(0.023)
Observations	46884	45332	37531	26231	24376	18658
Pseudo R2	0.0673	0.213	0.247	0.0535	0.218	0.258
Std dev dep. var.	0.112	0.114	0.122	0.142	0.147	0.161
Std dev LOGS1TOT	2.682	2.703	2.771	2.662	2.704	2.751
Eco sig LOGS1TOT	1.745	0.887	0.806	0.803	0.600	0.824

Panel C: General efficiency innovation						
	GENERALEFFCITRATIOWW			GENERALEFFCITRATIOEP		
LOGS1TOT	−0.058***	0.005	0.004	−0.045***	−0.003	0.002
	(0.006)	(0.008)	(0.008)	(0.009)	(0.011)	(0.011)
Observations	47040	46824	44287	26290	25943	23142
Pseudo R2	0.0460	0.121	0.148	0.0169	0.106	0.147
Std dev dep. var.	0.232	0.232	0.234	0.238	0.238	0.243
Std dev LOGS1TOT	2.684	2.686	2.708	2.662	2.667	2.684
Eco sig LOGS1TOT	0.674	0.0598	0.0498	0.504	0.0311	0.0184

Panel D: OECD env-tech innovation						
	OECDCITRATIOWW			OECDCITRATIOEP		
LOGS1TOT	0.111***	0.011	0.012	0.087***	−0.001	−0.011
	(0.006)	(0.008)	(0.008)	(0.007)	(0.011)	(0.011)
Observations	47037	46825	44042	26296	25901	23245
Pseudo R2	0.0371	0.115	0.140	0.0419	0.131	0.160
Std dev dep. var.	0.225	0.225	0.228	0.266	0.268	0.273
Std dev LOGS1TOT	2.684	2.686	2.716	2.662	2.671	2.709
Eco sig LOGS1TOT	1.327	0.132	0.143	0.873	0.0123	0.110

Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry-Year F.E.	no	no	yes	no	no	yes

TABLE A.IX: GREEN PATENT RATIO AND SCOPE 1 EMISSIONS - LEGACY SAMPLE PRE 2016

The unit of observation is firm-year. The dependent variable is *GREENRATIOWW* in Panel A.1 and Panel B.1 and *GREENRATIOEP* in Panel A.2 and Panel B.2. The sample period is 2005-2020 and the sample restricts inclusion of firms into those that Trucost covers in its database before 2016. In Panel A we cover the full Trucost sample if a firm has at least one granted or purchased patent in the full sample, while Panel B restricts observations to the intensive margin covering firms with *at least one* green patent at some patent office worldwide in Panel B.1 and one green patent at the European Office in Panel B.2. The regression includes the following controls in columns 4 to 6: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood in Panel A and pooled regression model in Panel B. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Trucost sample with firms patenting at one patent across sample					
	Panel A.1: Dependent variable GREENRATIOWW					
LOGS1TOT	0.119***	0.001	0.000	0.114***	−0.004	−0.005
	(0.005)	(0.007)	(0.006)	(0.007)	(0.010)	(0.010)
Observations	38639	38430	35627	38639	38430	35627
Pseudo R2	0.0390	0.133	0.155	0.0500	0.136	0.158
Std dev dep. var.	0.178	0.179	0.182	0.178	0.179	0.182
Std dev LOGS1TOT	2.643	2.643	2.676	2.643	2.643	2.676
Eco sig LOGS1TOT	1.761	0.0160	0.00636	1.694	0.0552	0.0684
	Panel A.2: Dependent variable GREENRATIOEP					
LOGS1TOT	0.100***	−0.026***	−0.030***	0.096***	−0.028**	−0.041***
	(0.005)	(0.007)	(0.007)	(0.008)	(0.011)	(0.012)
Observations	23207	22985	20359	23207	22985	20359
Pseudo R2	0.0257	0.125	0.153	0.0385	0.128	0.156
Std dev dep. var.	0.232	0.233	0.238	0.232	0.233	0.238
Std dev LOGS1TOT	2.550	2.553	2.573	2.550	2.553	2.573
Eco sig LOGS1TOT	1.097	0.282	0.326	1.056	0.309	0.447
	Panel B: Firm-year Trucost sample with at least one green patent					
	Panel B.1: Dependent variable GREENRATIOWW					
LOGS1TOT	0.005***	−0.022***	−0.022***	0.013***	−0.008***	−0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	19003	18984	17739	19003	18984	17739
R2	0.118	0.392	0.452	0.181	0.412	0.471
Std dev dep. var.	0.225	0.225	0.223	0.225	0.225	0.223
Std dev LOGS1TOT	2.585	2.585	2.608	2.585	2.585	2.608
Eco sig LOGS1TOT	0.0629	0.254	0.260	0.147	0.0875	0.0908
	Panel B.2: Dependent variable GREENRATIOEP					
LOGS1TOT	0.000	−0.038***	−0.038***	0.014***	−0.016***	−0.016***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Observations	11052	11021	9808	11052	11021	9808
R2	0.0965	0.456	0.519	0.180	0.481	0.544
Std dev dep. var.	0.280	0.279	0.277	0.280	0.279	0.277
Std dev LOGS1TOT	2.519	2.518	2.544	2.519	2.518	2.544
Eco sig LOGS1TOT	0.00148	0.341	0.351	0.129	0.143	0.147
Controls	no	no	no	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes

The unit of observation is firm-year. The dependent variable is *BROWNEFFRATIOWW* in Panel A.1 and Panel B.1 and *BROWNEFFRATIOEP* in Panel A.2 and Panel B.2. The sample period is 2005-2020 and the sample restricts inclusion of firms into those that Trucost covers in its database before 2016. In Panel A we cover the full Trucost sample if a firm has at least one granted or purchased patent in the full sample, while Panel B restricts observations to the intensive margin covering firms with *at least one* green patent at some patent office worldwide in Panel B.1 and one green patent at the European Office in Panel B.2. The regression includes the following controls in columns 4 to 6: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Trucost sample with firms patenting at one patent across sample						
Panel A.1: Dependent variable BROWNEFFRATIOWW						
LOGS1TOT	0.143***	0.037***	0.037***	0.091***	0.051***	0.044***
	(0.007)	(0.011)	(0.011)	(0.011)	(0.017)	(0.017)
Observations	38446	37334	30717	38446	37334	30717
Pseudo R2	0.0538	0.211	0.235	0.0675	0.212	0.236
Std dev dep. var.	0.101	0.102	0.110	0.101	0.102	0.110
Std dev LOGS1TOT	2.639	2.655	2.739	2.639	2.655	2.739
Eco sig LOGS1TOT	3.745	0.954	0.918	2.398	1.337	1.108
Panel A.2: Dependent variable BROWNEFFRATIOEP						
LOGS1TOT	0.141***	0.063***	0.064***	0.062***	0.058***	0.060***
	(0.008)	(0.013)	(0.013)	(0.014)	(0.021)	(0.021)
Observations	23139	21601	16350	23139	21601	16350
Pseudo R2	0.0351	0.212	0.236	0.0470	0.213	0.237
Std dev dep. var.	0.136	0.140	0.153	0.136	0.140	0.153
Std dev LOGS1TOT	2.549	2.575	2.620	2.549	2.575	2.620
Eco sig LOGS1TOT	2.647	1.152	1.092	1.158	1.074	1.023
Panel B: Firm-year Trucost sample with at least one green patent						
Panel B.1: Dependent variable BROWNEFFRATIOWW						
LOGS1TOT	−0.000	−0.017***	−0.016***	0.005***	−0.004***	−0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Observations	9887	9840	8728	9887	9840	8728
R2	0.115	0.379	0.457	0.191	0.398	0.473
Std dev dep. var.	0.177	0.176	0.177	0.177	0.176	0.177
Std dev LOGS1TOT	2.624	2.624	2.652	2.624	2.624	2.652
Eco sig LOGS1TOT	0.00613	0.246	0.242	0.0690	0.0572	0.0420
Panel B.2: Dependent variable BROWNEFFRATIOEP						
LOGS1TOT	−0.009***	−0.029***	−0.029***	0.002	−0.002	−0.000
	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
Observations	5217	5181	4228	5217	5181	4228
R2	0.0950	0.420	0.504	0.164	0.445	0.529
Std dev dep. var.	0.236	0.235	0.236	0.236	0.235	0.236
Std dev LOGS1TOT	2.518	2.522	2.551	2.518	2.522	2.551
Eco sig LOGS1TOT	0.0939	0.307	0.314	0.0176	0.0229	0.00452
Controls	no	no	no	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes

The unit of observation is firm-year. The sample period is 2005-2020. The dependent variable is GREEN-RATIOWW and GREENCITRATIOWW in Panel A, GREENRATIOEP and GREENCITRATIOEP in Panel B, BROWNEFFRATIOWW and BROWNEFFCITRATIOWW in Panel C and BROWNEFFRATIOEP and BROWNEFFCI-TRATIOEP in Panel D. The sample drops acquiring firms with M&A between 2005 and 2020 where the target firms has one or more green patents granted by some patent office worldwide in Panel A, one or more green patents granted by the European Patent Office in Panel B, one or more brown efficiency patents granted by some patent office worldwide in Panel C and one or more brown efficiency patents granted by the European Patent Office in Panel D. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT and the economic significance of a one standard deviation change in LOGS1TOT (Eco sig LOGS1TOT), calculated as $|Coef_{LOGS1TOT} * StdDev_{LOGS1TOT} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Worldwide patent office & green patenting						
		GREENRATIOWW			GREENCITRATIOWW	
LOGS1TOT	0.101***	−0.020**	−0.022**	0.104***	−0.011	−0.016*
	(0.006)	(0.009)	(0.009)	(0.006)	(0.009)	(0.009)
Observations	52567	52359	49297	46213	45846	42690
Pseudo R2	0.0423	0.127	0.148	0.0395	0.126	0.152
Std dev dep. var.	0.180	0.181	0.184	0.218	0.219	0.223
Std dev LOGS1TOT	2.705	2.707	2.730	2.687	2.691	2.715
Eco sig LOGS1TOT	1.510	0.306	0.324	1.276	0.131	0.197
Panel B: European patent office & green patenting						
		GREENRATIOEP			GREENCITRATIOEP	
LOGS1TOT	0.088***	−0.042***	−0.053***	0.088***	−0.032***	−0.040***
	(0.008)	(0.011)	(0.011)	(0.008)	(0.011)	(0.012)
Observations	27601	27331	24465	25823	25518	22694
Pseudo R2	0.0334	0.118	0.147	0.0354	0.121	0.153
Std dev dep. var.	0.241	0.242	0.247	0.264	0.265	0.273
Std dev LOGS1TOT	2.677	2.682	2.706	2.665	2.672	2.698
Eco sig LOGS1TOT	0.978	0.464	0.585	0.883	0.319	0.396
Panel C: Worldwide patent office & brown efficiency patenting						
		BROWNEFFRATIOWW			BROWNEFFCITRATIOWW	
LOGS1TOT	0.090***	0.052***	0.043***	0.073***	0.037*	0.035*
	(0.010)	(0.016)	(0.016)	(0.011)	(0.019)	(0.019)
Observations	52991	51612	43595	46710	45160	37292
Pseudo R2	0.0749	0.209	0.235	0.0672	0.213	0.248
Std dev dep. var.	0.0946	0.0958	0.102	0.112	0.113	0.122
Std dev LOGS1TOT	2.700	2.717	2.779	2.682	2.703	2.772
Eco sig LOGS1TOT	2.578	1.477	1.157	1.761	0.890	0.792
Panel D: European patent office & brown efficiency patenting						
		BROWNEFFRATIOEP			BROWNEFFCITRATIOEP	
LOGS1TOT	0.057***	0.044**	0.054***	0.045***	0.033	0.051**
	(0.013)	(0.021)	(0.021)	(0.015)	(0.023)	(0.023)
Observations	27605	25876	19694	25846	23996	18008
Pseudo R2	0.0513	0.213	0.240	0.0541	0.220	0.258
Std dev dep. var.	0.134	0.137	0.151	0.142	0.147	0.162
Std dev LOGS1TOT	2.674	2.707	2.775	2.663	2.705	2.764
Eco sig LOGS1TOT	1.132	0.868	0.992	0.837	0.607	0.868
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes

TABLE A.XII: PATENT CITATION RATIO AND SCOPE 1 EMISSIONS - PRE AND POST 2015

The unit of observation is firm-year. The dependent variable is GREENCITRATIOWW and GREENCITRATIOEP in Panel A and BROWNEFFCITRATIOWW and BROWNEFFCITRATIOEP in Panel B. Post2015 is a dummy that is equal to 1 for all years after 2015 and zero otherwise. We interact this variable with all control variables and report the coefficient on the LOGS1TOT and Post2015 interaction. The regressions also include the following controls: LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, and MSCI. All variables are defined in Table 5. The model is estimated using Poisson pseudo-maximum likelihood. All regression include country and year fixed effects. Columns 2 and 5 includes Trucost sector industry fixed effects and columns 3 and 6 includes Trucost sector industry fixed effects as well as industry-year fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of LOGS1TOT. *** 1% significance, ** 5% significance * 10% significance.

Panel A: Green innovation	(1)	(2)	(3)	(4)	(5)	(6)
		GREENRATIOWW			GREENRATIOEP	
LOGS1TOT	0.130***	0.011	0.011	0.111***	−0.012	−0.021
	(0.008)	(0.011)	(0.014)	(0.010)	(0.014)	(0.016)
LOGS1TOT X POST2015	−0.057***	−0.037***	−0.047**	−0.057***	−0.036**	−0.037
	(0.012)	(0.012)	(0.018)	(0.015)	(0.015)	(0.023)
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	47043	46692	43571	26308	26004	23238
Pseudo R2	0.040	0.126	0.151	0.036	0.120	0.152
Std dev dep. var.	0.218	0.218	0.222	0.264	0.265	0.272
Std dev LOGS1TOT	2.684	2.688	2.712	2.662	2.668	2.694

Panel B: Brown efficiency innovation						
		BROWNEFFCITRATIOWW			BROWNEFFCITRATIOEP	
LOGS1TOT	0.075***	0.011	0.028	0.057***	0.025	0.063**
	(0.015)	(0.021)	(0.026)	(0.019)	(0.026)	(0.030)
LOGS1TOT X POST2015	−0.011	0.050**	0.009	−0.040	0.013	−0.036
	(0.021)	(0.022)	(0.037)	(0.028)	(0.028)	(0.045)
Controls	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes
Industry F.E.	no	yes	yes	no	yes	yes
Industry X Year F.E.	no	no	yes	no	no	yes
Observations	46884	45332	37531	26231	24376	18658
Pseudo R2	0.070	0.213	0.247	0.057	0.219	0.260
Std dev dep. var.	0.112	0.114	0.122	0.142	0.147	0.161
Std dev LOGS1TOT	2.682	2.703	2.771	2.662	2.704	2.751

TABLE A.XIII: JEVONS PARADOX - GREEN INNOVATION (PATENT COUNT)

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $GREENCOUNTWW$ in Panel A and B and $GREENCOUNTEP$ in Panel C and D. $GREENCOUNTWW$ is the total number of "green classified" patent families granted or purchased at any patent office worldwide by a firm in a given year, while $GREENCOUNTEP$ captures patents granted or purchased at the European Patent Office. We winsorize both variables at 5% and 95%. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE$, $LOGPPE$, $LEVERAGE$, ROE, M/B, $INVEST/A$, $BETA$, $VOLAT$, MOM, RET, $MSCI$. All dependent and control variables are defined in 5. The model is estimated using pooled regression model. All regression inlcude country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - Green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 GREENCOUNTWW/100	0.309***	0.566***	0.186***	0.197	0.219***	−0.240***	0.065*	−1.063***	0.143**	0.169**
	(0.103)	(0.088)	(0.056)	(0.214)	(0.043)	(0.064)	(0.039)	(0.348)	(0.072)	(0.078)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. Dev. Dep Var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. Dev. Patent Var	0.0734	0.0734	0.0734	0.0734	0.0734	0.0734	0.0734	0.0735	0.0735	0.0729
Panel B: Worldwide Patent Office - Green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 GREENCOUNTWW/100	0.324***	0.411***	0.112*	0.451**	0.209***	−0.190***	0.059	−1.495***	−0.052	0.196**
	(0.107)	(0.096)	(0.065)	(0.216)	(0.046)	(0.065)	(0.060)	(0.395)	(0.093)	(0.089)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.946	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. Dev. Dep Var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. Dev. Patent Var	0.0716	0.0716	0.0716	0.0716	0.0716	0.0716	0.0716	0.0716	0.0716	0.0709
Panel C: European Patent Office - Green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 GREENCOUNTEP/100	−0.079	0.083	0.343***	−0.832**	−0.013	−0.437***	0.267***	−0.744	0.236*	0.285*
	(0.211)	(0.194)	(0.121)	(0.412)	(0.095)	(0.140)	(0.086)	(0.737)	(0.137)	(0.164)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. Dev. Dep Var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. Dev. Patent Var	0.0407	0.0407	0.0407	0.0407	0.0407	0.0407	0.0407	0.0407	0.0407	0.0409
Panel D: European Patent Office - Green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 GREENCOUNTEP/100	0.202	0.180	0.213	0.076	0.091	−0.101	0.094	−1.577*	−0.158	0.105
	(0.225)	(0.206)	(0.133)	(0.361)	(0.094)	(0.137)	(0.120)	(0.806)	(0.178)	(0.188)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. Dev. Dep Var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. Dev. Patent Var	0.0398	0.0398	0.0398	0.0398	0.0398	0.0398	0.0398	0.0398	0.0398	0.0401
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XIV: JEVONS PARADOX ON SLOPE OF CHANGES - GREEN INNOVATION

The unit of observation is firm-year. The dependent variables are S1TOTCHG, S2TOTCHG, S3TOTCHG, S1INTCHG, S2INTCHG, S3INTCHG, PPECHG, INVEST/A CHG, CAPEXCHG CASHCHG, and SALESCHG. *S1TOTCHG* (*S2TOTCHG* and *S3TOTCHG*) is the log change of firm-level scope 1 (2 and 3) emissions; *S1INTCHG* (*S2INTCHG* and *S3INTCHG*) is the log change in firm-level scope 1 (2 and 3) emission intensity defined as the level of emission divided by the firm sales; *PPECHG* is the log change of plant, property & equipment (in $ million); *INVEST/ACHG* is the log change of CAPEX divided by the book value of assets; CAPEXCHG is the log change of capital expenditures; CASHCHG is the log change of cash and short-term equivalents. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is *GREENRATIOWW* in Panel A and B and *GREENRATIOEP* in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are *LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI*. All variables are defined in 5. The model is estimated using pooled regression model. All regression inlcude country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - General Efficiency innovation - lag 1										
	S1TOTCHG	S2TOTCHG	S3TOTCHG	S1INTCHG	S2INTCHG	S3INTCHG	PPECHG	INVEST/A CHG	CAPEXCHG	CASHCHG
L1 Green Ratio WW	−0.007	−0.032	−0.013	0.008	−0.018	0.003	−0.015	−0.042*	−0.032	−0.008
	(0.024)	(0.028)	(0.016)	(0.019)	(0.022)	(0.007)	(0.012)	(0.022)	(0.021)	(0.020)
Observations	50843	50870	50899	50900	50900	50900	57807	57539	57539	56212
R2	0.173	0.182	0.261	0.133	0.132	0.290	0.386	0.292	0.260	0.142
Std. dev. dep var	0.563	0.520	0.346	0.454	0.393	0.131	0.356	0.620	0.567	0.454
Std. dev. patent ratio	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.177
Eco sig patent ratio	0.00226	0.0110	0.00639	0.00302	0.00793	0.00426	0.00751	0.0120	0.0101	0.00328
Panel B: Worldwide Patent Office - General Efficiency innovation - lag 3										
	S1TOTCHG	S2TOTCHG	S3TOTCHG	S1INTCHG	S2INTCHG	S3INTCHG	PPECHG	INVEST/A CHG	CAPEXCHG	CASHCHG
L3 Green Ratio WW	0.058**	−0.014	0.018	0.048**	−0.019	0.000	0.003	−0.008	0.010	−0.001
	(0.027)	(0.029)	(0.017)	(0.022)	(0.024)	(0.007)	(0.013)	(0.027)	(0.025)	(0.022)
Observations	45328	45352	45377	45379	45379	45379	49599	49375	49375	48280
R2	0.178	0.186	0.260	0.143	0.130	0.291	0.277	0.141	0.169	0.165
Std. dev. dep var	0.556	0.499	0.333	0.455	0.384	0.130	0.354	0.619	0.567	0.412
Std. dev. patent ratio	0.172	0.172	0.172	0.172	0.172	0.172	0.173	0.172	0.172	0.174
Eco sig patent ratio	0.0180	0.00495	0.00946	0.0183	0.00841	0.000600	0.00144	0.00221	0.00307	0.000309
Panel C: European Patent Office - General Efficiency innovation - lag 1										
	S1TOTCHG	S2TOTCHG	S3TOTCHG	S1INTCHG	S2INTCHG	S3INTCHG	PPECHG	INVEST/A CHG	CAPEXCHG	CASHCHG
L1 Green Ratio EP	−0.013	−0.045*	0.001	−0.004	−0.043**	0.008	−0.002	−0.004	−0.006	−0.006
	(0.024)	(0.024)	(0.015)	(0.019)	(0.019)	(0.006)	(0.011)	(0.018)	(0.016)	(0.013)
Observations	26588	26608	26616	26618	26618	26618	29522	29402	29402	29142
R2	0.159	0.171	0.234	0.122	0.118	0.285	0.376	0.314	0.271	0.184
Std. dev. dep var	0.558	0.506	0.355	0.457	0.385	0.132	0.327	0.524	0.453	0.394
Std. dev. patent ratio	0.234	0.234	0.234	0.234	0.234	0.234	0.235	0.235	0.235	0.236
Eco sig patent ratio	0.00548	0.0210	0.000706	0.00200	0.0259	0.0150	0.00158	0.00192	0.00327	0.00388
Panel D: European Patent Office - General Efficiency innovation - lag 3										
	S1TOTCHG	S2TOTCHG	S3TOTCHG	S1INTCHG	S2INTCHG	S3INTCHG	PPECHG	INVEST/A CHG	CAPEXCHG	CASHCHG
L3 Green Ratio EP	0.040	0.012	0.020	0.018	0.003	0.001	0.004	−0.043*	−0.002	0.013
	(0.026)	(0.026)	(0.016)	(0.022)	(0.022)	(0.006)	(0.013)	(0.026)	(0.023)	(0.014)
Observations	23754	23770	23783	23783	23783	23783	25162	25061	25061	24856
R2	0.158	0.171	0.243	0.118	0.113	0.283	0.297	0.152	0.193	0.177
Std. dev. dep var	0.544	0.488	0.339	0.454	0.382	0.130	0.325	0.523	0.450	0.353
Std. dev. patent ratio	0.230	0.230	0.230	0.230	0.230	0.230	0.232	0.232	0.232	0.232
Eco sig patent ratio	0.0170	0.00559	0.0135	0.00937	0.00188	0.00107	0.00276	0.0192	0.00104	0.00834
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XV: JEVONS PARADOX - GENERAL EFFICIENCY INNOVATION

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $GENERALEFFRATIOWW$ in Panel A and B and $GENERALEFFRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression inlcude country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Ratio WW	0.029	0.040*	0.004	−0.040	0.001	0.004	−0.006	−0.015	−0.009	0.013
	(0.021)	(0.021)	(0.011)	(0.054)	(0.008)	(0.010)	(0.013)	(0.084)	(0.020)	(0.021)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. dev. dep var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. dev. patent ratio	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.189
Eco sig patent ratio	0.00210	0.00361	0.000332	0.00159	0.000391	0.000507	0.000549	0.000719	0.000907	0.00138
Panel B: Worldwide Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Ratio WW	−0.049**	0.010	−0.016	−0.030	0.013	0.011	−0.029	−0.156*	−0.068***	−0.035
	(0.024)	(0.022)	(0.013)	(0.061)	(0.009)	(0.010)	(0.018)	(0.091)	(0.023)	(0.023)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.945	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. dev. dep var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. dev. patent ratio	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.185
Eco sig patent ratio	0.00355	0.000936	0.00141	0.00120	0.00441	0.00131	0.00260	0.00757	0.00657	0.00368
Panel C: European Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Ratio EP	−0.042*	−0.020	−0.002	−0.123**	−0.023**	−0.031**	−0.000	0.106	0.020	0.038
	(0.025)	(0.024)	(0.013)	(0.055)	(0.010)	(0.014)	(0.011)	(0.089)	(0.021)	(0.024)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. dev. dep var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. dev. patent ratio	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.204
Eco sig patent ratio	0.00325	0.00189	0.000217	0.00642	0.00858	0.00388	0.00000572	0.00587	0.00215	0.00450
Panel D: European Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Ratio EP	−0.057**	0.010	0.005	−0.086	−0.001	0.002	−0.017	0.043	−0.012	0.011
	(0.027)	(0.024)	(0.015)	(0.060)	(0.011)	(0.015)	(0.016)	(0.100)	(0.024)	(0.025)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. dev. dep var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. dev. patent ratio	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.202
Eco sig patent ratio	0.00444	0.000980	0.000422	0.00450	0.000537	0.000294	0.00168	0.00245	0.00120	0.00131
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XVI: JEVONS PARADOX - OECD ENV-TECH INNOVATION

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $OECDRATIOWW$ in Panel A and B and $OECDRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - OECD env-tech innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 OECD Green Ratio WW	0.015	0.037	−0.031**	−0.056	0.013	−0.022	−0.010	−0.069	−0.008	0.011
	(0.023)	(0.026)	(0.013)	(0.076)	(0.011)	(0.015)	(0.012)	(0.095)	(0.018)	(0.022)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. dev. dep var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. dev. patent ratio	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.186
Eco sig patent ratio	0.00101	0.00318	0.00266	0.00208	0.00436	0.00241	0.000848	0.00304	0.000718	0.00122
Panel B: Worldwide Patent Office - OECD env-tech innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 OECD Green Ratio WW	−0.010	−0.013	−0.036***	0.043	0.008	−0.002	−0.022	−0.091	−0.012	−0.024
	(0.025)	(0.026)	(0.014)	(0.078)	(0.012)	(0.014)	(0.016)	(0.100)	(0.021)	(0.022)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.945	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. dev. dep var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. dev. patent ratio	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.185
Eco sig patent ratio	0.000721	0.00112	0.00307	0.00160	0.00251	0.000167	0.00187	0.00418	0.00110	0.00254
Panel C: European Patent Office - OECD env-tech innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 OECD Green Ratio EP	0.025	−0.001	0.008	−0.068	−0.014	−0.005	0.005	−0.003	−0.000	−0.004
	(0.025)	(0.024)	(0.014)	(0.067)	(0.010)	(0.017)	(0.010)	(0.093)	(0.018)	(0.021)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. dev. dep var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. dev. patent ratio	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.237	0.238
Eco sig patent ratio	0.00227	0.0000945	0.000792	0.00407	0.00583	0.000752	0.000577	0.000176	0.0000414	0.000505
Panel D: European Patent Office - OECD env-tech innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 OECD Green Ratio EP	−0.012	−0.061**	−0.013	−0.005	−0.016	−0.016	0.002	−0.125	−0.011	−0.031
	(0.025)	(0.025)	(0.016)	(0.070)	(0.011)	(0.017)	(0.016)	(0.102)	(0.022)	(0.023)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. dev. dep var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. dev. patent ratio	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238
Eco sig patent ratio	0.00107	0.00661	0.00140	0.000286	0.00672	0.00236	0.000183	0.00820	0.00130	0.00416
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XVII: JEVONS PARADOX - GREEN INNOVATION (CITATION RATIO)

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $GREENCITRATIOWW$ in Panel A and B and $GREENCITRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Cit Ratio WW	−0.011	0.011	−0.016	−0.042	0.011	−0.008	−0.009	−0.184**	−0.006	−0.004
	(0.021)	(0.023)	(0.013)	(0.058)	(0.009)	(0.015)	(0.010)	(0.089)	(0.017)	(0.019)
Observations	52299	52299	52299	52299	52299	52299	52299	52278	52278	50437
R2	0.955	0.942	0.977	0.936	0.837	0.965	0.985	0.719	0.944	0.924
Std. dev. dep var	2.667	2.148	2.173	4.830	0.553	1.706	2.108	4.140	1.974	1.724
Std. dev. pat. cit. ratio	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.215
Eco sig pat. cit. ratio	0.000897	0.00113	0.00155	0.00186	0.00440	0.00105	0.000948	0.00944	0.000662	0.000438
Panel B: Worldwide Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Cit Ratio WW	0.008	0.010	−0.010	0.052	0.005	−0.004	−0.007	−0.079	0.008	0.006
	(0.022)	(0.024)	(0.014)	(0.064)	(0.010)	(0.014)	(0.015)	(0.095)	(0.020)	(0.021)
Observations	45764	45764	45764	45764	45764	45764	45764	45751	45751	44212
R2	0.957	0.946	0.975	0.939	0.855	0.970	0.975	0.691	0.937	0.928
Std. dev. dep var	2.654	2.154	2.163	4.776	0.562	1.681	2.116	3.981	1.996	1.742
Std. dev. pat. cit. ratio	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.210	0.211
Eco sig pat. cit. ratio	0.000619	0.000926	0.000988	0.00230	0.00199	0.000552	0.000735	0.00416	0.000850	0.000706
Panel C: European Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Cit Ratio EP	0.034	0.003	0.017	−0.025	−0.004	−0.005	0.007	−0.185**	−0.015	−0.011
	(0.024)	(0.022)	(0.014)	(0.058)	(0.009)	(0.014)	(0.010)	(0.082)	(0.016)	(0.019)
Observations	28152	28152	28152	28152	28152	28152	28152	28145	28145	27633
R2	0.953	0.947	0.977	0.923	0.842	0.960	0.987	0.726	0.957	0.925
Std. dev. dep var	2.656	2.190	2.243	3.973	0.559	1.636	2.108	3.706	1.955	1.733
Std. dev. pat. cit. ratio	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.261
Eco sig pat. cit. ratio	0.00337	0.000408	0.00201	0.00161	0.00206	0.000729	0.000863	0.0130	0.00200	0.00160
Panel D: European Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Cit Ratio EP	0.011	0.006	0.017	0.054	−0.000	0.004	0.021	−0.274***	−0.021	−0.010
	(0.024)	(0.024)	(0.015)	(0.060)	(0.010)	(0.015)	(0.015)	(0.093)	(0.019)	(0.020)
Observations	24338	24338	24338	24338	24338	24338	24338	24333	24333	23914
R2	0.956	0.949	0.976	0.932	0.861	0.967	0.978	0.694	0.948	0.931
Std. dev. dep var	2.653	2.197	2.232	3.896	0.569	1.593	2.122	3.602	1.974	1.749
Std. dev. pat. cit. ratio	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.259
Eco sig pat. cit. ratio	0.00105	0.000693	0.00191	0.00354	0.000161	0.000577	0.00259	0.0196	0.00268	0.00143
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XVIII: JEVONS PARADOX - BROWN EFFICIENCY INNOVATION (CITATION RATIO)

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $BROWNEFFCITRATIOWW$ in Panel A and B and $BROWNEFFCITRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Cit Ratio WW	0.074**	−0.066	−0.001	0.090	−0.028*	−0.000	0.011	−0.044	0.011	−0.016
	(0.036)	(0.043)	(0.018)	(0.123)	(0.017)	(0.024)	(0.015)	(0.145)	(0.028)	(0.037)
Observations	52299	52299	52299	52299	52299	52299	52299	52278	52278	50437
R2	0.955	0.942	0.977	0.936	0.837	0.965	0.985	0.719	0.944	0.924
Std. dev. dep var	2.667	2.148	2.173	4.830	0.553	1.706	2.108	4.140	1.974	1.724
Std. dev. pat. cit. ratio	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.110
Eco sig pat. cit. ratio	0.00302	0.00337	0.0000658	0.00204	0.00549	0.0000244	0.000555	0.00116	0.000633	0.000987
Panel B: Worldwide Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Cit Ratio WW	0.010	−0.070	−0.054**	0.203	−0.004	0.000	−0.018	0.056	−0.015	−0.052
	(0.042)	(0.046)	(0.022)	(0.149)	(0.017)	(0.023)	(0.023)	(0.171)	(0.036)	(0.039)
Observations	45764	45764	45764	45764	45764	45764	45764	45751	45751	44212
R2	0.957	0.946	0.975	0.940	0.855	0.970	0.975	0.691	0.937	0.928
Std. dev. dep var	2.654	2.154	2.163	4.776	0.562	1.681	2.116	3.981	1.996	1.742
Std. dev. pat. cit. ratio	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
Eco sig pat. cit. ratio	0.000381	0.00343	0.00265	0.00451	0.000723	0.00000212	0.000904	0.00148	0.000815	0.00320
Panel C: European Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Cit Ratio EP	0.067*	−0.020	−0.002	0.133	0.003	−0.012	0.002	0.022	0.009	−0.007
	(0.037)	(0.036)	(0.017)	(0.117)	(0.013)	(0.024)	(0.015)	(0.130)	(0.027)	(0.037)
Observations	28152	28152	28152	28152	28152	28152	28152	28145	28145	27633
R2	0.953	0.947	0.977	0.923	0.842	0.960	0.987	0.726	0.957	0.925
Std. dev. dep var	2.656	2.190	2.243	3.973	0.559	1.636	2.108	3.706	1.955	1.733
Std. dev. pat. cit. ratio	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.142
Eco sig pat. cit. ratio	0.00356	0.00128	0.000111	0.00472	0.000654	0.00105	0.000148	0.000832	0.000671	0.000575
Panel D: European Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Cit Ratio EP	0.036	−0.015	−0.011	−0.057	−0.010	−0.009	0.002	−0.034	−0.006	0.011
	(0.037)	(0.040)	(0.021)	(0.124)	(0.013)	(0.024)	(0.021)	(0.139)	(0.033)	(0.036)
Observations	24338	24338	24338	24338	24338	24338	24338	24333	24333	23914
R2	0.956	0.949	0.976	0.932	0.861	0.967	0.978	0.693	0.948	0.931
Std. dev. dep var	2.653	2.197	2.232	3.896	0.569	1.593	2.122	3.602	1.974	1.749
Std. dev. pat. cit. ratio	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141
Eco sig pat. cit. ratio	0.00192	0.000991	0.000691	0.00204	0.00254	0.000836	0.000103	0.00133	0.000405	0.000902
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is *GENERALEFFCITRATIOWW* in Panel A and B and *GENERALEFFCITRATIOEP* in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are *LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI*. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Cit Ratio WW	0.015	0.018	0.003	−0.026	−0.006	0.002	0.001	0.005	−0.020	0.016
	(0.018)	(0.018)	(0.009)	(0.043)	(0.007)	(0.010)	(0.010)	(0.065)	(0.016)	(0.018)
Observations	52299	52299	52299	52299	52299	52299	52299	52278	52278	50437
R2	0.955	0.942	0.977	0.936	0.837	0.965	0.985	0.719	0.944	0.924
Std. dev. dep var	2.667	2.148	2.173	4.830	0.553	1.706	2.108	4.140	1.974	1.724
Std. dev. pat. cit. ratio	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.225	0.217
Eco sig pat. cit. ratio	0.00127	0.00192	0.000338	0.00122	0.00253	0.000200	0.0000894	0.000276	0.00232	0.00200
Panel B: Worldwide Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Cit Ratio WW	−0.035*	0.016	−0.014	−0.003	0.012	0.017*	−0.022	−0.063	−0.050***	−0.019
	(0.020)	(0.019)	(0.011)	(0.049)	(0.008)	(0.010)	(0.015)	(0.076)	(0.018)	(0.020)
Observations	45764	45764	45764	45764	45764	45764	45764	45751	45751	44212
R2	0.957	0.946	0.975	0.939	0.855	0.970	0.975	0.691	0.937	0.928
Std. dev. dep var	2.654	2.154	2.163	4.776	0.562	1.681	2.116	3.981	1.996	1.742
Std. dev. pat. cit. ratio	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.213
Eco sig pat. cit. ratio	0.00294	0.00162	0.00142	0.000154	0.00469	0.00225	0.00233	0.00353	0.00558	0.00235
Panel C: European Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Cit Ratio EP	−0.061***	−0.038*	0.001	−0.093*	−0.031***	−0.022*	−0.002	0.083	0.024	0.037*
	(0.024)	(0.021)	(0.012)	(0.053)	(0.008)	(0.013)	(0.010)	(0.075)	(0.017)	(0.020)
Observations	28152	28152	28152	28152	28152	28152	28152	28145	28145	27633
R2	0.953	0.947	0.977	0.923	0.842	0.960	0.987	0.726	0.957	0.925
Std. dev. dep var	2.656	2.190	2.243	3.973	0.559	1.636	2.108	3.706	1.955	1.733
Std. dev. pat. cit. ratio	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.229	0.225
Eco sig pat. cit. ratio	0.00529	0.00399	0.0000604	0.00535	0.0128	0.00311	0.000164	0.00513	0.00285	0.00483
Panel D: European Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1 Intensity	S2 Intensity	S3 Intensity	Log (PPE)	Inv/Assets		
L3 Gen Eff Cit Ratio EP	−0.046*	0.004	0.007	−0.045	−0.001	0.014	−0.019	−0.076	−0.024	0.001
	(0.024)	(0.021)	(0.013)	(0.050)	(0.009)	(0.012)	(0.016)	(0.088)	(0.020)	(0.022)
Observations	24338	24338	24338	24338	24338	24338	24338	24333	24333	23914
R2	0.956	0.949	0.976	0.932	0.861	0.967	0.978	0.693	0.948	0.931
Std. dev. dep var	2.653	2.197	2.232	3.896	0.569	1.593	2.122	3.602	1.974	1.749
Std. dev. pat. cit. ratio	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.224
Eco sig pat. cit. ratio	0.00396	0.000375	0.000681	0.00264	0.000210	0.00206	0.00205	0.00480	0.00274	0.000121
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XX: JEVONS PARADOX - GREEN INNOVATION (TOP QUINTILE)

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is *GREENRATIOWW* in Panel A and B and *GREENRATIOEP* in Panel C and D. The sample period is 2005 to 2020. The sample restricts inclusion to firms in the top quintile by *GREENRATIOWW* calculated for 5 year intervals in Panel A and B, respectively *GREENRATIOEP*. Controls included with the same lag are *LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI*. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Ratio WW	−0.034	−0.004	−0.033*	−0.163*	0.007	−0.005	−0.012	0.026	0.009	−0.023
	(0.026)	(0.029)	(0.017)	(0.093)	(0.012)	(0.017)	(0.013)	(0.124)	(0.021)	(0.024)
Observations	12005	12005	12004	12005	12005	12005	12005	11995	11995	11747
R2	0.972	0.948	0.981	0.944	0.876	0.955	0.988	0.714	0.963	0.936
Std. dev. dep var	3.103	2.394	2.437	6.448	0.658	1.622	2.349	4.244	2.169	1.843
Std. dev. patent ratio	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292
Eco sig patent ratio	0.00319	0.000492	0.00393	0.00738	0.00324	0.000830	0.00152	0.00180	0.00115	0.00372
Panel B: Worldwide Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Ratio WW	0.021	0.035	0.010	0.056	0.026*	0.007	0.031*	0.047	0.045*	0.019
	(0.028)	(0.032)	(0.020)	(0.095)	(0.014)	(0.018)	(0.018)	(0.129)	(0.025)	(0.026)
Observations	10095	10095	10095	10095	10095	10095	10095	10090	10090	9853
R2	0.975	0.951	0.980	0.951	0.883	0.958	0.982	0.691	0.954	0.939
Std. dev. dep var	3.122	2.405	2.417	6.406	0.666	1.591	2.374	4.045	2.196	1.867
Std. dev. patent ratio	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.289	0.289
Eco sig patent ratio	0.00196	0.00417	0.00114	0.00255	0.0111	0.00120	0.00378	0.00339	0.00589	0.00293
Panel C: European Patent Office - green innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Green Ratio EP	0.010	0.001	0.015	0.028	−0.018	0.019	0.021	0.028	0.021	−0.033
	(0.034)	(0.035)	(0.024)	(0.087)	(0.014)	(0.024)	(0.017)	(0.159)	(0.017)	(0.030)
Observations	4850	4850	4849	4850	4850	4850	4850	4850	4850	4805
R2	0.976	0.957	0.981	0.962	0.886	0.956	0.990	0.677	0.990	0.941
Std. dev. dep var	3.272	2.499	2.596	6.479	0.701	1.586	2.424	3.863	2.424	1.843
Std. dev. patent ratio	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346	0.346
Eco sig patent ratio	0.00109	0.000163	0.00205	0.00148	0.00912	0.00407	0.00306	0.00248	0.00306	0.00611
Panel D: European Patent Office - green innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Green Ratio EP	−0.015	−0.016	0.034	−0.050	−0.007	0.011	−0.008	−0.175	−0.005	−0.030
	(0.029)	(0.036)	(0.024)	(0.098)	(0.015)	(0.026)	(0.021)	(0.166)	(0.029)	(0.032)
Observations	4049	4049	4049	4049	4049	4049	4049	4049	4049	4015
R2	0.981	0.962	0.983	0.962	0.906	0.955	0.987	0.660	0.966	0.945
Std. dev. dep var	3.278	2.498	2.592	6.500	0.704	1.568	2.457	3.618	2.237	1.877
Std. dev. patent ratio	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345	0.345
Eco sig patent ratio	0.00162	0.00222	0.00457	0.00263	0.00365	0.00242	0.00116	0.0167	0.000815	0.00550
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XXI: JEVONS PARADOX - BROWN EFFICIENCY INNOVATION (TOP QUINTILE)

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $BROWNEFFRATIOWW$ in Panel A and B and $BROWNEFFRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. The sample restricts inclusion to firms in the top quintile by $BROWNEFFRATIOWW$ calculated for 5 year intervals in Panel A and B, respectively $BROWNEFFRATIOEP$. Controls included with the same lag are $LOGSIZE$, $LOGPPE$, $LEVERAGE$, ROE, M/B, $INVEST/A$, $BETA$, $VOLAT$, MOM, RET, $MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio}/StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Ratio WW	−0.018	−0.036	−0.030	−0.088	−0.006	−0.036	−0.029	−0.028	−0.042	0.050
	(0.036)	(0.046)	(0.021)	(0.138)	(0.015)	(0.027)	(0.021)	(0.179)	(0.035)	(0.046)
Observations	12722	12722	12722	12722	12722	12722	12722	12721	12721	12044
R2	0.971	0.935	0.979	0.949	0.878	0.956	0.985	0.759	0.947	0.924
Std. dev. dep var	2.888	2.100	1.928	7.006	0.645	1.725	2.022	3.864	1.985	1.756
Std. dev. patent ratio	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.176
Eco sig patent ratio	0.00107	0.00298	0.00272	0.00219	0.00155	0.00362	0.00249	0.00126	0.00367	0.00502
Panel B: Worldwide Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Ratio WW	−0.017	0.005	−0.019	−0.008	−0.006	−0.011	−0.034	0.216	0.015	0.024
	(0.042)	(0.046)	(0.024)	(0.146)	(0.016)	(0.024)	(0.026)	(0.226)	(0.039)	(0.043)
Observations	10452	10452	10452	10452	10452	10452	10452	10451	10451	9906
R2	0.972	0.941	0.979	0.950	0.886	0.960	0.977	0.729	0.945	0.932
Std. dev. dep var	2.894	2.118	1.950	6.581	0.632	1.671	2.065	3.681	2.032	1.778
Std. dev. patent ratio	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.178	0.179
Eco sig patent ratio	0.00101	0.000430	0.00174	0.000225	0.00164	0.00114	0.00291	0.0104	0.00132	0.00243
Panel C: European Patent Office - Brown Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Brown Eff Ratio EP	0.017	−0.021	−0.011	−0.025	0.014	0.014	−0.004	0.036	−0.007	0.003
	(0.040)	(0.039)	(0.019)	(0.127)	(0.012)	(0.024)	(0.019)	(0.153)	(0.031)	(0.040)
Observations	5964	5964	5964	5964	5964	5964	5964	5964	5964	5856
R2	0.971	0.941	0.979	0.941	0.885	0.957	0.986	0.799	0.964	0.930
Std. dev. dep var	2.780	2.052	1.842	6.140	0.676	1.581	2.009	3.409	1.970	1.775
Std. dev. patent ratio	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238
Eco sig patent ratio	0.00143	0.00248	0.00145	0.000977	0.00501	0.00217	0.000448	0.00253	0.000888	0.000407
Panel D: European Patent Office - Brown Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Brown Eff Ratio EP	0.023	0.035	−0.009	−0.043	0.013	−0.005	−0.007	−0.008	0.001	−0.009
	(0.041)	(0.043)	(0.022)	(0.145)	(0.012)	(0.029)	(0.025)	(0.170)	(0.037)	(0.038)
Observations	4929	4929	4929	4929	4929	4929	4929	4929	4929	4831
R2	0.975	0.948	0.979	0.950	0.919	0.964	0.977	0.743	0.956	0.939
Std. dev. dep var	2.795	2.065	1.827	6.120	0.686	1.546	2.016	3.336	2.002	1.780
Std. dev. patent ratio	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241	0.241
Eco sig patent ratio	0.00198	0.00412	0.00114	0.00171	0.00461	0.000785	0.000887	0.000593	0.0000810	0.00117
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XXII: Jevons Paradox - general efficiency innovation (top quintile)

The unit of observation is firm-year. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $GENERALEFFRATIOWW$ in Panel A and B and $GENERALEFFRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. The sample restricts inclusion to firms in the top quintile by $GENERALEFFRATIOWW$ calculated for 5 year intervals in Panel A and B, respectively $GENERALEFFRATIOEP$. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression inlcude country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Ratio WW	0.035	0.026	−0.009	−0.019	0.005	−0.002	−0.011	−0.014	−0.019	−0.003
	(0.023)	(0.022)	(0.011)	(0.057)	(0.008)	(0.010)	(0.014)	(0.088)	(0.022)	(0.023)
Observations	12010	12010	12010	12010	12010	12010	12010	12000	12000	10943
R2	0.959	0.945	0.979	0.931	0.888	0.968	0.979	0.771	0.943	0.926
Std. dev. dep var	2.694	2.139	1.993	4.625	0.599	1.613	2.196	4.299	2.025	1.784
Std. dev. patent ratio	0.328	0.328	0.328	0.328	0.328	0.328	0.328	0.327	0.327	0.321
Eco sig patent ratio	0.00428	0.00395	0.00156	0.00134	0.00266	0.000403	0.00171	0.00103	0.00311	0.000575
Panel B: Worldwide Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Ratio WW	−0.058**	0.006	−0.017	−0.057	0.008	−0.005	−0.013	−0.119	−0.053**	−0.050**
	(0.024)	(0.022)	(0.013)	(0.055)	(0.008)	(0.011)	(0.020)	(0.097)	(0.025)	(0.025)
Observations	9869	9869	9869	9869	9869	9869	9869	9866	9866	9008
R2	0.967	0.953	0.980	0.943	0.905	0.977	0.974	0.755	0.942	0.930
Std. dev. dep var	2.720	2.166	1.993	4.602	0.615	1.632	2.201	4.110	2.048	1.797
Std. dev. patent ratio	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.329	0.321
Eco sig patent ratio	0.00702	0.000894	0.00283	0.00410	0.00423	0.000927	0.00189	0.00953	0.00845	0.00887
Panel C: European Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Ratio EP	−0.022	−0.015	−0.012	0.015	−0.026**	−0.043**	0.016	0.143	0.048*	0.048
	(0.032)	(0.030)	(0.019)	(0.068)	(0.012)	(0.021)	(0.016)	(0.115)	(0.025)	(0.032)
Observations	3942	3942	3942	3942	3942	3942	3942	3940	3940	3786
R2	0.965	0.953	0.984	0.946	0.890	0.962	0.987	0.812	0.959	0.942
Std. dev. dep var	2.737	2.154	1.933	3.985	0.639	1.602	2.165	4.002	2.001	1.805
Std. dev. patent ratio	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.347
Eco sig patent ratio	0.00277	0.00246	0.00217	0.00131	0.0141	0.00939	0.00260	0.0125	0.00835	0.00931
Panel D: European Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Ratio EP	−0.012	−0.005	0.012	0.024	−0.017	0.000	0.004	0.125	−0.002	−0.003
	(0.035)	(0.031)	(0.020)	(0.063)	(0.013)	(0.018)	(0.023)	(0.128)	(0.028)	(0.035)
Observations	3181	3181	3181	3181	3181	3181	3181	3181	3181	3056
R2	0.970	0.957	0.983	0.959	0.907	0.970	0.982	0.806	0.958	0.945
Std. dev. dep var	2.799	2.210	1.957	4.236	0.671	1.613	2.168	3.868	2.000	1.840
Std. dev. patent ratio	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.351	0.348
Eco sig patent ratio	0.00153	0.000782	0.00208	0.00202	0.00907	0.0000110	0.000671	0.0113	0.000406	0.000569
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TABLE A.XXIII: JEVONS PARADOX - GENERAL EFFICIENCY INNOVATION (INTENSIVE MARGIN)

The unit of observation is firm-year. All firm-year observations with at least one general efficiency patent are included. The dependent variables are LOGS1TOT, LOGS2TOT, LOGS3TOT, S1INT, S2INT, S3INT, LOGPPE, INVEST/A, LOGCAPEX and LOGCASH. In Panel A and C, the independent variables are lagged by one year. In Panel B and D, the independent variables are lagged by three years. The key explanatory variables of interest is $GENERALEFFRATIOWW$ in Panel A and B and $GENERALEFFRATIOEP$ in Panel C and D. The sample period is 2005 to 2020. Controls included with the same lag are $LOGSIZE, LOGPPE, LEVERAGE, ROE, M/B, INVEST/A, BETA, VOLAT, MOM, RET, MSCI$. All variables are defined in 5. The model is estimated using pooled regression model. All regression include country, year, and firm fixed effects. We cluster standard errors at the firm and year dimension. We report the standard deviation of the dependent variable as well as of the patent ratio and the economic significance of a one standard deviation change in the patent ratio (Eco sig patent ratio), calculated as $|Coef_{patentratio} * StdDev_{patentratio} / StdDev_{dep.var.}|$. *** 1% significance, ** 5% significance * 10% significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Worldwide Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Ratio WW	0.029	0.040*	0.004	−0.040	0.001	0.004	−0.006	−0.015	−0.009	0.013
	(0.021)	(0.021)	(0.011)	(0.054)	(0.008)	(0.010)	(0.013)	(0.084)	(0.020)	(0.021)
Observations	58004	58004	58003	58004	58004	58004	58004	57981	57981	55952
R2	0.955	0.941	0.977	0.934	0.837	0.966	0.984	0.708	0.943	0.924
Std. dev. dep var	2.688	2.157	2.182	4.987	0.557	1.724	2.126	4.203	1.986	1.735
Std. dev. patent ratio	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.189
Eco sig patent ratio	0.00210	0.00361	0.000332	0.00159	0.000391	0.000507	0.000549	0.000719	0.000907	0.00138
Panel B: Worldwide Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Ratio WW	−0.049**	0.010	−0.016	−0.030	0.013	0.011	−0.029	−0.156*	−0.068***	−0.035
	(0.024)	(0.022)	(0.013)	(0.061)	(0.009)	(0.010)	(0.018)	(0.091)	(0.023)	(0.023)
Observations	49774	49774	49772	49774	49774	49774	49774	49757	49757	48076
R2	0.958	0.945	0.975	0.940	0.855	0.971	0.974	0.683	0.936	0.927
Std. dev. dep var	2.675	2.160	2.167	4.924	0.566	1.695	2.130	4.019	2.003	1.752
Std. dev. patent ratio	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.185
Eco sig patent ratio	0.00355	0.000936	0.00141	0.00120	0.00441	0.00131	0.00260	0.00757	0.00657	0.00368
Panel C: European Patent Office - General Efficiency innovation - lag 1										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L1 Gen Eff Ratio EP	−0.042*	−0.020	−0.002	−0.123**	−0.023**	−0.031**	−0.000	0.106	0.020	0.038
	(0.025)	(0.024)	(0.013)	(0.055)	(0.010)	(0.014)	(0.011)	(0.089)	(0.021)	(0.024)
Observations	29587	29587	29586	29587	29587	29587	29587	29580	29580	29025
R2	0.953	0.948	0.978	0.922	0.843	0.961	0.987	0.720	0.956	0.926
Std. dev. dep var	2.667	2.205	2.268	3.995	0.561	1.645	2.127	3.743	1.967	1.743
Std. dev. patent ratio	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.204
Eco sig patent ratio	0.00325	0.00189	0.000217	0.00642	0.00858	0.00388	0.00000572	0.00587	0.00215	0.00450
Panel D: European Patent Office - General Efficiency innovation - lag 3										
	LOGS1TOT	LOGS2TOT	LOGS3TOT	S1INT	S2INT	S3INT	LOGPPE	INVEST/A	LOGCAPEX	LOGCASH
L3 Gen Eff Ratio EP	−0.057**	0.010	0.005	−0.086	−0.001	0.002	−0.017	0.043	−0.012	0.011
	(0.027)	(0.024)	(0.015)	(0.060)	(0.011)	(0.015)	(0.016)	(0.100)	(0.024)	(0.025)
Observations	25217	25217	25217	25217	25217	25217	25217	25212	25212	24764
R2	0.956	0.950	0.976	0.933	0.861	0.967	0.978	0.692	0.947	0.931
Std. dev. dep var	2.661	2.205	2.241	3.923	0.569	1.600	2.134	3.615	1.980	1.757
Std. dev. patent ratio	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.202
Eco sig patent ratio	0.00444	0.000980	0.000422	0.00450	0.000537	0.000294	0.00168	0.00245	0.00120	0.00131
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm F.E.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes