Green Revenues*

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[PRELIMINARY AND INCOMPLETE]

Abstract

Using a novel measure of a firm's green revenues, this paper sizes up the green economy. We shed light on the drivers behind global public firms increasing business activities that help with the transition to a low-carbon and more environmentally sustainable economy. Our analysis shows that the green economy grew at an accelerated pace after the Paris Agreement. This green shift is driven by innovative US firms converting green patents into actual revenues from green products and services. Additionally, we find that several regulatory initiatives have led to an acceleration in the growth of the green economy in Europe. While responsible institutional investors are more likely to be invested in firms with higher green revenues, we do not find their presence to be associated with the post-Paris shift. Finally, we examine the stock returns of firms with high green revenues and find only modest evidence of a green alpha which seems to be concentrated in US stocks in the post-Paris period.

Keywords: green revenues, sustainability, climate change, climate finance, green impact, ESG

JEL Classifications: G15, G18, G23, G30, Q55

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1 Introduction

The detrimental effects of climate change and, more generally, environmental degradation pose a major challenge for economies to become "greener", whereby businesses are asked to transition to models that are low-carbon, more resource-efficient, and overall more environmentally sustainable. Despite the adoption of the Paris Agreement in 2015, only a few sectors of the economy have achieved net-zero emissions, and the pace of emissions reduction remains insufficient to align with the climate objectives outlined in the Agreement. Furthermore, there is still a limited global roll out of carbon pricing schemes and difficulties to globally enforce policies that would result in the internalization of the social costs related to environmental externalities (Tirole, 2008).

In order to speed up the "greening" of their economies, some jurisdictions have introduced green classification systems – the highest-profile being the EU Taxonomy on Sustainable Finance (Regulation (EU) 2020/852 and from here referred to as the *EUTSF*).[1] At the core of the EUTSF are six environmental goals. Those are (1) climate change mitigation, (2) climate change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to a circular economy, (5) pollution prevention and control, and (6) protection and restoration of biodiversity and ecosystems. In its novel approach, the EUTSF considers an investment as "green" if it positively contributes to one of the goals without harming any of the other environmental objectives.

Notwithstanding policy makers' focus on greening the economy, it is challenging to assess how much progress corporations have made so far in transitioning existing activities to "greener" alternatives given technological and market constraints. It also remains unclear whether the shift towards green initiatives has provided profitable investment opportunities or has indeed incurred costs to shareholders. In this paper, we provide a comprehensive analysis of (i) the extent to which publicly-listed firms around the world are shifting to greener economic activities, (ii) the channels that contribute to the greening of business activities, and (iii) the financial consequences of firms transitioning to green

[1] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

business models.

The difficulty in answering these questions stems primarily from the lack of data measuring the extent to which companies are engaged in “green” economic activities and shifting away from “non-green” ones. While a common way of assessing the greenness of firms’ business activities has been to use ESG ratings (Pastor et al., 2022), this approach has received criticism from both academics (Berg et al., 2022) and policymakers[2] alike. Besides ESG ratings, studies have also employed measures of carbon emissions (Bolton and Kacperczyk, 2021, 2023; Aswani et al., 2024), yet, the main focus of these is often on Scope 1 and 2 emissions stemming from firms’ business operations, which usually do not capture the firms’ environmental impact of their products and services.

In this paper, we take a novel approach and use data that captures the extent to which firms sell products and services that contribute positively to the environment. For this purpose, we use the FTSE Russell Green Revenues data which–to the best of our knowledge–is one of, if not the first to provide comprehensive and detailed information on the scope to which firms generate revenues from green business activities. The data covers over 16,000 publicly-listed firms from 48 developed and emerging markets between 2008 and 2022, spanning a wide range of industries. The data provides an estimate of the proportion of the firm’s total revenue that come from green products, services, and economic activities. The classification is similar in structure to the more recently introduced EUTSF.

The majority of firms with green revenues sell both green and non-green products. For instance, Toyota Motor had 30% green revenues in 2022 coming primarily from its line of hybrid vehicles. However, there are also “pure plays” such as Tesla, for which FTSE Russell estimated that all its revenues that same year came from green sources. Specifically, the sale of electric vehicles (EVs) represented 93% of green revenues and the remaining 7% came from solar panels and power storage solutions. The example of Tesla helps to illustrate how the green revenues data differs from traditional ESG ratings where there has been lot of divergence on whether to measure the sustainability of a

[2] https://bit.ly/49J9bfU

firm by looking at the sustainability footprint of its operations (or conduct) versus its products.[3] We show that this finding of a low association between ESG ratings and green revenues is more general and goes beyond Tesla. The green revenues measure used in our study provides new information and has a weak correlation with either environmental scores issued by ESG rating providers or firm-level carbon emissions that have been more prominently studied in the academic literature to date (Bolton and Kacperczyk, 2021; Pastor et al., 2022).

We start our analysis by sizing the "green economy" which provides many interesting and novel insights. While the majority of public companies around the world still remain primarily engaged in non-green business activities, we document an acceleration of the shift to green in the period after the Paris Agreement entered into effect in 2016. The global percentage of green revenues was essentially flat at about 4% from 2008 until 2015 but then grew to 6.5% by 2022 (the end of our sample period). While this green revenue share calculated as green to total revenues may seem modest, it comprised close to 3,000 companies that generated green revenues (a fifth of the sample of firms). Translating the green revenue share to dollar revenues the aggregate green revenue share adds up to a total of USD $4 trillion. Interestingly, this puts the green economy at about the size of the oil and gas sector to which it is often compared[4]. Green economic activities are iversified across several industries with manufacturing being the largest, followed by utilities, but also comprises technology companies. Green revenues are generated all over the world: While the US, China, and Japan have the largest dollar aggregate green revenues, the highest green revenue exposure is observed in Europe where the green share exceeded 10% of aggregate company revenues in countries like France. This suggest that European companies are getting more aligned with their countries' net-zero goals.

In the second part of the paper we examine possible channels that facilitate the gen-

[3]Wall Street Journal, "Is Tesla or Exxon More Sustainable? It Depends Whom You Ask" (Sept. 17, 2018)."*Perhaps the biggest surprise is Tesla, ranked by MSCI at the top of the industry, and by FTSE as the worst carmaker globally on ESG issues. Sustainalytics puts it in the middle. (...) MSCI gives Tesla a near-perfect score for environment, because it has selected two themes as the most important for the car industry: the carbon produced by its products, and the opportunities the company has in clean technology. FTSE gives Tesla a "zero" on environment, because its scores ignore emissions from its cars, rating only emissions from its factories (...).*"

[4]IBISWorld, "Global Oil and Gas Exploration - Production Market Size 2005–2028".

eration of green revenues at the corporate level. For this purpose, we follow Seltzer et al. (2022), amongst other, and use the passage of the Paris Agreement as a shock to the global commitment to combat climate change and address environmental degradation more generally. Engle et al. (2020) lend credence to this choice showing that their climate change news index spikes around the Paris Agreement. Following the literature, the Paris Agreement not only made climate change a much more salient issue among many different economic players (e.g., regulators, investors, firms, or consumers), but the Agreement also raised expectations that more stringent environmental regulations would be imposed. For instance, article 2(c) of the Agreement called for "*...making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development*". Overall, we explore three economic channels that could facilitate the corporate shift to green: (1) the importance of corporate innovation to overcome technological limitations; (2) the role of public policies, particularly the regulatory push towards sustainable finance in Europe post Paris; and (3) the importance of the presence of (a) institutional shareholders and (b) their alignment with ESG initiatives.

Our analysis provides novel evidence that corporate innovation, in the form of green patents, has led to actual green revenues, particularly in the period after the Paris Agreement. We estimate that compared to firms that did not have a green patent prior to the Paris Agreement, firms with at least one green patent before the Agreement experienced an average increase of 2.2 percentage points in green revenues after the Agreement came into effect. The effect is economically meaningful and represents about 15% of the standard deviation of green revenues. Exploring regional variation, we find, however, that the conversion of green patents into environmental solutions is stronger for US companies where there was less policy support.[5] In fact, limiting the sample to European firms, we do not find a statistically significant relation between green patents and green revenues after the Paris Agreement.

The second channel we explore is related to public policy aimed at promoting greener

[5]Our study does not measure the impact of the subsequent government support programs such as the landmark 2022 US Inflation Reduction Act which might have produced effects only after the end of our sample period.

business activities. Interestingly, we find that the increase in green activities of companies based in Europe seems to be more related to the roll out of regulatory policies rather than to green innovative capacity. We examine post-Paris policy initiatives that enable the "European Green Deal" and focused on shifting capital to flow towards sustainable finance[6]. Specifically, we study the effects of the ambitious European Sustainable Finance regulatory agenda, which started with the creation of the High-level expert group on sustainable finance in 2016 and the publication of its first draft proposal in 2018[7]. We also examine the effects of the launch in 2020 of its cornerstone regulation, the EU taxonomy[8]. Depending on whether we focus on the period after the Paris Agreement, after the publication of the first Technical Expert Group (TEG) draft proposal, or the introduction of the EU Taxonomy regulation, we estimate treatment effects for European firms between 1.2 and 1.4 percentage points higher green revenues. These differential effects for European firms are economically significant and amount to about 10 percent of a standard deviation of green revenues, highlighting the important impact of regulatory efforts in promoting green revenues in the post-Paris Agreement era.

The last channel we explore is the role played by institutional investors in pushing firms to shift to green. Prior research documents that shareholder activism can be associated with increases in operating performance (Denes et al., 2017), and there has also been evidence of ESG-oriented activism by shareholders (Dimson et al., 2015, 2021). We first examine whether there is evidence of higher green revenues post-Paris in firms in which more institutional shareholders are present before the passage of the Agreement. The focus of institutional ownership pre-Paris intends to rule out that our results are driven by institutional investors' portfolio adjustments as a reaction to the Paris Agreement. Secondly, we test if institutional shareholders' ESG commitments play a role. We document that there is some association between stronger presence of institutional owners and the ramp up of green revenues post-Paris. We estimate that a standard deviation higher level of institutional ownership at the signing of the Paris Agreement is associ-

[6] https://bit.ly/4aagjBE
[7] https://bit.ly/3wRpTLC
[8] https://bit.ly/48MjdeR

ated with an about 0.7 percentage points higher green revenue share afterwards. Next, we focus on the role of responsible investors, which we measure by the extent to which the equity of the firm is held by signatories of the Principles for Responsible Investment (PRI) (Gibson Brandon et al., 2022). We do no find evidence that a stronger presence of PRI institutions is associated with more green revenues after the Paris Agreement. Our findings speak more broadly to the larger debate around the impact of engagement and exit strategies (Berk and Van Binsbergen, 2021; Edmans et al., 2022; Heath et al., 2023; Hartzmark and Shue, 2022; Becht et al., 2023).

A final question we try to answer in this study is what have been the financial returns of the corporate shift to green? Just because firms have commercialized green products and services this does not necessarily imply that these have a positive effect on a firm's profitability and generated a good return on the invested capital and firm resources to undertake the shift to green. Shifting towards sustainable business activities could be profit-driven if it creates, for example, new market opportunities for firms or green product differentiation can be passed through to costumers that have green preferences. This may be consistent with our evidence above that mostly general institutional ownership, and not ownership by ESG motivated shareholders, plays a role in the promotion of green revenues. However, it could also be the case that green products and services entail lower profit margins or higher capital investments such that there are net costs to shifting green and therefore a trade-off between the social benefits of environmental performance and stock performance. Interestingly, our estimations show that firms with lower ROA and higher CAPEX generate higher green revenues, consistent with there being upfront costs for firms to generate green revenues.

To understand the financial consequences of green revenues more generally, we focus our analysis on the stock market performance of firms with higher green revenues and replicate some of the FTSE Russell green revenues indices which show some outperformance in terms of raw returns. We document that there is no overall green "alpha" in our full sample period once we account for exposures to systematic asset pricing factors. However, there is some evidence of alpha for portfolios of green firms (i.e. those with high levels of green revenues) in the period after the Paris Agreement of heightened attention to climate concerns but, again, this result seems to be concentrated only in US stocks. We do not observe green alpha for European stocks. The green alpha for US firms is robust to controlling for the Pastor et al. (2022) green-minus-brown factor, suggesting that green revenues are not spanned by firms' environmental ratings. We conclude that the market favorably received the green transition by US companies, which had more flexibility to adopt green products voluntarily, as opposed to European firms, which were more compelled to act due to regulatory pressures.

Our study contributes to the finance literature examining the implications of climate change and environmental concerns. Prior studies have examined carbon emissions (Bolton and Kacperczyk, 2021, 2023; Ilhan et al., 2021; Aswani et al., 2024), industrial pollution (Hsu et al., 2023) or measures of environmental performance from ESG ratings (Pastor et al., 2022; Karolyi et al., 2023; Alves et al., 2023; Eskildsen et al., 2024). Most of these studies tend to use either the "E" component of ESG ratings or firms' carbon footprints based on Scope 1 and 2 emissions. These measures reflect firms' past environmental footprints based mostly on the operations or the conduct of the firms. In contrast, the green revenues measure we use in this paper is more forward-looking focusing on the "solution" or product side. In other words, our measure captures the extent to which the usage of firm's output is contributing to climate change or environmental degradation and and not the impact of the the production. In a sense, the green revenues captures how a firm is going to benefit commercially from a shift to a greener economy.

A second stream of literature to which our paper offers a contribution are studies examining green patents and R&D (Cohen et al., 2023; Hege et al., 2022; Bolton et al., 2022). In our paper, we take the extra step to examine whether (green) inventions convert to actual adoption of those technologies and firms actually achieve higher commercial revenues.

A third stream examines whether investors are willing to pay more for holding green securities. Pastor et al. (2021) and Zerbib (2022) shed light on mechanisms whereby environmental preferences can create a "taste" premium in green stocks. Heeb et al. (2023)

present experimental evidence suggesting that investors are willing to pay to be aligned with their sustainable preferences. Other studies demonstrate significant variability in greenium estimates across municipal and corporate bond markets. These estimates range from zero (Larcker and Watts, 2020), to relatively small (e.g., -8 bps in Caramichael and Rapp (2022), -6 bps in Baker et al. (2018), and -2 bps in Zerbib (2019)), to substantial, for instance, -63 bps in Colombage and Nanayakkara (2020)). Furthermore, Karpf and Mandel (2018) and Flammer (2021) elicit factors beyond environmental preferences that influence greenium estimates, such as issuance size, issuer creditworthiness and credibility, as well as noise in ESG ratings.

Finally, we also provide novel evidence on the impact of public policies that establish taxonomies for firms' sustainable activities in order to direct private capital into these activities. More recently, there have been several papers in the sustainable finance literature that have looked at the EU policy frameworks, for instance Hoepner et al. (2023), Sautner et al. (2022), Dai et al. (2023), Lambillon and Chesney (2023), or Scheitza and Busch (2024). While the EU taxonomy is only starting to be implemented, in our study we are able to test whether–in the past–firms started to shift towards taxonomy-aligned business activities, what drives these shifts, and how stock markets started to price the shift to green revenues.

2 Data and Variables

Our sample comprises publicly listed firms in FactSet Fundamentals with a minimum market capitalization of USD $100 million and domiciled in the 48 countries that are classified as developed or emerging markets by FTSE Russell for which we have data coverage for our main variable on green revenues (thus excluding companies from frontier and other markets). We get annual company financials and monthly stock prices from FactSet Fundamentals. The sample period stretches from 2008 to 2022 and the companies in our sample represent more than 90% of global total market capitalization.

2.1 Green Revenues

Our main variable of interest is *Green Revenues %* – i.e., the percentage of revenues a company derives from "green" products and services.[9] Our data source is FTSE Russell, the leading global index provider, which developed a methodology to measure how firms' revenues are shifting towards a low carbon economy. The objective of this data is to identify risks and opportunities related to the transition. FTSE Russell's Green Revenues Classification System (GRCS) provides firm-level revenue exposure to environmentally sustainable business activities for over 16,000 publicly-listed firms. The GRCS taxonomy comprises 10 green sectors and 64 sub-sectors based on their impact on climate change mitigation and adaptation, water, resource use, pollution, and agricultural efficiency (see A.1 in appendix for more details).

This classification system was originally developed by FTSE Russell with Impax Asset Management and responded to investor demand for tracking the performance of the green economy and to construct financial products that sought exposure to it (ex: FTSE Russell's Environmental Markets Index Series). More recently, investors use this data also for regulatory and environmental reporting requirements such as the the eligibility of sustainable activities for the EU Taxonomy regulation that was adopted in 2020. In fact, the GRCS was used by the European Commission's Joint Research Center in its impact assessment report of the Taxonomy and has shaped the proposal from the EU High-Level Expert Group on Sustainable Finance, indicating a significant alignment between the GRCS and the EU taxonomies (in subsequent sections, we show how our main results are robust using instead the EU taxonomy).[10]

The GRCS data shows that close to 3,000 companies generate revenues from green products and services. FTSE Russell uses 3 methods to calculate green revenues:

[9] Few papers have used this novel dataset on firm green revenues. Amongst them are (Bassen et al., 2023; Kruse et al., 2020).

[10] The roll out of the EU taxonomy occurs after our sample period ends. Starting in 2022, financial institutions offering investment products in the EU were required to report to what extent their portfolios were taxonomy-aligned. In 2023 EU banks started to disclose lending indicators directly related to the Taxonomy. Over the coming years, large EU firms will be required to disclose information about their taxonomy-aligned activities. The EU has also set up the International Platform on Sustainable Finance to map common agendas and promote consistency across the emerging national taxonomies.

1. **Disclosed**: Less than a third of the GRCS data comes directly from detailed publicly disclosed information (company websites, annual reports, CSR or sustainability reports, etc.) where company-reported business segments are mapped into the GRCS classifications of business activities. This is followed by semantic screening of keywords (ex: "biofuel" or "electric vehicles") and FTSE Russell analysts then verifying a company's involvement in green products or services.

2. **Company-specific estimates**: This is the case when FTSE Russell analysts start with other available non-revenue data (e.g. production volumes, market shares of a product, etc.) and then engage directly with companies to confirm the estimates on the breakdown of revenues by green activity.

3. **Sector-specific estimates**: This occurs for companies with known green revenues but no available public disclosures. In this case FTSE Russell uses a quantitative model that takes reported data from sector peers to estimate a firm's revenues from each GRCS green sector. The approach of estimating green-revenue exposure is akin to carbon emissions data used by other data providers such as S&P Trucost, which is also commonly estimated and used frequently in the academic literature (e.g., Bolton and Kacperczyk (2021) and many other papers).

The GRCS Green Revenues 2.0 data model was launched in 2020 and provides point estimate data for *Green Revenues %* since 2016. It builds on earlier versions going back to 2008 that provided only upper and lower bounds of estimated green revenues. We consulted with FTSE Russell on how to backfill estimates from 2016 going back to 2008. Starting in 2016, FTSE Russell provides both point estimates as well as a confidence interval of green revenues for each firm. The lower bound is a conservative estimate and the upper bound a more optimist view on the green revenues of a company. For the period before 2016, FTSE Russell did not provide point estimates, but only confidence intervals going back to 2008. Based on the information provided to us by FTSE Russell, we are able to calculate a factor that allows to us to backfill the point estimates using the minimum and maximum green revenues in the data. The factor is obtained by calculating

$$Factor_{i,2016} = \frac{GR_{i,2016} - GR_{i,min,2016}}{GR_{i,max,2016} - GR_{i,min,2016}} \quad (1)$$

where $Factor_{i,2016}$ is the factor of firm i in 2016, $GR_{i,2016}$ is the point estimate, $GR_{i,min,2016}$ the lower bound and $GR_{i,max,2016}$ the upper bound. We backfill this factor for the years 2008 to 2015. To obtain the point estimate for years before 2016, we apply the formula

$$GR_{i,t} = GR_{i,min,t} + Factor_{i,2016} \times (GR_{i,max,t} - GR_{i,min,t}) \quad (2)$$

where $GR_{i,t}$ is the new point estimate, $GR_{i,min,t}$ the lower bound in a given year between 2008 and 2015 and $GR_{i,max,t}$ the upper bound, respectively.

Table 1 provides the top companies ranked by green revenues per geographical region. The table shows many global leaders in energy, mostly in terms of generation from renewable and alternative energy sources (Nuclear: Electricité de France; Wind: EnBW; Hydro: Electrobras; Solar: Canadian Solar), as well as well as firms providing equipment (Hanwha) and firms enabling efficiencies via IT processes (e.g., Amazon and Microsoft with cloud computing) or buildings management and power storage. A second main category is transportation that minimises the environmental impacts such as electric road vehicles (Tesla, BYD, or Toyota Motor) as well as railways manufacturer (Alstom) or operators (China Railway). Finally, the table provides some examples of firms active in environmental resources, namely providers of key raw minerals and metals for the energy transition (SQM for lithium), sustainable forestry, waste management, or water infrastructure. In our analyses, we consider that several technologies are controversial and policy makers are at strife whether they should be labelled as green or not. A prominent example is nuclear energy, which is free of emissions, but has other environmental risk associated with it.[11] To tackle this concern, we use an alternative definition of green revenues based on the EUTSF excluding controversial technologies to alleviate doubts that the results might be driven by exactly these divisive green revenues.

To check whether this new data offers new information on the green transition, we

[11] See, for example, https://www.reuters.com/business/sustainable-business/eu-parliament-vote-green-gas-nuclear-rules-2022-07-06/.

explore the correlations of green revenues with other measures of environmental sustainability previously used in the finance literature. Those include corporate carbon emissions and environmental scores and ratings. There are several reasons to believe that green revenues are different from those other measures. First, green products and services are not necessarily related to the greenness of a firm's business operations. For example, the environmental efficiency in the production of cars is different from the environmental footprint of the cars once they are used. Secondly, environmental scores are often best-in-class and mostly measure how firms implement or manage environmental issues, which is more related to their conduct rather than their products. It is easy to envision firms that have good best-in-class environmental scores but sell products and services with a negative environmental impact (e.g., oil companies). The new measure that we use captures a firm's contribution to the green transition through its products. Third, we computed the correlations between green revenues with E-scores from MSCI, a modified version proposed in Pastor et al. (2022) as well as levels and intensities of firms carbon emissions (see e.g. Bolton and Kacperczyk (2021) or Bolton and Kacperczyk (2023)). We find that none of these commonly used measures have low correlations with the share of a firm's green revenues. From this preliminary analysis we conclude that, indeed, green revenues provide novel insights into how firms contribute to the green transition.

2.2 Green Patents

To gauge how green products and services, and ultimately green revenues are associated with green patents, we gather data from the Global Corporate Patent Dataset (GCPD) developed by Bena et al. (2017).[12] Following prior literature, we measure granted green patents based on the technology classes that are classified by the OECD as related to the environment. The details on the mapping are outlined in Haščič and Migotto (2015) and the definition of green patents has been utilized in academic studies such as Cohen et al. (2023), Hege et al. (2022) and Atta-Darkua et al. (2022). After categorizing green patents held by each publicly-listed firm, we construct the variable *GP Ratio* per firm, calculated

[12] This data is available at https://patents.darden.virginia.edu/.

as the ratio of green patents to total patents granted by year. In cases of missing firm data, we impute zeros. This measure spans from 2005 to 2012 due to a lag until filed patents are approved and incorporated into GCPD. While we take granted green patents as a measure of successful technological innovation we acknowledge its limitations as firms may strategically choose not to patent all inventions, the propensity to patent with the USPTO varying across industries or geographies.

2.3 Institutional Ownership

Institutional investors play an increasingly important role in global capital markets. We access data on institutional ownership from the FactSet/LionShares database which has global coverage (Ferreira and Matos (2008)) and consider in particular if an institution has signed the United Nations' sponsored Principles for Responsible Investment (PRI), the world's largest initiative on ESG investing. We use the data from Gibson Brandon et al. (2022) who matched the institution names in FactSet with the list of signatories from the PRI website. That paper finds that PRI signatories who incorporate ESG into their active equity holdings have better portfolio ESG scores than non-PRI signatories (but less so for US-domiciled institutions). A related paper by Pastor et al. (2023) also finds that after institutions become PRI signatories, their ESG portfolio tilts tend to become "greener" (and that this is more the case for European institutions than US ones). In robustness tests, we consider also ownership by institutions that joined other leading investor initiatives focused on tackling climate change and other environmental goals. We access the data from Atta-Darkua et al. (2022) and measure ownership by institutions that were members of the CDP (originally the Carbon Disclosure Project focused on disclosure of corporate carbon emissions but subsequently expanded to cover also water and deforestation risks) and also alternatively the Climate Action 100+ (set up after the Paris Agreement and focused on shareholder engagement on carbon emissions).

3 Sizing the Green Economy

As a first step (See Table 1), we tabulate the countries per region where firms generate the highest total amount in green revenues. For each of the top countries, we then provide details for the the five firms with the highest USD amount in green revenues to provide more clarity on the definition of green revenues in the FTSE Russell GRCS data. Across Europe, North America and the Asia-Pacific region is becomes apparent that electric vehicles play a crucial role in the green transition (Tesla, Mercedes-Benz, or Toyota Motor are some of the examples) as well as railways. Also transportation companies such as China Railway and technology companies like Microsoft exhibit large amounts in green revenues. Last but not least, there are also several utility companies such as E.ON. who provide clean electricity to their clients. In the following part of this section, we provide details on the aggregate size of the green economy and further break it down by countries and sectors.

We quantify the size of the green economy in terms of its revenues generated from environmentally sustainable activities and its revenue share within the global equity market. Companies without any green revenue are categorized as having zero contribution. This classification aligns with the methodology adopted by FTSE Russell in their research reports, wherein missing green revenue data is interpreted as zero. We utilize a revenue-weighted metric to represent global revenues in US dollars and a percentage of total firm revenues. Figure 1 illustrates green revenues in trillions of USD on the left axis, alongside the percentage of total revenues on the right axis. Both absolute and relative measures of green revenues exhibit an upward trend over the period of analysis, exceeding $4 trillion and 6.5% of total revenues by 2022. Notably, this increase accelerates post-2016, coinciding with the Paris Agreement entering into force, which stands as the largest and most significant global initiative aimed at achieving net zero emissions.

We further investigate whether the green economy is concentrated in a few countries. Figure 2 shows that the US is the leading country with one trillion dollars in terms of USD green revenues. Table 1 shows that about a good fraction comes from the top three companies: Amazon, Tesla and Microsoft. It is not surprising that in the Asia-

Pacific region green revenues are also concentrated around the large economies of China and Japan. In Europe, green revenues tend to be more evenly distributed compared to Asia and North America. More importantly, the bottom part of Figure 2 brings to light that relative to the size of the overall economy, Europe has on average a much larger percentage share in green revenues compared to other regions in the world. By 2022 there were already multiple European economies where the green economy makes up more than 10% of total revenues, whereas for example the US only had a green share of approximately 5%. In conclusion, while North America and Asia-Pacific have more total green revenues, Europe's economy has transitioned more toward green revenues in relative terms.

Another lingering question pertains to the distribution of green revenues across various industries. We calculate USD and percentage green revenues for each Factset industry. Figure 3 illustrates that no singular industry dominates the landscape. Naturally, certain sectors, such as Health Services, exhibit small to negligible green revenue contributions. Conversely, the Manufacturing and Utilities sectors collectively contribute approximately 1.4 trillion USD in green revenues, while the Consumer Durables sector (largely comprising electric vehicles), adds another 0.5 trillion USD in green revenues. Within these industries, the green revenue share ranges from around 14% for Consumer Durables to up to 22% in Utilities. These results suggest that the transition towards environmentally sustainable products and services is not confined to a single or a few industries; rather, it manifests across diverse sectors.

We have established the green revenue share across the industries the firms operate in. However, this characterization may offer an incomplete understanding of the green corporate landscape. Instead of solely assessing green revenues based on traditional industry affiliation, we now delve into the green industry breakdown by business activities that is used by FTSE Russell. The GRCS green revenues classification divides firms' green revenues into distinct business activities. For instance, while Tesla's primary revenue source is electric vehicle sales, the company also generates some revenue from efficient power storage solutions. As depicted in Figure 4, we segment green sales into the 10 GRCS sectors, while Figure 5 offers a more detailed view by showcasing the distribution of green revenues across the 64 GRCS sub-sectors. Notably, the largest portion of green business activities originates from the energy sector, comprising management, generation, and equipment components. This delineation between traditional sectors and GRCS green business activities proves significant, as the allocations exhibit fundamental differences.

4 Drivers of the Green Economy

Given the growth in the green economy we documented in the prior sections, we now turn to the underlying drivers fueling this transition. We test three channels that potentially influence the green transition: (1) the importance of corporate innovation to overcome technological limitations; (2) the role of public policies, particularly the regulatory push towards sustainable finance in Europe post Paris; and (3) the importance of the presence of (a) institutional shareholders and (b) their alignment with ESG initiatives.

In Table 2 we show descriptive statistics of our sample. The pooled equal-weighted average firm has about 3.6% of green revenues (this is lower than the revenues-weighted averages shown in the previously discussed figures). The divergence between equal- and revenue-weighted average green revenues suggests that green revenues tend to be higher amongst larger firms. Relative to the Paris Agreement, our sample is also nicely balanced with about half of the observations falling before and half after the Paris Agreement (2008-2015 and 2016-2022). In terms of the geographic distribution, half of the firm-year observations fall into the region of Asia Pacific, 20% originate from North America, 16.4% from Europe and the remainder from firms that are located in the rest of the world.

4.1 The Role of Green Innovation

Our first test is to assess whether a firm's pre-Paris green innovative capacity is associated with stronger green revenues. We perform the following OLS regression

$$GR_{i,t} = \alpha + \beta_1 PostParis_t + \beta_2 GPRatio_{i,preParis} + \beta_3 PostParis_t \times \ GPRatio_{i,preParis} + \beta_n X_{i,t} + \mu_j + \tau_t + \epsilon_{i,t}, \tag{3}$$

where $GR_{i,t}$ is the percentage green revenue shares of company i in year t. $PostParis_t$ is an indicator variable equal to 1 if the year is larger or equal to 2016. $GPRatio_{i,preParis}$ is the average ratio of green over total patents between the years 2008 to 2013 that a company created. We control for several firm characteristics $X_{i,t}$. Our regressions additionally include sector and year-fixed effects in the form of μ_j and τ_t, respectively. Standard errors are clustered at the country level.

Table 3 reveals that companies that were more innovative and held more green patents before 2016 generated higher green revenues after the Paris Agreement. The baseline findings indicate that companies with a higher number of green inventions were more apt to transition at a faster pace. We acknowledge that some sectors and firms are generally more predisposed to patent their innovations and therefore implement a ratio of green over total patents as main measure. Moreover, to address the possibility of a single (or a few) green patents being highly influential, we also implement an indicator variable equal to 1 when a firm created a green patent in any year between 2008 and 2013 (see column 2). We end in 2013 since the green patent data is not yet available beyond 2013.[13] As an additional robustness check, we utilize the count of green patents without adjusting for total patents generated by a firm. Across all specifications, our analysis suggests that increased green innovation enables firms to respond to the shock of the Paris Agreement, as evidenced by the positive coefficients of the interaction terms. The specification in column (2) using the *GP Indicator* variable is particularly useful in evaluating the economic magnitude of the effect. Looking at the coefficient for the interaction effect *Post Paris* $\times$ *GP Indicator*, we find that firms with at least one green patent before the Agreement experienced an average increase of 2.2 percentage

[13] In future versions of this paper, we are able to employ an updated version of the patent dataset.

points in green revenues after the Agreement came into effect. The effect is economically meaningful and represents about 15% of the standard deviation of green revenues.

We further split the sample by regions (US in column 3 and Europe in column 4) and zoom into the energy sector (column 5), which arguably plays a crucial role in the transition. The difference between the US and Europe is striking. In both regions, green innovation is correlated with more green revenues. Yet, only in the US the Paris shock led to a disproportional increase in green revenues for firms holding relatively more green patents after the Paris Agreement. One interpretation is that European firms were already more prepared and therefore the Paris Agreement did not impact them as much as US companies. Previous finding by Cohen et al. (2023) suggest that firms in the energy sector hold over-proportionally more green patents. We now test whether intangible green capital translates into more tangible outcomes in the Energy sector. Column 5 shows that energy companies do not generate more green revenues despite their green patents. There are several plausible explanations for this results. First, the transition for formerly brown firms might be slow since it requires a fundamental change in the business orientation. Second, green patents could be used by energy firms to prevent new (green) competitors from entering the market (hold up).

4.2 The Role of Regulation

With the introduction of the EU Taxonomy for Sustainable Finance (EUTSF), an unprecedented regulatory framework has been established to delineate criteria for investments to qualify as "green". A green activity is defined as one that contributes positively to at least one of the six EU environmental objectives without causing harm to any of the others. This regulatory push stands out prominently among other initiatives aimed at promoting green investing, such as Article 173 (Ilhan et al., 2023) in France or mandatory greenhouse gas (GHG) disclosures in the UK (Downar et al., 2021; Jouvenot and Krueger, 2019). While these efforts have been hailed as significant milestones, a crucial question remains: do regulations effectively lead to greener outcomes? We aim to tackle this question by examining whether regions with more stringent green regulations, particularly

Europe, exhibit different responses compared to the rest of our sample.

We examine the effects of three pivotal milestones in the progression towards the implementation of the EUTSF. Phase 1 commenced post-Paris, where the EU launched a call for applications to establish an expert group commissioned to develop the first large-scale taxonomy on sustainable investing. Phase 2 started in 2018 when the Technical Expert Group convened for the first time to commence work on developing the taxonomy. Two years later, in 2020, the EUTSF was finalized and formally enacted. We study the impact of each phase independently as well as in combination.

Table 4 shows that European firms, on average, exhibit significantly higher proportions of green revenue shares. More importantly, that share increased faster across Europe compared to the rest of the sample. We observe an uptick post-Paris (column 1), which becomes even more pronounced following the creation of the Technical Expert Group (TEG) (column 2), and later upon the official enactment of the taxonomy (column 3). Moreover, the findings indicate that the most rapid acceleration occurred between 2018 and 2020 (column 4), suggesting that firms were able to anticipate the roll out of the EUTSF. The economic magnitude is non-negligible as firms based in Europe exhibit on average 1.4 percentage points higher green revenues, which is equivalent to 10% of one standard deviation change in green revenues.

We conduct several robustness checks to ensure the reliability of our findings. Initially, we were concerned that our results might be influenced by firms incorporated in European countries outside the European Union, such as Norway, Switzerland, and the UK. However, excluding firms from these nations did not significantly alter our results. It's worth noting that the UK remained part of the EU for several years post-Brexit and thus was engaged in the green taxonomy.

Another concern pertains to the definition of the dependent variable. There remains ongoing debate among policymakers whether investments in sectors such as nuclear energy should be deemed "green".[14] To address this concern, we excluded revenues that do not align with the standards of the EUTSF, specifically those that fail to contribute positively

[14] see e.g. https://bit.ly/3vcANLk

to one environmental pillar without causing harm to another. Even after this adjustment, our results remain consistent.

Furthermore, we considered the possibility that European firms may differ in observable characteristics, prompting us to employ a matching approach. We conduct a propensity score matching approach using both kernel and nearest neighbor matching to rule out that the results are driven by other firm characteristics. The findings remain unchanged, reinforcing our conclusion that more stringent regulation indeed accelerates the transition toward a green economy.

4.3 The Role of Institutional Investors

The previous analyses show that both green regulations and corporate innovation influence the share of firms' green revenues after the Paris Agreement. Prior archival research (Dyck et al., 2019) suggests that institutional investors push firms to improve their ESG profiles. In a similar spirit, survey evidence by Krueger et al. (2020) finds that institutional investors indeed care about climate risk.Apart from institutional investors' direct preferences for ESG, institutions might also care about firms' green revenues for purely financial reasons. We now explore whether and how institutional ownership relates to firms' green revenues. We also test how *green/responsible institutional ownership*–which has increased significantly over the recent past with initiatives such as the PRI (Gibson Brandon et al., 2022) becoming more prominent in financial markets–is associated with green revenues.

It is challenging to establish a causal relationship in this part of the analysis since a link between (responsible) institutional investors and green revenues could be interpreted in two ways. On the one hand, investors might engage with firms to encourage more green investing. On the other hand, investors with green mandates (e.g. ESG mutual funds) pick stocks to "green their portfolios".

Similar to Ilhan et al. (2021), we set up a regression model where (responsible) institutional ownership is predetermined, that is we consider a firm's institutional ownership share before the Paris shock in 2015 and keep it constant in the post-Paris period. Using this approach, we can reasonably rule out that the results are driven by institutional investors changing their holdings after the Paris Agreement.

In a first test, we investigate the link between institutional ownership pre-Paris and green revenues after the Paris Agreement. We find that firms that exhibited higher institutional ownership around the signing of the Paris Agreement indeed show higher green revenues afterwards. Next, we categorize investors as responsible if they have signed the PRI. In column 2, we observe that firms held by responsible investors tend to exhibit higher green revenues. However, we do not observe any significant acceleration in green revenues following the Paris Agreement. This pattern remains consistent when considering the ratio of responsible institutional ownership to total institutional ownership, as depicted in column 3, or horse race type regressions that include both institutional ownership and responsible institutional ownership at the same time (column 4). Overall, the results presented in Table 5 suggest that higher institutional ownership pre-Paris is associated with greater proportions of green revenue shares afterwards.

We test various alternative definitions of green ownership. For example, we investigate how investors who are part of the CDP (formerly the Carbon Disclosure Project) influence firms' green revenues. We find the same results as for the PRI. Additionally, we further restrict green ownership to investors who are members of the Climate 100+ coalition. Again, we find similar results. Lastly, we employ a regression model where institutional ownership is time-varying. Also this analysis corroborates the previous findings.

5 Do Investors Value Green Revenues?

A shift to more environmental sustainability is a desirable goal in itself. Yet, it remains an open question whether the market values firms with more green revenues and whether it is possible to generate profitable trading strategies from investing in such firms. We create four portfolios and plot their cumulative raw returns from the beginning until the end of our sample period. As a benchmark, we plot cumulative returns for all stocks in our sample. Next, we split the sample and divide it into three green sub-samples based on the magnitude of green revenue shares. To examine the role of different “shades of green”, we choose the same green revenue cutoffs as FTSE Russell in their index creation, but also tested alternative cutoffs and observed a positive monotonic relationship between cumulative portfolio returns and green revenues. The first green portfolio includes all stocks that have green revenues. The second green portfolio requires a stock to have more than 20% in green revenues and for the last portfolio, we define the cutoff at 50% green revenues. The green portfolio does not outperform the all stocks portfolio, but higher green revenue shares appear to be linked to higher cumulative returns over the sample period. The question is: do these seemingly higher returns reflect alpha or do they capture asset pricing factors that are commonly used in the finance literature?

In Table 6, we investigate this question and test the *Green Revenues* > 20% portfolio with several standard asset pricing models. In the CAPM, the observed alpha is positive but insignificant. That result holds across all models that we employ. The *Green Revenues* > 20% portfolio significantly loads on the market portfolio. It is also negatively correlated with value, which indicates that green stock returns are mostly driven by growth stocks. Overall, we can conclude that significant positive alphas are unattainable between 2008 and 2022 through investing into green revenue stocks.

From the previous analyses we know that green revenues were relatively flat until the Paris Agreement. Thus, we extend the analysis and split the sample into two periods: pre- and post Paris Agreement, for each of the portfolios. In addition to that, we also examine US and European firms separately. Lastly, we focus on a sample comprising global energy stocks.

In the full sample we observe a positive and significant alpha post Paris for stocks with higher green revenues. This result seems to be driven by US stocks whereas profitable strategies including European green firms seem impossible. In the energy sector, there were no firms with more than 50% in green revenues, however, the portfolio of firms with *Green Revenues* > 20% outperformed in the post Paris period. In a nutshell, before the implementation of the Paris Agreement, profitable trading strategies based on green revenues were unattainable. After 2016, this changed, but not everywhere in the world.

The results on the financial profitability of investing into firms with (high) green revenues remain mixed.

6 Conclusions

In this paper, we use data on green revenues to provide novel evidence on the ramping up of the green economy, which accelerated after the Paris Agreement. We show that innovative US firms possessing green patents can effectively translate these patents into tangible green revenues. Additionally, we find that several regulatory initiatives have led to an acceleration in the growth of the green economy in Europe. Finally we document that while (responsible) institutional owners are more likely to be invested in firms with high green revenues, we do not find their presence to be associated with the post-Paris shift. Turning to the financial implications of firms going green, we examine the stock returns of firms with high green revenues and find only modest evidence of a green alpha, which is concentrated in US stocks in the post-Paris period. Our paper leaves many questions open for future research. For example, how much has the shift to green actually contributed to reducing greenhouse gas emissions or achieve other environmental goals? Are there perhaps refined and more granular trading strategies based on green revenues that exhibit more systematic alpha? Is the modest green alpha that we observe related to mispricing or systematic risk exposure?

Figures

Figure 1. The Growth of the Green Economy
This figure illustrates the growth of corporate revenue exposures to the green economy. The left axis shows total annual revenues from green products and services for publicly-listed companies around the world (in USD $ trillions). The right axis shows the percentage in green revenues relative to total company revenues. The data comes from FTSE Russell's Green Revenues Classification System (GRCS) which identifies products and services with positive impact on climate change mitigation and adaptation, water, resource use, pollution and agricultural efficiency.

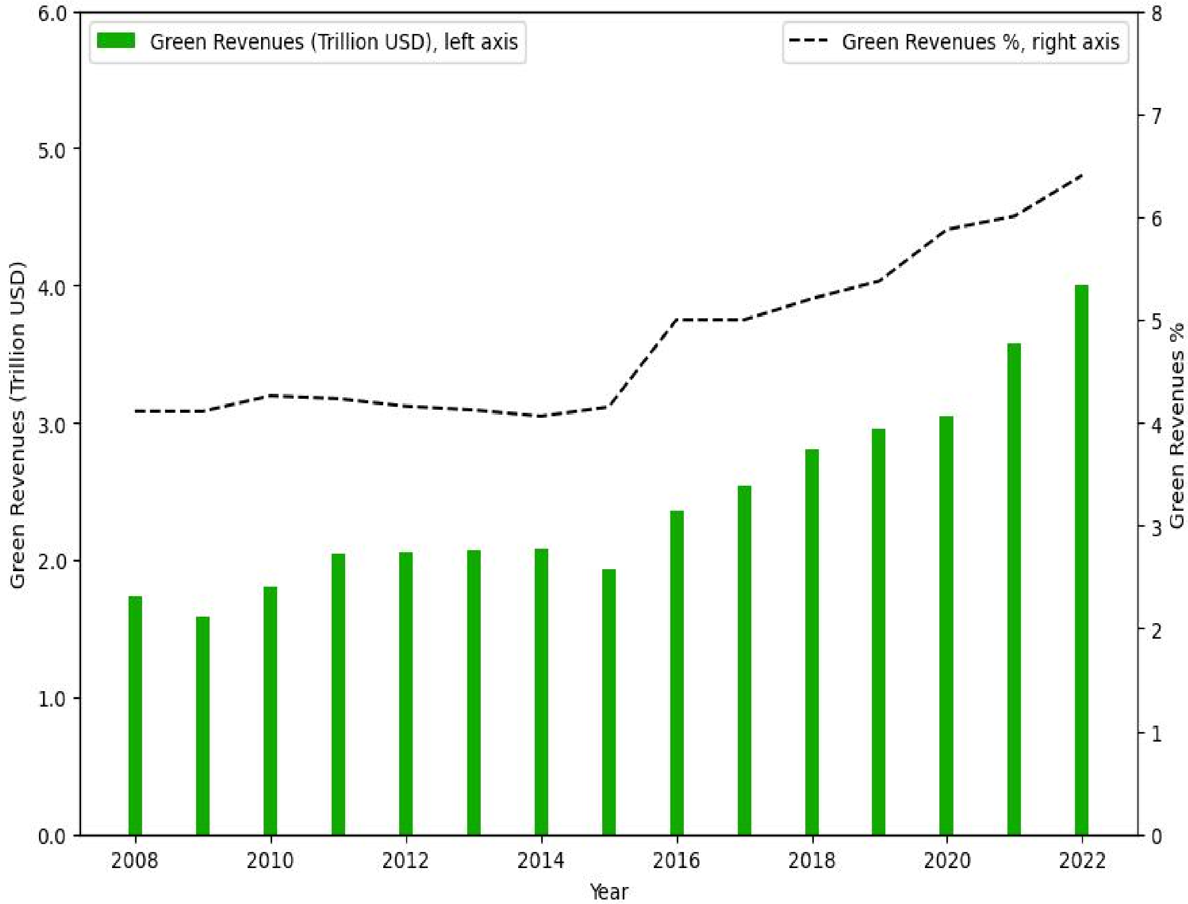


Figure 2. Green Revenues by Country

This figure shows the annual revenues from green products and services by geographical regions based on each company's country of incorporation at the end of the sample period (2022). The top graph shows total annual green revenues (in USD $ trillions) while the bottom graph shows the percentage share of green revenues relative to total revenues for companies in each country, respectively.

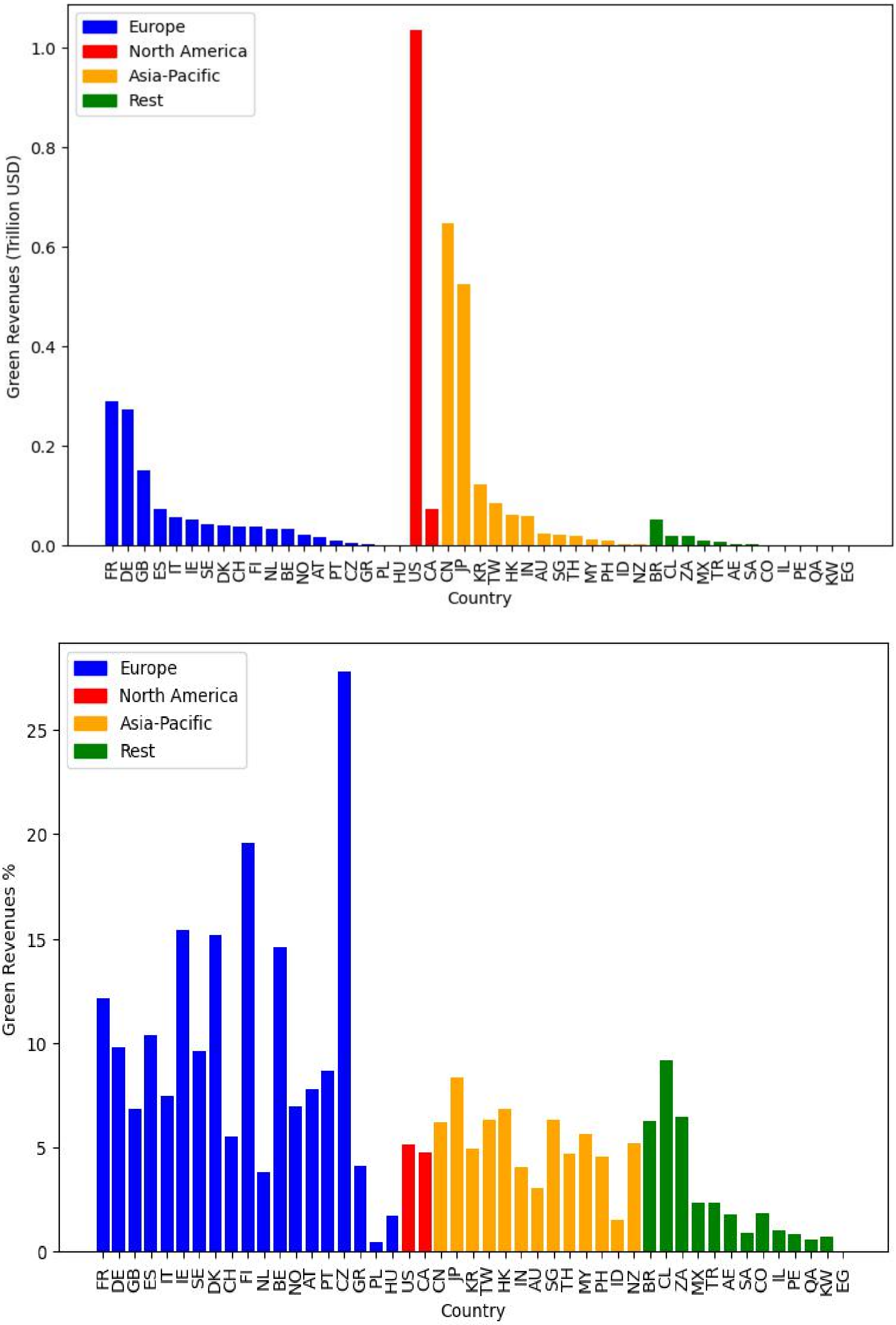


Figure 3. Green Revenues by Industry

This figure maps green revenues into different traditional industries based on a company's Factset sector classification at the end of the sample period (2022). The green bar chart shows total annual green revenues (in USD $ trillions) and the black dashed line plots green revenues relative to total revenues for companies in each industry.

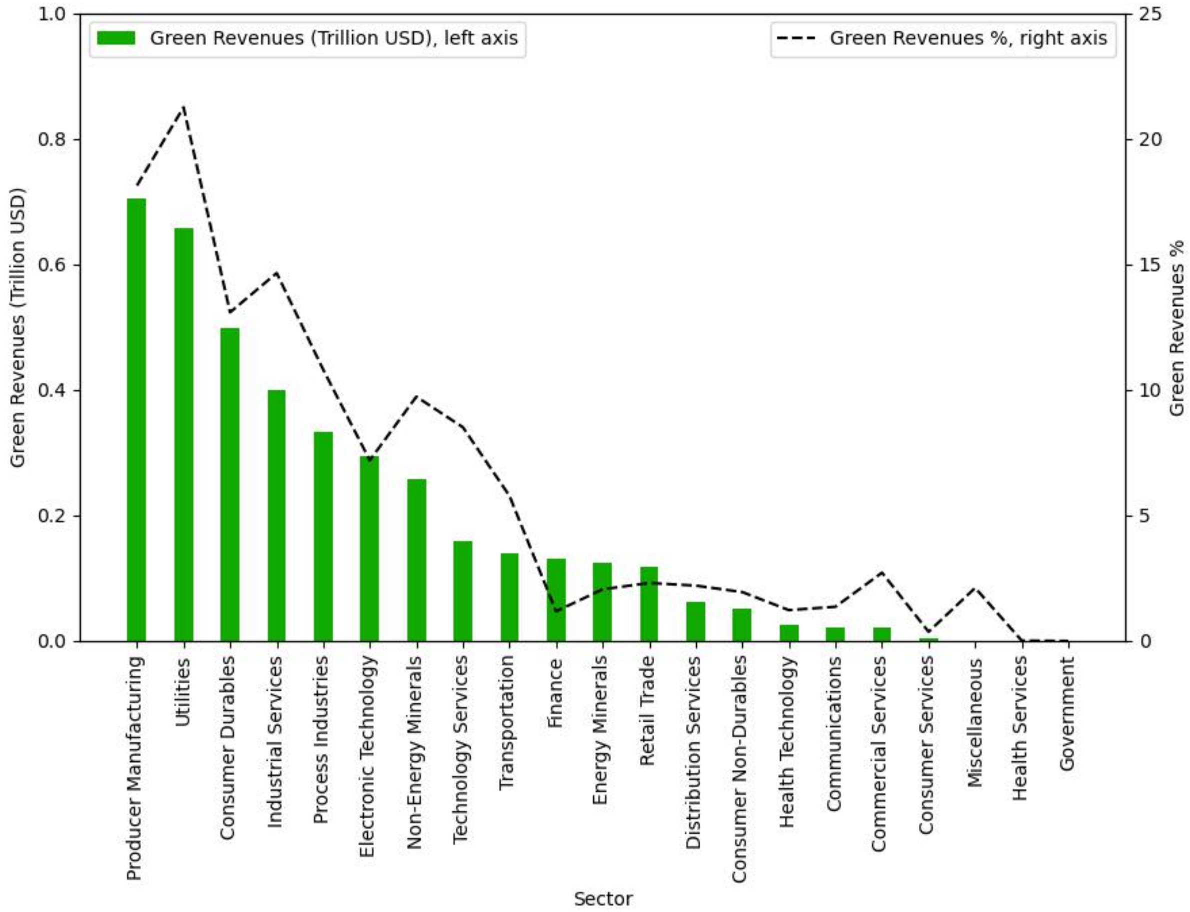


Figure 4. Green Revenues by Business Activity

This figure shows the growth of revenues by type of green business activity based on FTSE Russell's Green Revenue Classification System (GRCS). The graph plots the percentage of green revenues in each of the 10 GRCS green sectors relative to total revenues per year. More details on the GRS taxonomy system is provided in Table A.1.

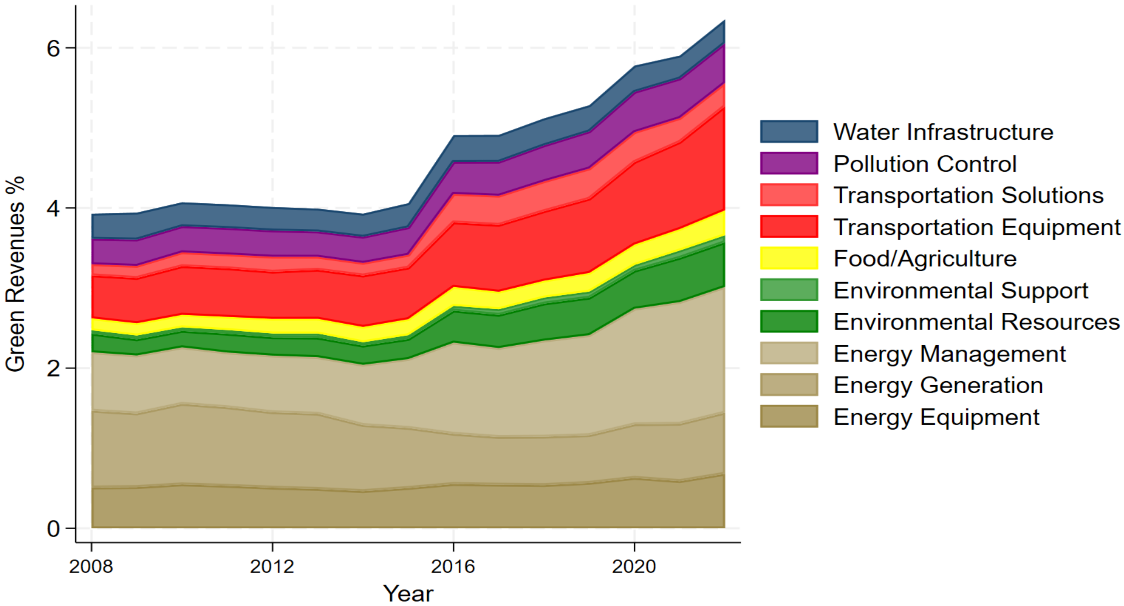


Figure 5. Decomposition of Green Revenues by Business Activity

The tree map breaks down total 2022 green revenues based on the the 10 GRCS green sectors (and into the 64 GRCS subsectors) of FTSE Russell's Green Revenue Classification System (GRCS). Total green revenues sum to approximately USD $4 trillion in 2022. More details on the GRCS taxonomy system is provided in Table A.1.

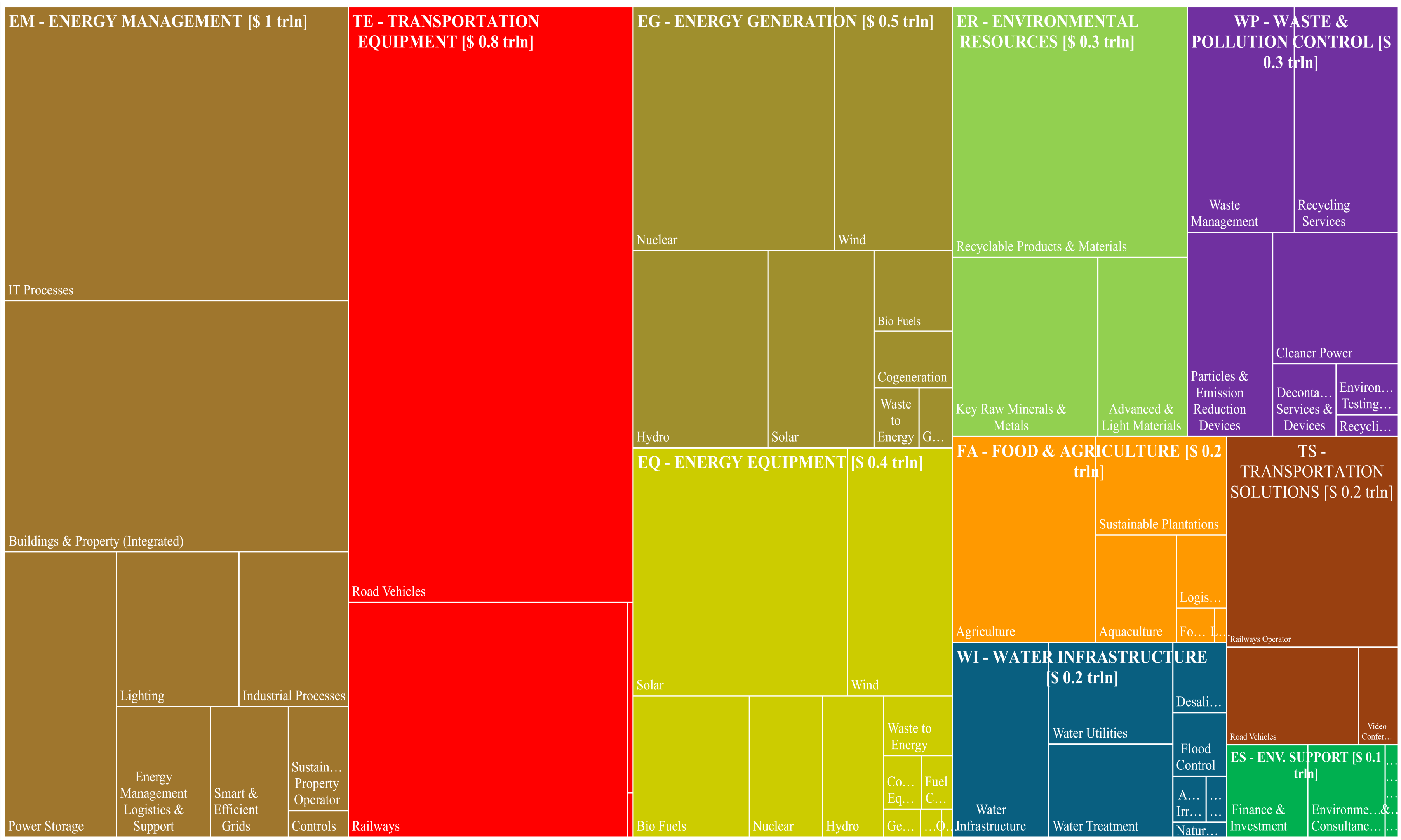
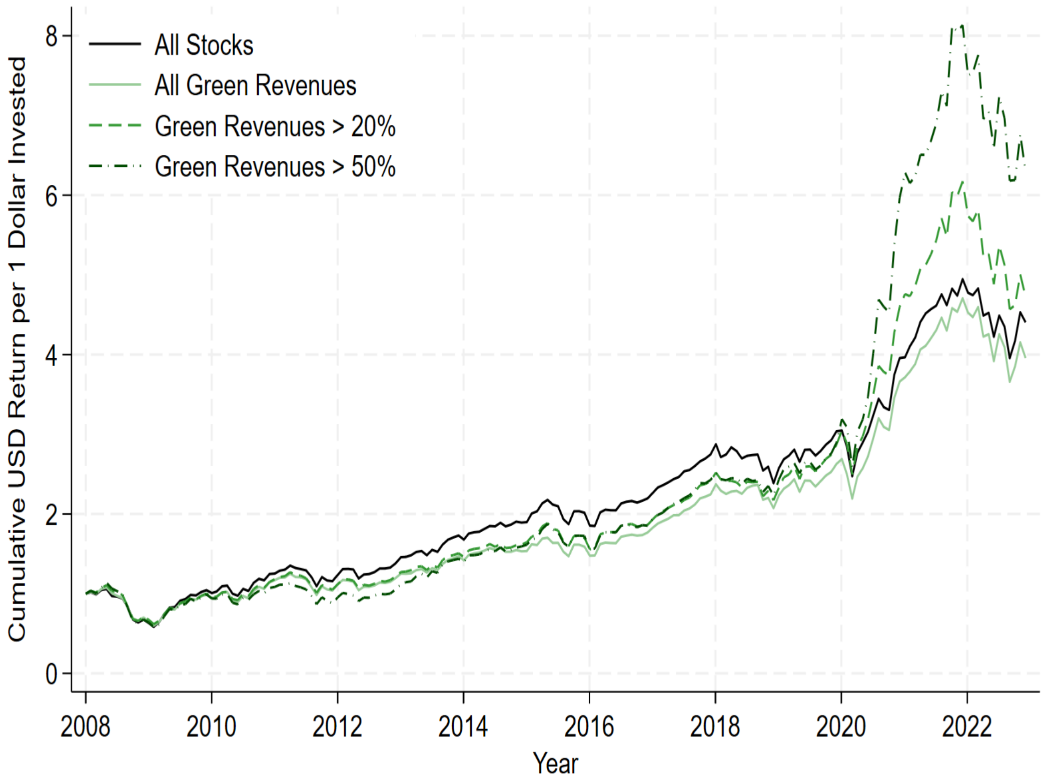


Figure 6. Green Revenues Portfolio Returns

We plot cumulative returns per 1 USD invested for the value-weighted green stocks portfolio (light green) and contrast it with the portfolios that contain stocks with at least 20% (dashed green) and 50% (dashed darker green) green revenues, respectively. The black line plots cumulative returns for the portfolio including all stocks in our sample and serves as a benchmark.



Tables

Table 1. Top Green Revenue Firms by Region

This table provides green revenues for the companies with the largest USD green revenues incorporated in the main countries for each geographical region. More details on the FTSE Russell's Green Revenue Classification System (GRCS) taxonomy system is provided in Table A.1

Region	Country	Nr of Firms in 2008	2008 Green Revenues (in US$ trlns)	2008 Green Revenues (in %)	Nr of Firms in 2022	2022 Green Revenues (in US$ trlns)	2022 Green Revenues (in %)	TOP 1 - 5 by country COMPANY NAME Green Revenues (in US$ bln) % of Green Revenues (of which % in top FTSE GRCS sector & micro-sector)				
Europe	France	313	$ 0.280	10.0	283	$ 0.291	12.2	**ELECTRICITE DE FRANCE** $ 97 bln 64% (52% in EG - Nuclear)	**VEOLIA ENVIRONNEMENT** $ 42 bln 93% (33 % in WI - Water Utilities)	**SCHNEIDER ELECTRIC** $ 26 bln 72% (23% in EM - Industial Processes)	**ENGIE** $ 19 bln 19% (3% in EG - Solar)	**ALSTOM** $ 14 bln 85% (85% in TE - Trains Electric)
	Germany	289	$ 0.150	5.1	285	$ 0.274	9.8	**MERCEDES-BENZ** $ 30 bln 19% (15% in TE - Electrified Road Vehicles & Devices)	**UNIPER** $ 29 bln 10% (5% in EM - Power Storage)	**E.ON** $ 28 bln 23% (22% in EM - Energy Management Logistics)	**EnBW** $ 20 bln 35% (7% in EG - Wind)	**BASF** $ 20bln 22% (7% in ER - Recyclable Materials)
	U.K.	655	$ 0.112	4.8	596	$ 0.150	6.8	**SHELL** $ 34 bln 9% (7% in TE - Electrified Road Vehicles & Devices)	**JOHNSON MATTHEY** $ 21 bln 94% (76% in ER - Platinum)	**BP** $ 9 bln 4% (4% in TE - Electrified Road Vehicles & Devices)	**ANGLO AMERICAN** $ 9 bln 26% (26% in ER - Platinum)	**BARRATT** $ 6 bln 97% (97% in EM - Buildings & Property (Integrated))
	... others	1,267	$ 0.250	5.1	1,159	$ 0.468	9.9					
North America	U.S.	2,848	$ 0.303	2.4	2,515	$ 1.034	5.2	**AMAZON** $ 104 bln 20% (15% in EM - Cloud Computing)	**TESLA** $ 81 bln 100% (93% in TE - Electrified Road Vehicles & Devices)	**MICROSOFT** $ 57 bln 29% (29 % in EM - Cloud Computing)	**BERKSHIRE HATHAWAY** $ 28 bln 10% (7% in TS - Railways Operator)	**FORD MOTOR** $ 21 bln 13% (13 % in TE - Electrified Road Vehicles & Devices)
	Canada	450	$ 0.026	2.3	457	$ 0.073	4.7	**CN RAILWAY** $ 12 bln 91 % (91 % in TS - General Railways)	**WEST FRASER TIMBER** $ 9 bln 92% (92% in FA - Sustainable Forestry)	**CANADIAN SOLAR** $ 7 bln 100% (83% in EQ - Solar)	**WASTE CONNECTIONS** $ 7 bln 100% (50% in WP - Waste Management & Recycling)	**CANFOR** $ 5 bln 85% (85% in FA - Sustainable Forestry)
Asia Pacific	China	1,409	$ 0.047	2.7	3,383	$ 0.648	6.2	**CHINA RAILWAY** $ 60 bln 35% (35% in TE - Railway)	**CHINA RAILWAY CONSTRUCTION** $ 34 bln 21% (20% in TE - Railway)	**POWER CHINA** $ 25 bln 30% (8% in EQ - Hydro)	**BYD** $ 24 bln 38% (14% in TE - Electrified Road Vehicles & Devices)	**ENERGY CHINA** $ 23 bln 43% (5% in EQ - Solar)
	Japan	1,808	$ 0.370	5.7	1,956	$ 0.526	8.4	**TOYOTA MOTOR** $ 71 bln 30% (30% in TE - Electrified Road Vehicles & Devices)	**ENEOS** $ 25 bln 30% (20% in EG - Solar)	**BRIDGESTONE** $ 24 bln 76% (75% in TE - Energy Use Reduction Devices)	**DAIKIN** $ 21 bln 91% (91% in EM - Buildings & Property)	**TEL** $ 14 bln 94% (94% in EM - Industrial Processes)
	South Korea	345	$ 0.049	3.4	892	$ 0.123	4.9	**KIA** $ 17 bln 25% (25% in TE - Electrified Road Vehicles & Devices)	**HYUNDAI MOTOR** $ 12 bln 11% (11% in TE - Electrified Road Vehicles & Devices)	**SK HYNIX** $ 10 bln 28% (28% in EM - Efficient IT)	**HANWHA** $ 7 bln 15% (7% in EQ - Solar)	**SK INNOVATION** $ 8 bln 10% (5% in EM - Power Storage)
	... others	2,079	$ 0.076	3.3	3,416	$ 0.302	4.8					
Rest of the World	Brazil	169	$ 0.047	6.4	138	$ 0.052	6.2	**MARFRIG** $ 15 bln 58% (58% in FA - Meat & Dairy Alternatives)	**GERDAU** $ 14 bln 85% (85% in ER - Recyclable Materials)	**SABESP** $ 4 bln 88% (66% in WI -Water Utilities)	**ELECTROBRAS** $ 4 bln 56% (53% in EG - Hydro)	**METALURGICA GERDAU** $ 3 bln 20% (20% in WP - Recycling Services)
	Chile	165	$ 0.011	6.8	160	$ 0.020	9.2	**SQM** $ 4 bln 41% (33% in ER - Lithium)	**EMPRESAS COPEC** $ 4 bln 12% (12% in EA - Sustainable Forestry)	**ENEL AMERICAS** $ 3 bln 17% (10% in EG - Hydro)	**ENEL CHILE** $ 2 bln 48% (36% in EG - Hydro)	**CMPC** $ 2 bln 25% (15% in ER - Recyclable & Reusable Products)
	... others	1,488	$ 0.010	0.6	1,749	$ 0.046	1.7					
	Total =	13,285	$ 1.731	5.0	Total =	$ 4.008	6.9					

Table 2. Summary Statistics

This table provides summary statistics for the main variables used in the regression analysis. Detailed definitions of the variables are provided in Table A.2. Continuous variables are winsorized at the 1% and 99% levels.

Variable	N	Mean	Median	SD	Min	Max
Green Revenues %	224,571	3.630	0.000	14.403	0.000	100.000
Post Paris	224,571	0.505	1.000	0.500	0.000	1.000
Post TEG	224,571	0.356	0.000	0.479	0.000	1.000
Post EUTSF	224,571	0.211	0.000	0.408	0.000	1.000
All Patents	224,571	2.691	0.000	14.016	0.000	109.500
GP	224,571	0.153	0.000	0.902	0.000	7.333
GP Ratio	224,571	0.007	0.000	0.036	0.000	0.277
GP Indicator	224,571	0.037	0.000	0.169	0.000	1.000
Sales ($ Million)	224,571	2277.32	417.79	6118.60	1.25	57104.00
Tobin's Q	224,571	1.979	1.362	1.850	0.553	17.395
Leverage	224,571	0.238	0.213	0.195	0.000	0.852
ROA	224,571	0.066	0.064	0.096	-0.474	0.403
Cash	224,571	0.173	0.121	0.168	0.000	0.842
Capex	224,571	0.043	0.028	0.049	0.000	0.349
R&D	224,571	0.016	0.000	0.040	0.000	0.293
Europe	224,571	0.164	0.000	0.370	0.000	1.000
North America	224,571	0.203	0.000	0.402	0.000	1.000
Asia-Pacific	224,571	0.557	1.000	0.497	0.000	1.000
Rest of World	224,571	0.089	0.000	0.285	0.000	1.000
IO	204,130	0.208	0.083	0.280	0.000	1.000
IO CDP	204,130	0.071	0.022	0.102	0.000	1.000
IO PRI	204,130	0.078	0.025	0.118	0.000	1.000
IO Climate	204,130	0.072	0.022	0.102	0.000	1.000
IO CDP / IO	204,086	0.301	0.287	0.264	0.000	1.000
IO PRI / IO	204,086	0.369	0.330	0.319	0.000	1.000
IO Climate / IO	204,086	0.302	0.288	0.264	0.000	1.000

Table 3. The Role of Green Innovation

In this regression analysis we test whether corporate green innovation (measured by *GP*, the average number of green patents generated per year between 2008 and 2013 for each firm), impacts the sales of green products and services captured by the variable *Green Revenues %*. This analysis aims to explore the heterogeneity in green corporate innovation before the Paris Agreement and how it impacts green revenues generated through the sales of green products and services. *Post Paris* is a dummy equal to 1 if the year $\geq$ 2016. *GP Ratio* measures average annual green patents relative to all patents created by a company between 2008 and 2013. The GP Indicator is equal to one if a company had at least one green patent between 2008 and 2013. We interact *GP Ratio/Indicator* with *Post Paris* to explore how firms with different levels of green innovation are differently prepared for a green transition after the Paris Agreement. By *, **, and *** we denote p-levels below 10%, 5%, and 1%, respectively. Standard errors clustered on the country level (exception in column (3)) are in parentheses.

Regressions	(1)	(2)	(3)	(4)	(5)
Variables	Green Revenues %				
Post Paris	1.885***	1.849***	3.187***	3.548***	0.144
	(0.300)	(0.300)	(0.480)	(0.579)	(0.212)
GP Ratio	44.91***		63.15***	33.73**	5.597
	(11.87)		(1.747)	(13.79)	(5.006)
PostParis × GP Ratio	14.91***		14.50***	4.591	0.704
	(1.980)		(2.578)	(6.149)	(8.488)
GP Indicator		4.504***			
		(1.485)			
PostParis × GP Indicator		2.226***			
		(0.266)			
ln(Sales)	0.747***	0.755***	-0.273***	1.172***	0.137**
	(0.208)	(0.224)	(0.0506)	(0.194)	(0.0523)
Tobin's Q	0.128***	0.142***	-0.0263	0.276	-0.0246
	(0.0366)	(0.0372)	(0.0425)	(0.173)	(0.0393)
Leverage	-0.214	-0.274	-1.783***	-1.477	0.120
	(0.443)	(0.448)	(0.399)	(1.284)	(0.452)
ROA	-4.801***	-5.410***	-1.586**	-8.996***	-0.0716
	(1.194)	(1.213)	(0.786)	(2.053)	(0.871)
Cash	-0.890	-0.962	-1.038*	-0.525	0.304
	(0.635)	(0.621)	(0.579)	(1.684)	(0.677)
Capex	7.362***	7.457***	15.20***	4.233	-1.181*
	(2.442)	(2.511)	(1.838)	(5.376)	(0.659)
R&D	-2.110	-3.703	-8.886***	7.246	23.95
	(4.405)	(4.864)	(1.978)	(4.241)	(29.44)
Constant	-2.255	-1.989	4.362***	-1.058	-0.418
	(1.351)	(1.548)	(0.712)	(3.027)	(0.332)
Observations	224,571	224,571	38,064	36,783	7,085
R-squared	0.081	0.072	0.131	0.092	0.041
Sample	GLOBAL	GLOBAL	USA	EUROPE	ENERGY
Sector Fixed Effect	YES	YES	YES	YES	NO
Year Fixed Effect	YES	YES	YES	YES	YES
Country Cluster	YES	YES	NO	YES	YES

Table 4. The Role of Regulatory Push

In this table, we estimate the effect of increased green regulation on firm *Green Revenues %*. We split the sample into firms incorporated in *Europe*, where a strong regulatory push occurred after the Paris Agreement, and the rest of the sample comprised of countries with less green regulation. *Post Paris* is a dummy equal to 1 if the year $\geq$ 2016. *Post TEG* is equal to 1 if the year $\geq$ 2018, where *TEG* indicates the creation of the Technical Expert Group commissioned to create the EU green taxonomy. *Post EUTSF* is equal to 1 if the year $\geq$ 2020, where *EUTSF* stands for the EU Taxonomy on Sustainable Finance rolled out in 2020. By *, **, and *** we denote *p*-levels below 10%, 5%, and 1%, respectively. Standard errors clustered on the country level are in parentheses.

Regression	(1)	(2)	(3)	(4)
Variables		Green Revenues %		
Europe	0.790**	0.916**	1.092**	0.790**
	(0.377)	(0.389)	(0.410)	(0.377)
Post Paris	1.666***			1.405***
	(0.312)			(0.153)
Europe × Post Paris	1.200**			0.579
	(0.457)			(0.371)
Post TEG		1.654***		0.117
		(0.312)		(0.117)
Europe × Post TEG		1.342***		0.566***
		(0.430)		(0.142)
Post EUTSF			1.658***	0.0734
			(0.310)	(0.138)
Europe × Post EUTSF			1.394***	0.551**
			(0.484)	(0.266)
Observations	224,571	224,571	224,571	224,571
R-squared	0.066	0.066	0.066	0.066
Controls	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES
Year Fixed Effect	YES	YES	YES	YES
Country Cluster	YES	YES	YES	YES

Table 5. The Role of Institutional Investors

In this table, we explore the role of institutional shareholders in the green transition. The dependent variable is *Green Revenues %* and the main explanatory variables are total institutional ownership (*IO*), responsible institutional ownership (*IO PRI*) and the ratio of green over total ownership (*IO PRI / IO*) in the year 2015, which we keep constant over the sample period in our main regression setup to explore how institutional ownership pre-Paris influenced firm green revenues post Paris. *Post Paris* is a dummy equal to 1 if the year $\geq$ 2016. Institutional ownership is considered green when institutional investors are signatories of the Principles of Responsible Investing (*IO PRI*). By *, **, and *** we denote p-levels below 10%, 5%, and 1%, respectively. Standard errors clustered on the country level are in parentheses.

Regression	(1)	(2)	(3)	(4)
Variables		Green Revenues %		
IO	2.095***			-0.481
	(0.231)			(0.560)
IO PRI		8.599***		9.732***
		(0.657)		(1.712)
IO PRI / IO			2.281***	
			(0.489)	
Post Paris	1.361***	1.034***	1.093***	0.955***
	(0.255)	(0.230)	(0.292)	(0.263)
Post Paris × IO	2.309***			0.205
	(0.669)			(0.846)
Post Paris × IO PRI		1.570		0.937
		(1.332)		(2.391)
Post Paris × IO PRI / IO			-0.270	
			(0.517)	
Observations	204,130	204,130	204,086	204,130
R-squared	0.070	0.072	0.069	0.072
Controls	YES	YES	YES	YES
Sector Fixed Effect	YES	YES	YES	YES
Year Fixed Effect	YES	YES	YES	YES
Country Cluster	YES	YES	YES	YES

Table 6. Green Revenues Portfolios: Returns and Factor Loadings

We compare monthly raw cumulative value-weighted green returns in column (1) with excess green returns (*Alpha*) adjusted for various asset pricing factors in columns (2)-(5). Monthly returns are from 2008 until 2022. The green testing portfolio includes firms with *Green Revenues* > 20%. Column (2) shows the results for the CAPM model. Column (3) implements the Fama-French 3-factor model. Column 4 employs the Carhart 4-factor model and in column 5 we add the profitability factor. By *, **, and *** we denote p-levels below 10%, 5%, and 1%, respectively. Standard errors are in parentheses.

Portfolio	*Green Revenues* > 20%				
Regression Model	(1) Raw	(2) CAPM	(3) FF3	(4) Carhart	(5) 5 Factors
Alpha	0.907**	0.0338	0.0134	0.0220	0.0122
	(0.392)	(0.109)	(0.0990)	(0.0994)	(0.119)
Market		1.016***	1.068***	1.065***	1.066***
		(0.0238)	(0.0237)	(0.0263)	(0.0280)
Size			-0.0147	-0.0178	-0.00467
			(0.0657)	(0.0671)	(0.0998)
Value			-0.254***	-0.267***	-0.264***
			(0.0433)	(0.0627)	(0.0657)
Momentum				-0.0244	-0.0248
				(0.0763)	(0.0762)
Profitability					0.0286
					(0.155)
Observations	180	180	180	180	180
R-squared	0.000	0.922	0.937	0.937	0.937

Table 7. Green Revenues Portfolios: Alphas by Level of Greenness

In this table, we aim to examine how different shades of green are valued by the market and whether different tierings based on the level of "greenness" result in a green *Alpha*. We further split the sample into two periods. *Pre Paris* includes all years from 2008 to 2015 and *Post Paris* considers the time period from 2016 to 2022. We calculate monthly value-weighted portfolio returns and regress them on the 5-factor model as proposed in Table 6 in column 5. The first green portfolio includes all stocks with *Green Revenues* > 0% (column (1), the second portfolio includes stocks with *Green Revenues* > 20% (column 2), and the third portfolio considers stocks with *Green Revenues* > 50% (column 3). Panel A uses the full global sample. Panel B restricts to US firms and Panel C limits the sample to European firms. Lastly, Panel D employs a global sample of firms operating in the energy sector. By *, **, and *** we denote p-levels below 10%, 5%, and 1%, respectively. Standard errors are in parentheses.

Regression	(1)	(2)	(3)
Variable		Green Revenues %	
Portfolio	> 0%	> 20%	> 50%
		Panel A: All Firms	
Alpha	-0.101	0.0122	0.204
	(0.0843)	(0.119)	(0.186)
Alpha (Pre Paris)	-0.275***	-0.240*	-0.213
	(0.0971)	(0.126)	(0.188)
Alpha (Post Paris)	0.102	0.308*	0.693**
	(0.122)	(0.178)	(0.288)
2008: Nr firms	1,401	485	215
Total USD trln	$8.3	$2.0	$0.7
2022: Nr firms	2,693	991	499
Total USD trln	$29.3	$10.5	$3.9
		Panel B: US Firms	
Alpha	0.0293	0.157	0.721*
	(0.135)	(0.189)	(0.38a)
Alpha (Pre Paris)	-0.220	-0.223	0.000
	(0.133)	(0.193)	(0.371)
Alpha (Post Paris)	0.320	0.601**	1.563**
	(0.217)	(0.289)	(0.609)
		Panel C: European Firms	
Alpha	-0.244**	-0.301**	-0.166
	(0.102)	(0.123)	(0.185)
Alpha (Pre Paris)	-0.337**	-0.558***	-0.641***
	(0.140)	(0.145)	(0.235)
Alpha (Post Paris)	-0.136	-0.00494	0.380
	(0.122)	(0.173)	(0.250)
		Panel D: Energy Firms (Global)	
Alpha	-0.0537	0.912	-
	(0.127)	(0.554)	-
Alpha (Pre Paris)	0.0697	0.195	-
	(0.199)	(0.600)	-
Alpha (Post Paris)	-0.197	1.741**	-
	(0.125)	(0.865)	-

Appendix

Table A.1. FTSE Russell's Green Revenue Classification System (GRCS)

This table provides details on FTSE Russell's Green Revenue Classification System (GRCS) which identifies green products and services covering 10 sectors and 64 subsectors. Source: FTSE Russell *"Green Revenues Data Model"*

EG - ENERGY GENERATION	EQ - ENERGY EQUIPMENT	EM - ENERGY MANAGEMENT	ER - ENVIRONMENTAL RESOURCES	ES - ENVIRONMENTAL SUPPORT
Revenue generating activities from the generation of power from renewable and alternative energy sources.	*Revenue generating activities from the renewable and alternative energy value chain, excluding power generation activities.*	*Revenue generating activities from products and services enabling more efficient methods of energy usage and management.*	*Revenue generating activities from production, processing and sale of key and advanced materials which specifically enable the minimisation of negative environmental impacts and improve the efficiency of natural resource use*	*Revenue generating activities from environmental support services relating to consulting, investment or urban design that enable or indirectly contribute to green activities resulting in a large breadth of environmental utility*
Bio Fuels Cogeneration Clean Fossil Fuels Geothermal Hydro Nuclear Ocean & Tidal Solar Waste to Energy Wind	Bio Fuels Cogeneration Equipment Clean Fossil Fuels Fuel Cells Geothermal Hydro Nuclear Ocean & Tidal Solar Waste to Energy Wind	Buildings & Property (Integrated) Controls Energy Management Logistics & Support Industrial Processes IT Processes Lighting Power Storage Smart & Efficient Grids Sustainable Property Operator	Advanced & Light Materials Key Raw Minerals & Metals Recyclable Products & Materials	Environmental Consultancies Finance & Investment Smart City Design & Engineering

FA - FOOD & AGRICULTURE	TE - TRANSPORTATION EQUIPMENT	TS - TRANSPORTATION SOLUTIONS	WP - WASTE & POLLUTION CONTROL	WI - WATER INFRASTRUCTURE
Revenue generating activities from products that improve yield, productivity and sustainability in agriculture, silviculture, aquaculture and food production or distribution, whilst minimising negative environmental impacts	*Revenue generating activities from the provision of technologies, systems and services which minimise the environmental impacts and improve the efficiency of natural resource use associated with the transportation industry*	*Revenue generating activities from the operation of transportation solutions and services which minimise the environmental impacts and improve the efficiency of natural resource use associated with the transportation industry*	*Revenue generating activities from products and services which reduce, monitor, or prevent the contamination of air, water and soil to address global, regional and local environmental issue and technologies, systems and services for waste management, reuse and recycling*	*Revenue generating activities from technologies, infrastructure, products and services for the supply, management and treatment of water*
Agriculture Aquaculture Land Erosion Logistics Food Safety, Efficient Processing & Sustainable Packaging Sustainable Plantations	Aviation Railways Road Vehicles Shipping	Railways Operator Road Vehicles Video Conferencing	Cleaner Power Decontamination Services & Devices Environmental Testing & Gas Sensing Particles & Emission Reduction Devices Recycling Equipment Recycling Services Waste Management	Advanced Irrigation Systems & Devices Desalination Flood Control Meteorological Solutions Natural Disaster Response Water Infrastructure Water Treatment Water Utilities

Table A.2. Variable Definitions and Data Sources

Variable	**Definition**
Green Revenues %	Percentage of green revenues relative to annual company revenues, with missing values filled in as zeros (source: FTSE Russell GRCS).
Post Paris	Dummy = 1 if the year $\geq$ 2016, which captures the period after the Paris Agreement.
Post TEG	Dummy = 1 if the year $\geq$ 2018, which captures the creation of the Technical Expert Group commissioned to create a taxonomy for green investing (TEG).
Post EUTSF	Dummy = 1 if the year $\geq$ 2020, which captures the roll out of the EU Taxonomy of Sustainable Finance (EUTSF).
Europe	Dummy = 1 if the company is headquartered in Europe (source: FactSet).
North America	Dummy = 1 if the company is headquartered in North America (source: FactSet).
Asia Pacific	Dummy = 1 if the company is headquartered in the Asia-Pacific region (source: FactSet).
Rest of World	Dummy = 1 if the company is headquartered in another region (source: FactSet).
GP Ratio	Ratio of green patents to total patents. Patent data is from the Global Corporate Patent Dataset (https://patents.darden.virginia.edu/) and green patents are classified using the OECD Environmental-related technology mapping developed by Hascic and Migotto (2015) and updated in 2020 ($http://stats.oecd.org/wbos/fileview2.aspx?IDFile = 0befc58e-d72f-4ff9-b27e-84e446240e34$).

Table A.2 (continued): Variable Definitions

Variable	**Definition**
GP Indicator	Dummy = 1 if the company had at least one green patent between 2008 and 2013.
IO	Holdings by institutional investors as a fraction of market capitalization (source: FactSet Ownership).
IO_PRI	Holdings by institutional investors that are signatories of the Principles for Responsible Investment (PRI) as a fraction of market capitalization (sources: FactSet Ownership and Gibson Brandon et al. (2022)).
IO_PRI/IO	Ratio of ownership by PRI institutional investors to total institutional ownership.
Sales	Total sales in million of U.S. dollars (FactSet item FF_SALES).
Tobin's Q	Total assets (FactSet item FF_ASSETS) plus market value of equity (Factstet item FF_MKT_VAL) minus book value of equity (Factstet item FF_COM_EQ) divided by total assets.
Leverage	Total debt (FactSet item FF_DEBT) divided by total assets (FactSet item FF_ASSETS).
ROA	Operating income (FactSet item FF_OPER_INC) plus interest expenses (FactSet item $FF\_INT\_EXP\_DEBT$) divided by total assets (FactSet item FF_ASSETS).
Cash	Cash and short-term investments (FactSet item FF_CASH_ST) divided by total assets (FactSet item FF_ASSETS).
Capex	Capital expenditures (FactSet item FF_CAPEX_FIX) divided by total assets (FactSet item FF_ASSETS).

Table A.2 (continued): Variable Definitions

Variable	**Definition**
R&D	Research and development expenditures (FactSet item *FF_RD_EXP*) divided by total assets (FactSet item *FF_ASSETS*).
Returns	Monthly gross returns are calculated using stock prices from Factset (item *ADJ_PRICE*).
Market	Value-weighted returns of all firms in our sample using prices from Factset (item *ADJ_PRICE*).
Size	Global size factor from Jensen et al. (2023) (source: https://jkpfactors.com/).
Value	Global value factor from Jensen et al. (2023) (source: https://jkpfactors.com/).
Momentum	Global momentum factor from Jensen et al. (2023) (source: https://jkpfactors.com/).
Profitability	Global profitability factor from Jensen et al. (2023) (source: https://jkpfactors.com/).

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