The Green Transition: Evidence from Corporate Green Revenues

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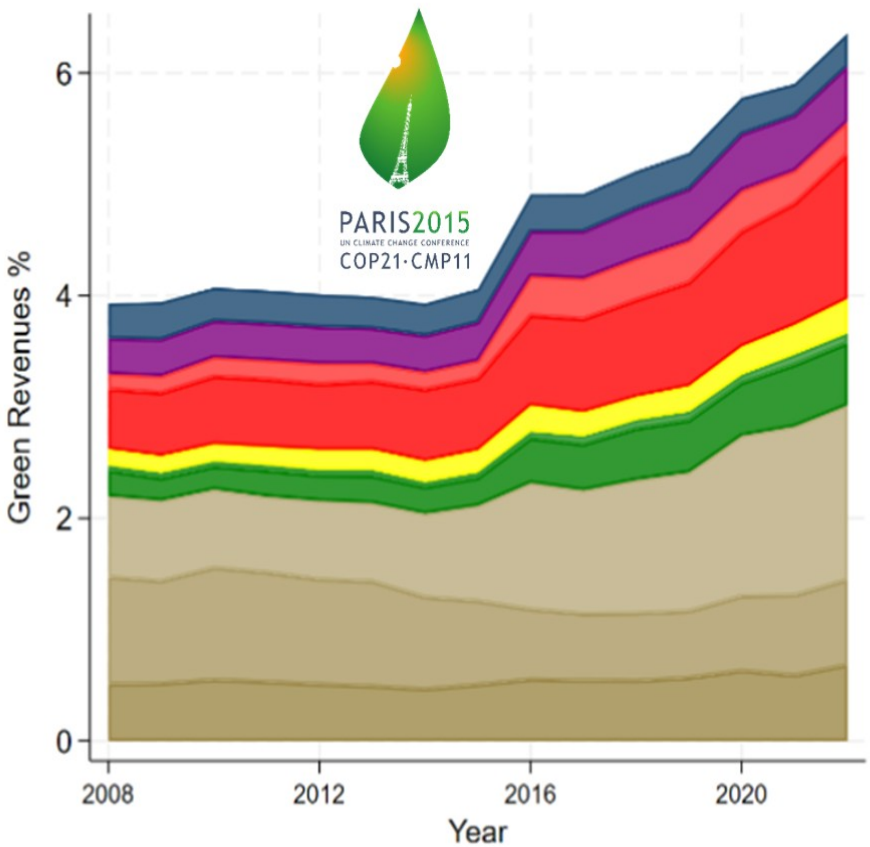
October 2026

Motivation

- Transition has been slow to a ''green" low-carbon, resource-efficient and more environmentally sustainable economy
- How do green technologies translate into a greener economy?
  - Developing green technologies is only the first step: firms must bring green products and services to market.
  - Do firms with pre-existing green technological capabilities expand green revenues when market and policy incentives strengthen?
  - How do capital markets value this green commercial activity?
- **This paper:** Employ a novel dataset and approach to capture the extent to which firms sell products and services that contribute positively to the environment (Next slide: How to measure ''green revenues"?)
  - **Question 1:** How large is the green economy and how is it evolving?
  - **Question 2:** Do firms successfully commercialize their green innovations?
  - **Question 3:** How do investors value green revenues, and is there a "green alpha"?

Green Revenues accelerate *post* Dec 2015 Paris Agreement

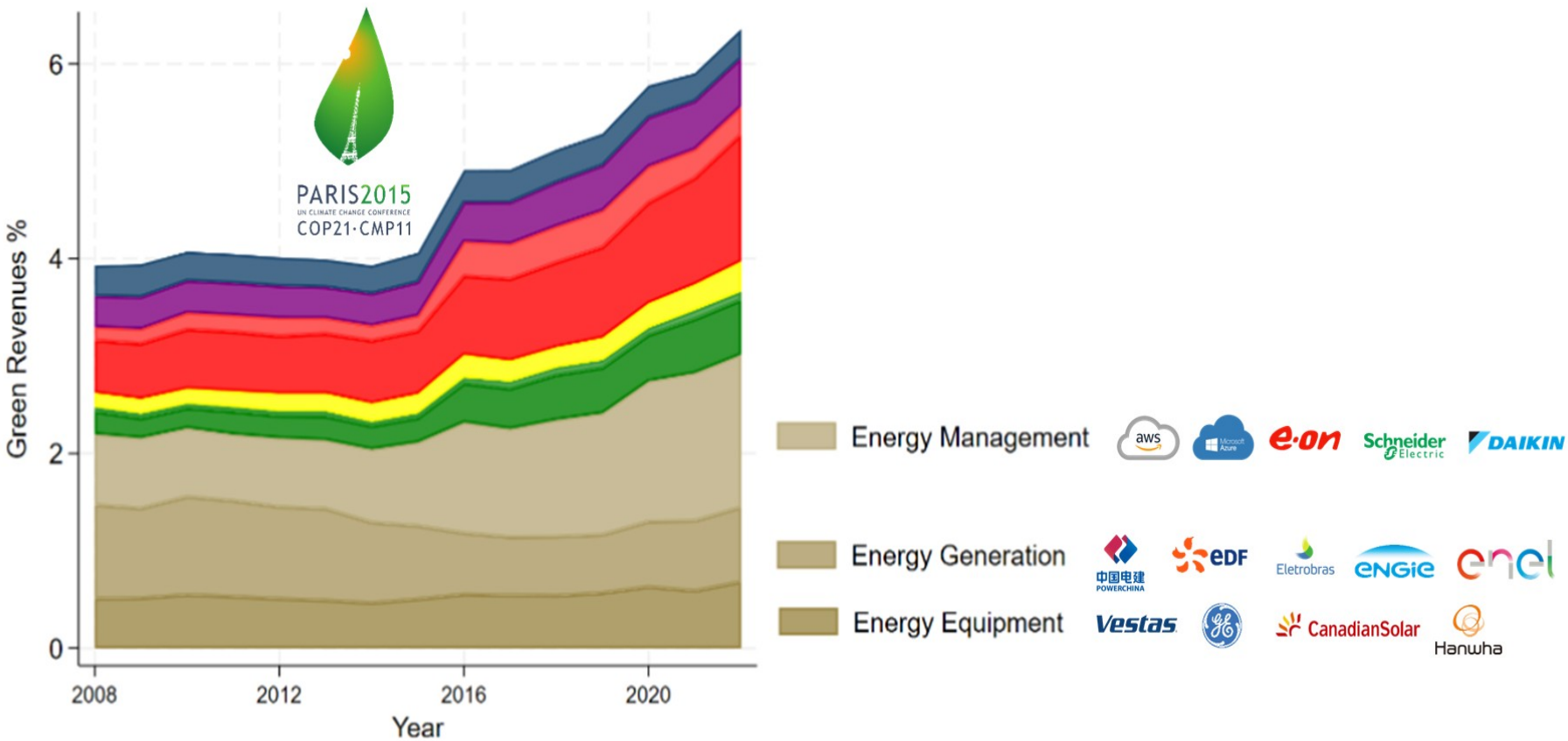
- Data: FTSE Russell Green Revenues Classification System (GRCS)
- 2022: 6.5% (aggregate revenues USD $4 trillion ≈ Oil & Gas sector)



Size of Non-Green Energy Sector

Green Revenues accelerate *post* Dec 2015 Paris Agreement

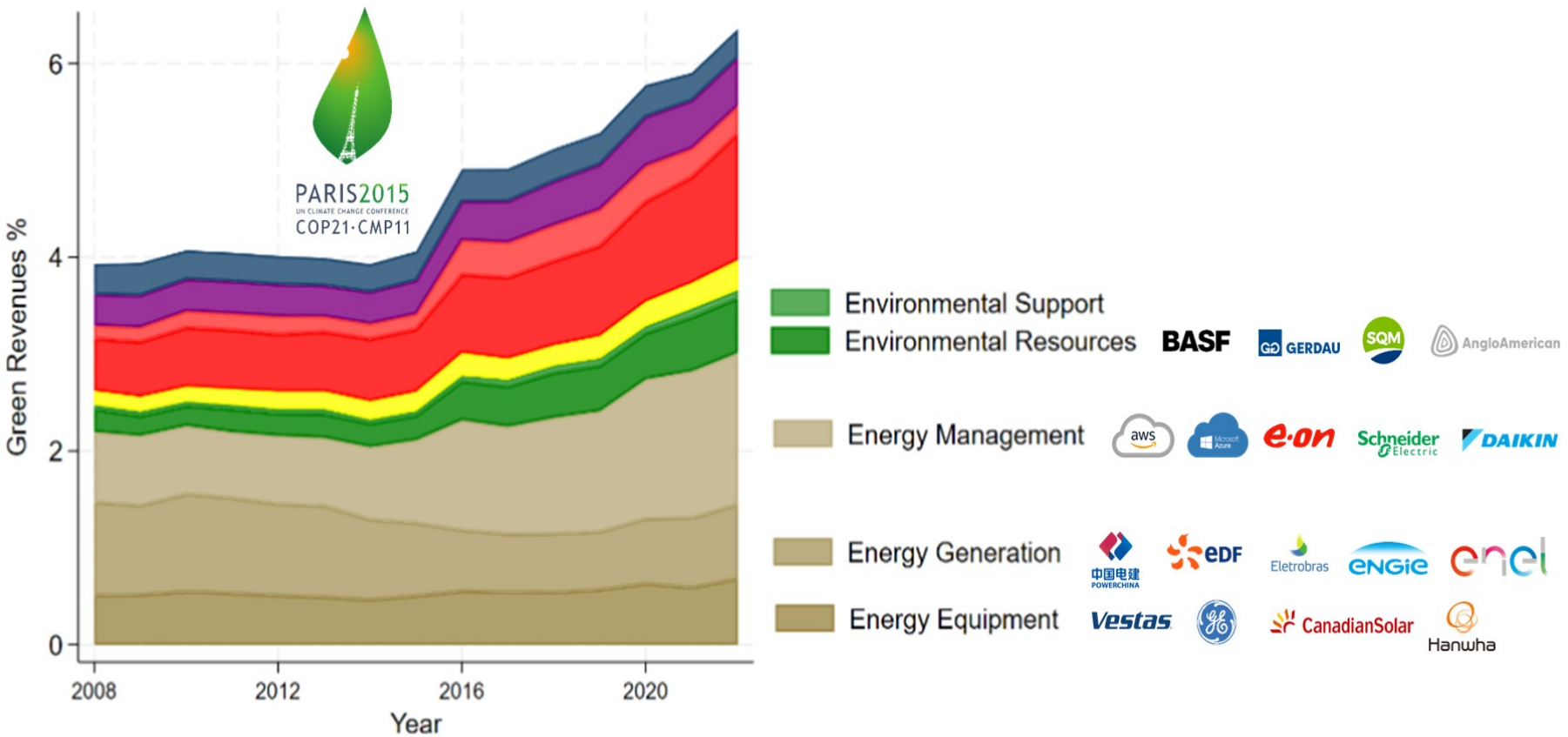
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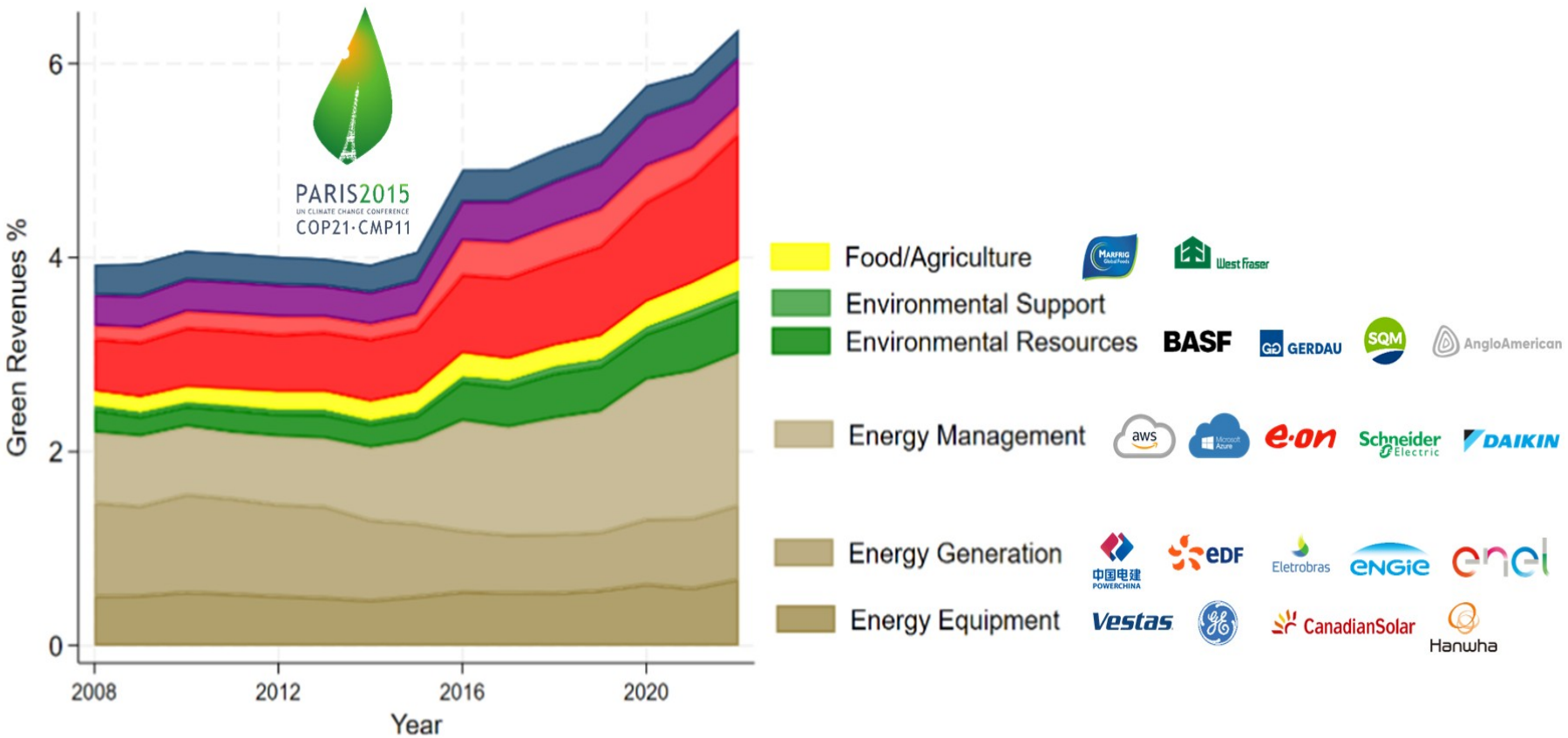
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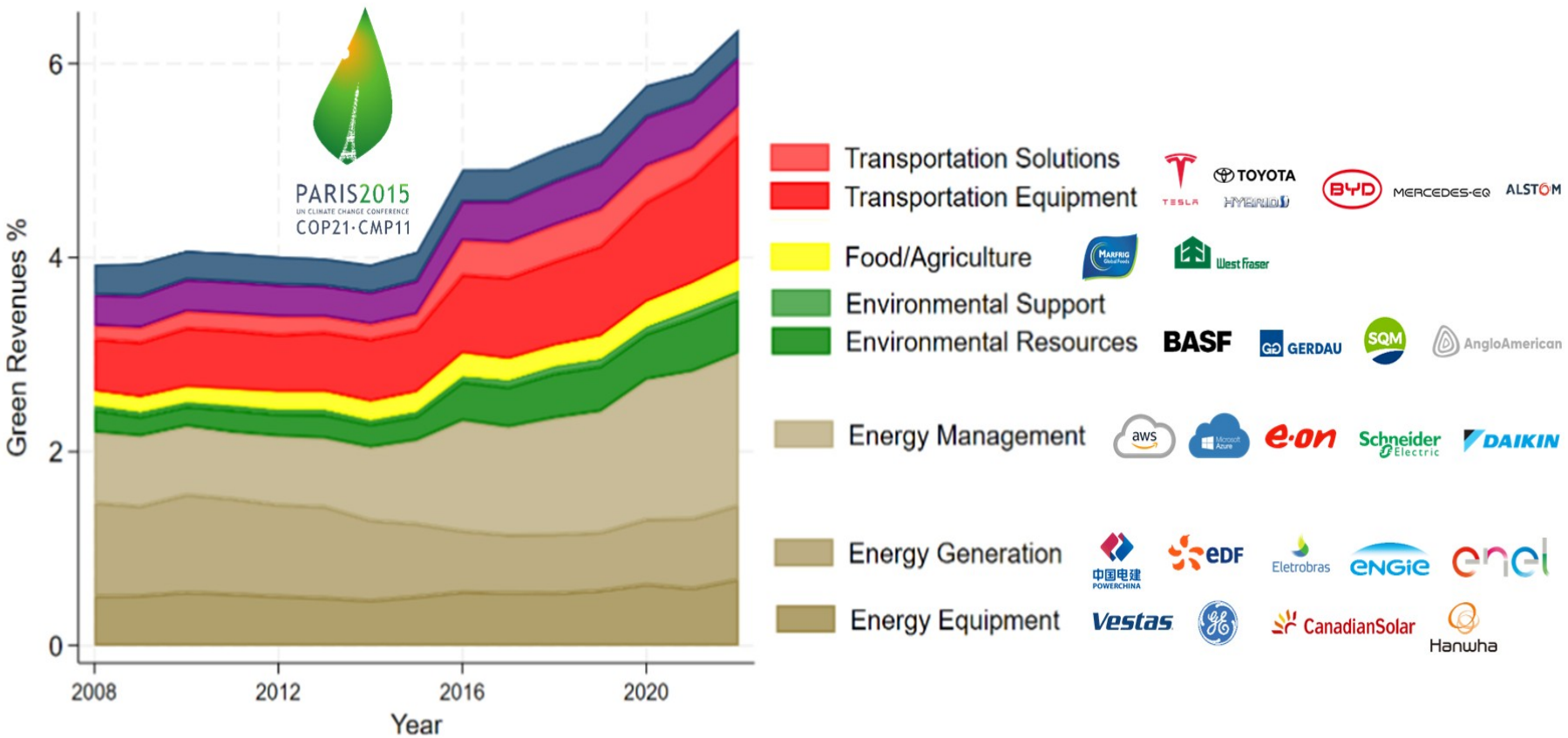
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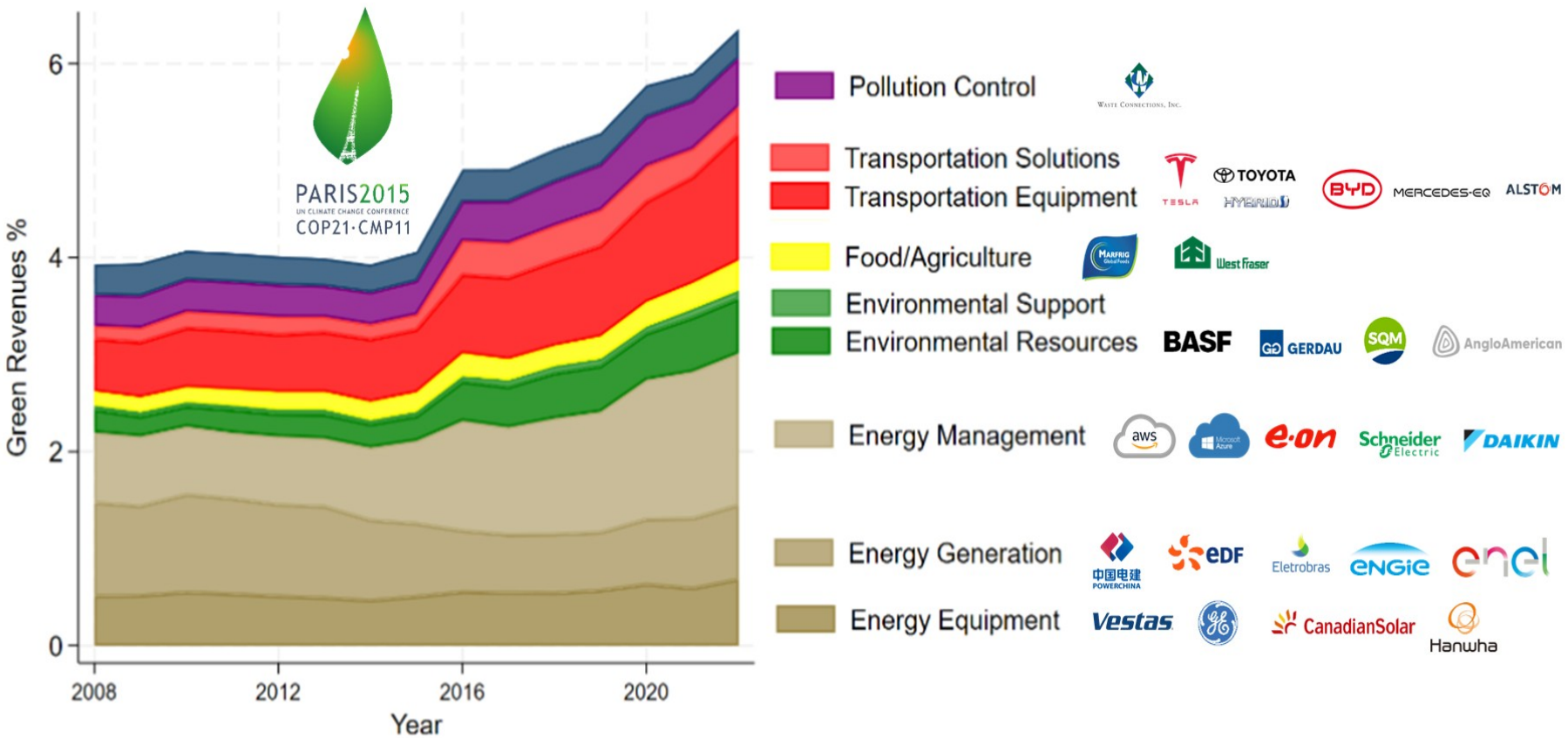
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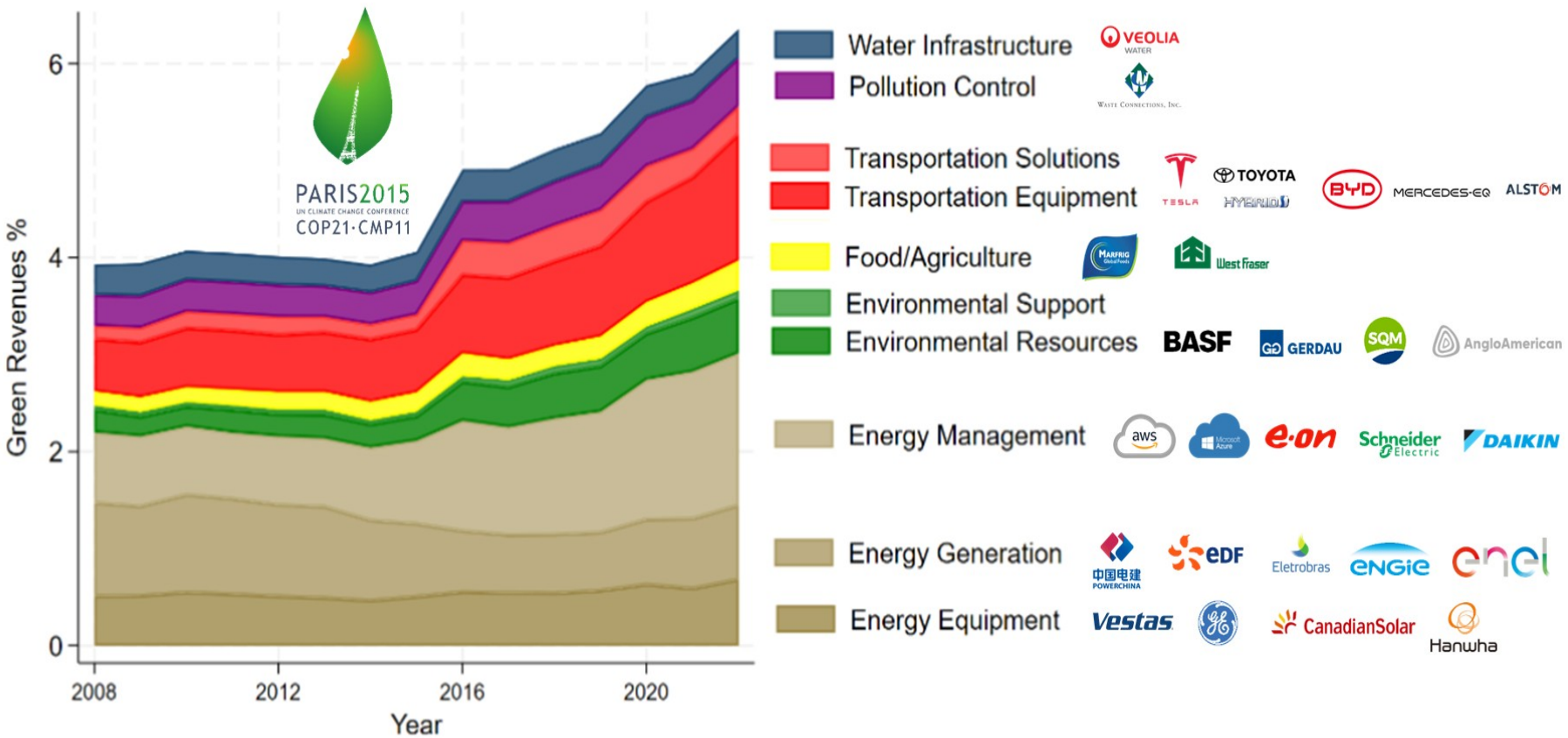
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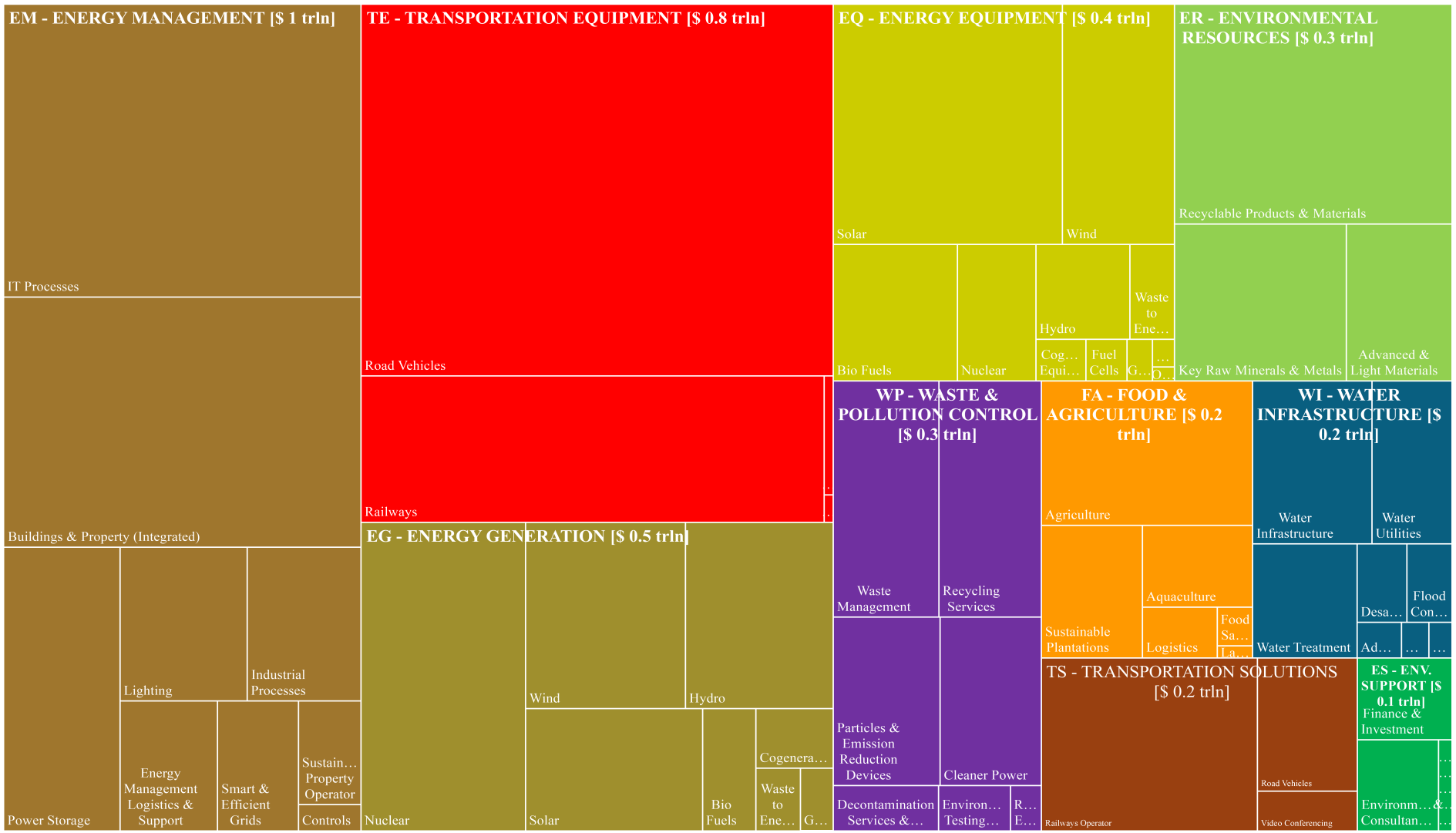
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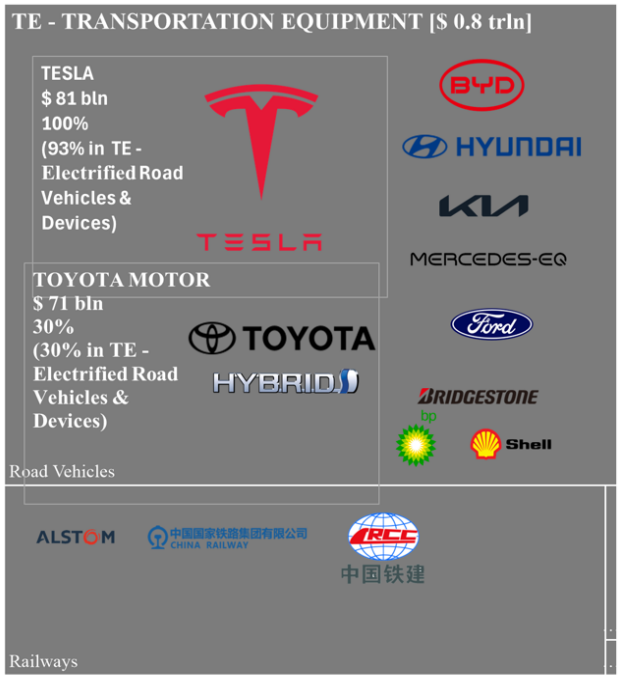
Green Revenues in 2022: USD $4 trillion

- Data: FTSE Russell's 10 GRCS green sectors



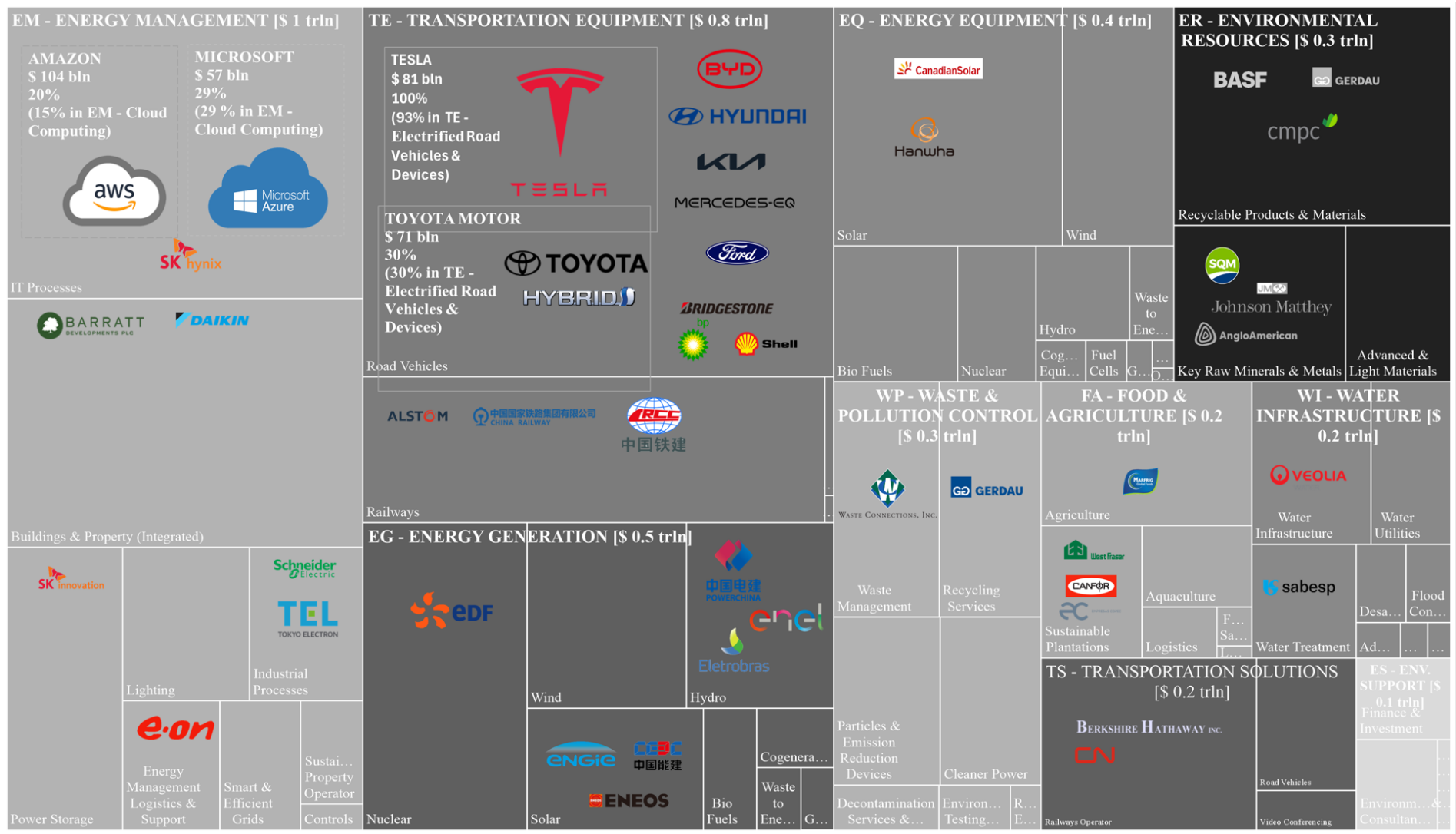
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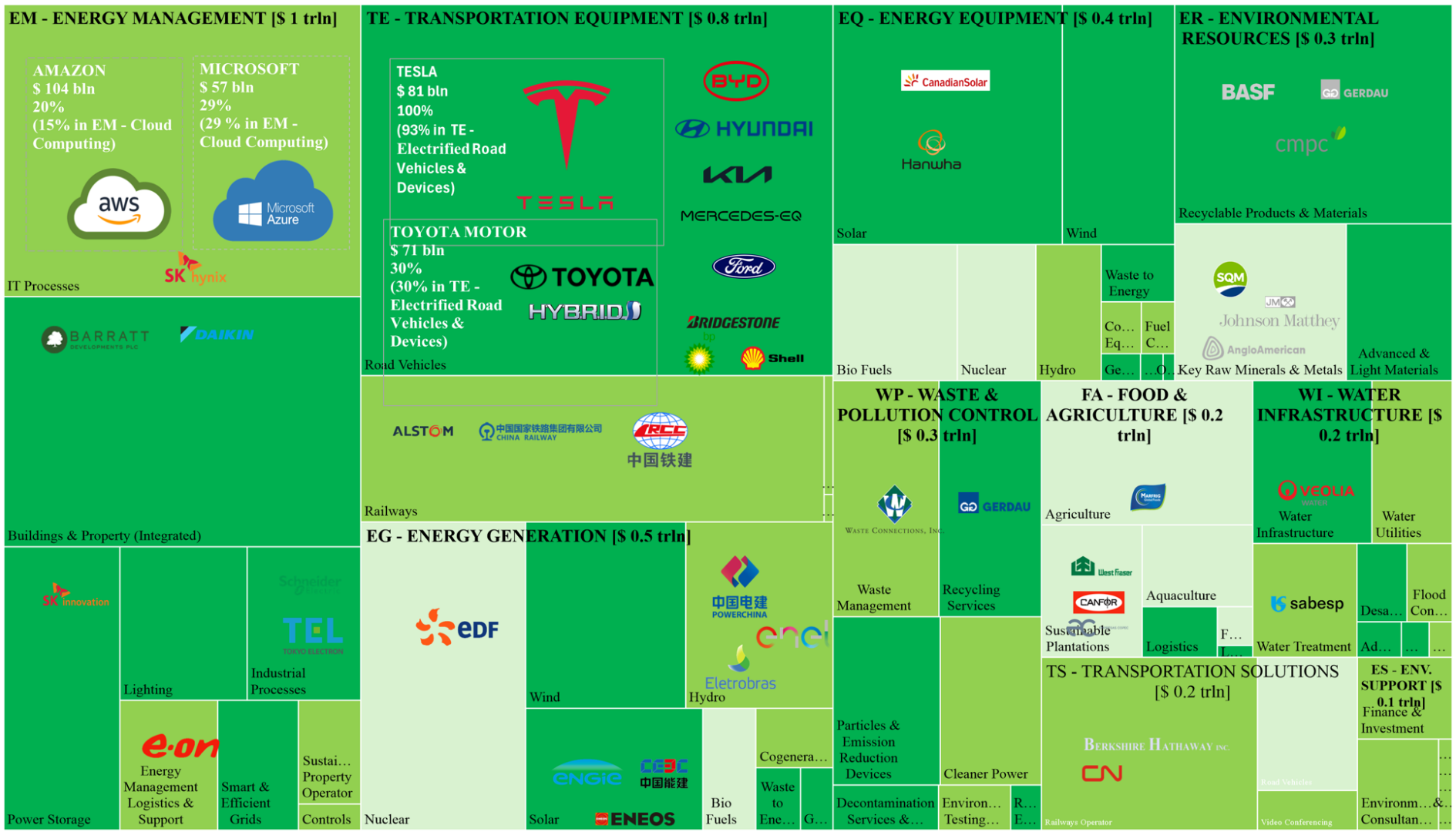
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Green Revenues in 2022: USD $4 trillion

- Data: FTSE Russell GRCS by **Tier 1**/**2**/**3** of greenness



Case Study

What's new with Green Revenue data?

% Green Revenues: the new measures of transition to green (overall, **Tier 1** and Midpoint %) exhibit low correlations with measures used in prior literature:

- (1) S&P Trucost: greenhouse gas (CO2-equivalent) emissions [ex: Bolton & Kacperczyk (2021, 2023)]
- (2) MSCI: industry-adjusted ESG scores or Pastor, Stambaugh & Taylor (2022) modified E-score:
  $EScore\ PST_{i,t} = -(10 - EScore_{i,t})\ x\ (EWeight_{i,t}/100)$]

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Green Revenues %	1							
(2) Midpoint %	0.844***	1						
(3) Tier 1 %	0.814***	0.692***	1					
(4) CO2 Int. Scope 1	0.042***	0.068***	0.011***	1				
(5) CO2 Int. Scope 2	0.013***	0.015***	0.003	0.067***	1			
(6) CO2 Int. Scope 3	0.066***	0.118***	0.085***	0.245***	0.067***	1		
(7) E-Score PST	-0.119***	-0.176***	-0.075***	-0.360***	-0.171***	-0.505***	1	
(8) Adj. ESG Score	0.085***	0.102***	0.092***	-0.101***	-0.015*	-0.01	0.272***	1

Correlations (Intensive Margin)

Main Findings

- **Q1**: How big is the green economy?
  - At the end of the sample period, USD $4 trillion green revenues (≈ Oil & Gas sector)
  - Concentrated in sectors such as Utilities and Transportation
  - Acceleration post Paris Agreement (ex: EU regulatory push)
- **Q2**: Do firms successfully commercialize their green innovations when incentives strengthen?
  - Firms with pre-existing green patents expand green revenues more strongly after Paris
  - This relation is driven by green product (rather than process) patents
- **Q3**: How do investors value green commercial activity?
  - Post-Paris green alpha is concentrated among U.S. firms with high green-revenue shares and pre-existing green patents
  - Consistent with Roy-style sorting: firms with existing green capabilities benefit more as green commercial opportunities become more profitable — Roy (1951); Cauthorn et al. (2024)

Literature

- Climate change and environmental concerns
  - Carbon emissions: Bolton & Kacperczyk (2021, 2023), Zhang (2024), Donadelli, Gruening & Hitzemann (2025)
  - Industrial pollution: Hsu, Li & Tsou (2023), Tian, Venugopal & Yerramilli (2023)
  - ESG/Environmental scores: Pastor, Stambaugh & Taylor (2022), Karolyi, Wu & Xiong (2023), Starks, Venkat & Zhu (2023)
- Green patents & R&D
  - Cohen, Gurun & Nguyen (2023), Hege, Pouget & Zhang (2024), Bolton, Kacperczyk & Wiedemann (2022)
- Greenium
  - Pastor, Stambaugh, & Taylor (2021, 2022), Zerbib (2022), D'Amico, Klausmann & Pancost (2024)
- Green taxonomies
  - Green revenues: Hoepner et al. (2024), Bassen et al. (2023, 2024), Lel (2024), Chiu, Hsu, Li & Tong (2026)
  - EUTSF: Hoepner et al. (2023), Sautner et al. (2022), Dai et al. (2023), Lambillon & Chesney (2023), Scheitza & Busch (2024), Giglio, Kuchler, Stroebel & Zeng (2023), Opp & Inderst (2025)

Beyond Just EU Green Taxonomy

ESG Today

Canada to Launch Sustainable Investment Taxonomy

The Government of Canada outlined a plan to develop a new sustainable investment taxonomy, a set of guidelines to help categorize sustainable economic...

Oct 10, 2024

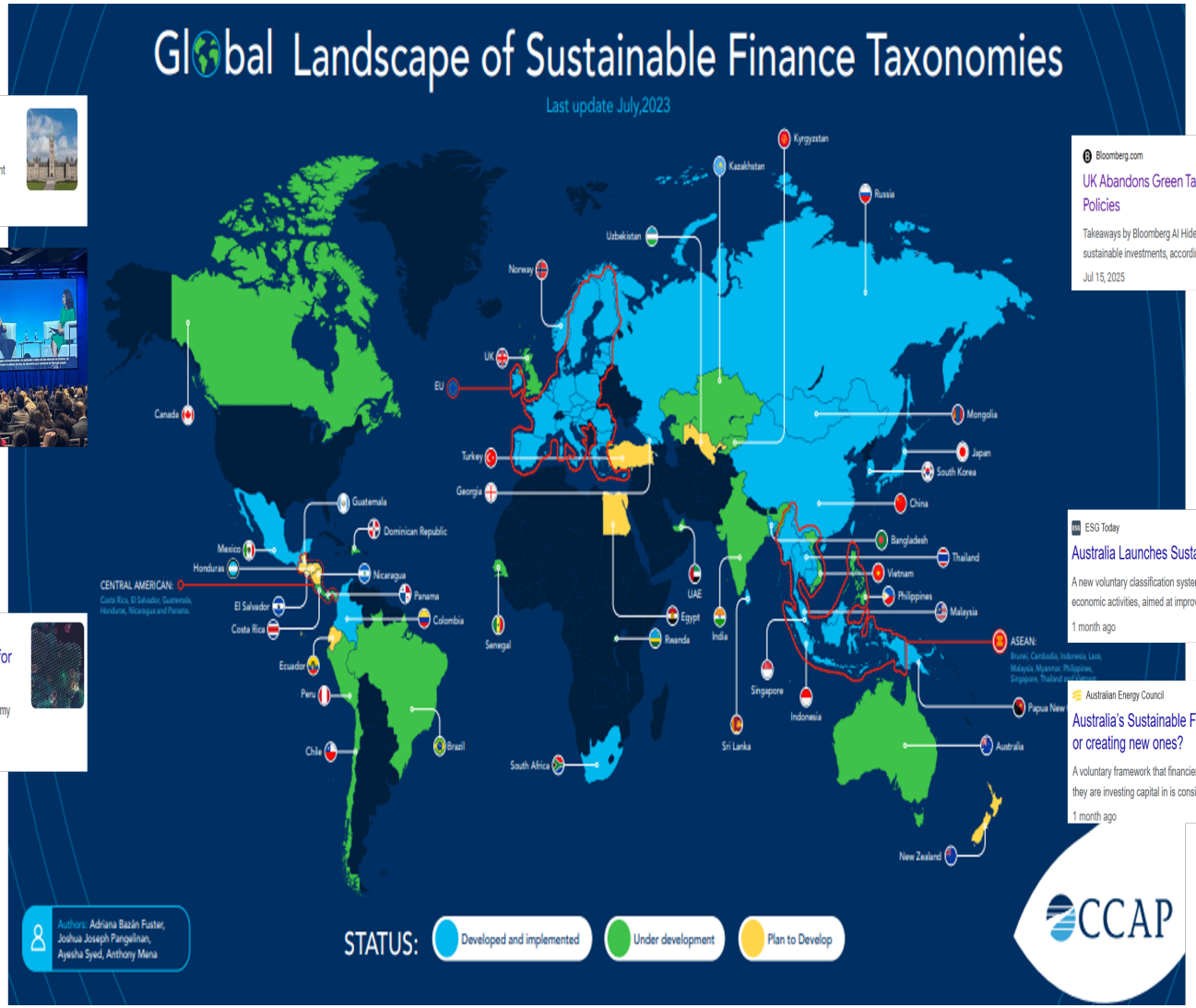


Latham & Watkins LLP

Brazil Publishes Draft Sustainable Taxonomy Framework for Public Consultation

In late 2024, Brazil published a draft of the country's proposed sustainable taxonomy framework (the Taxonomy), which the country aims to...

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UK Abandons Green Taxonomy Plan to Focus on Other Policies

Takeaways by Bloomberg AI Hide · The UK will not create its own framework for sustainable investments, according to a consultation document...

Jul 15, 2025



ESG Today

Australia Launches Sustainable Finance Taxonomy

A new voluntary classification system for categorizing green and transition-focused economic activities, aimed at improving transparency and facilitating...

1 month ago



Australian Energy Council

Australia's Sustainable Finance Taxonomy: Solving problems or creating new ones?

A voluntary framework that financiers and investors can use to ensure economic activity they are investing capital in is consistent with a 1.5°C trajectory.

1 month ago



Empirical Methodology

- Exploiting the **Dec 12, 2015 Paris Agreement** as a global shock and regime shift in commitments to environmental sustainability and expected climate risk regulations
- We are not the first to exploit the Paris Agreement: Seltzer, Starks & Zhu (2022) or Ramadorai & Zeni (2021)
- In our baseline regression, we test how "predetermined" corporate innovative capabilities (*GP*, green patents) *pre Paris* impact green revenues *post Paris:* Year $\geq$ 2016

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

- Validating the Paris Regime Shift

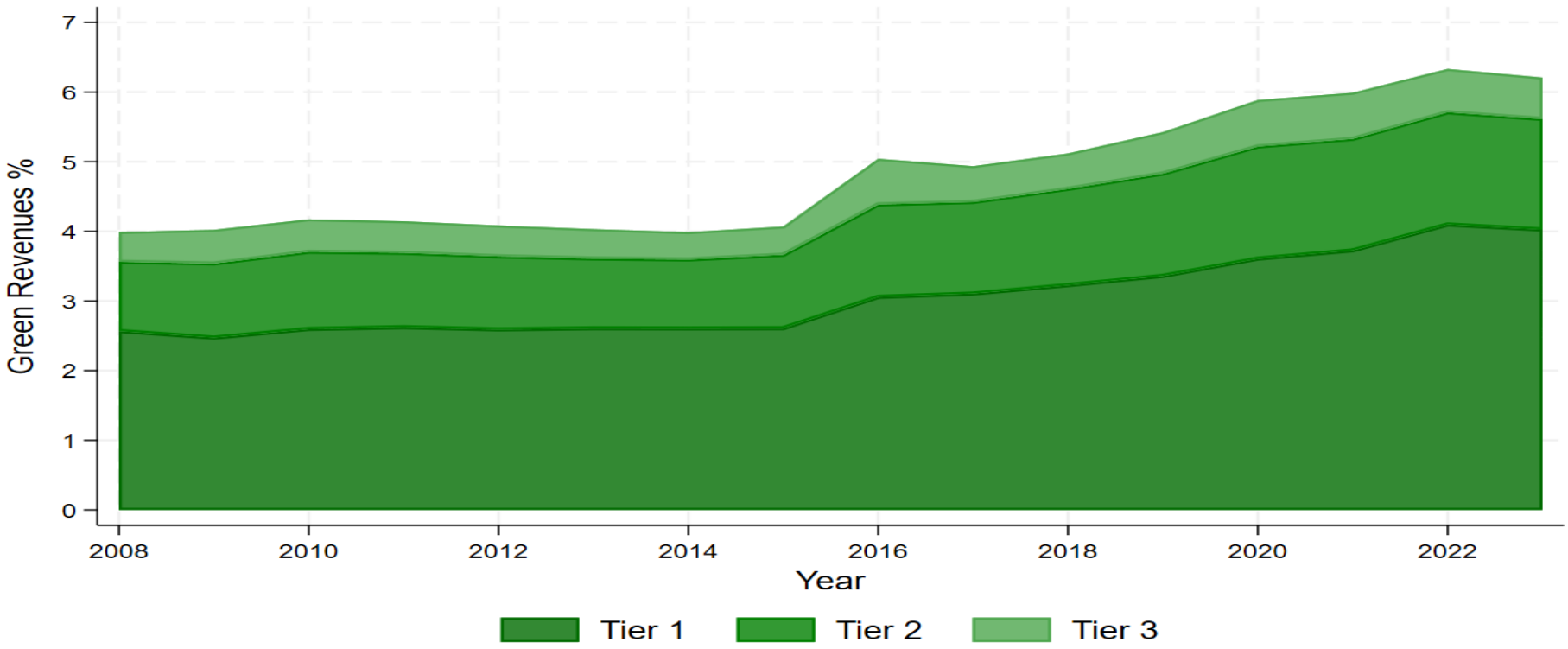
Expectations before the Paris Meeting | Regulatory and EU-Taxonomy Evidence | Institutional-Ownership Evidence | Cross Country and Consumer-Demand Evidence

Data

- Sample period: 2008 - 2023
- **Main variable:** *% Green Revenues*.
  - FTSE Russell: Green Revenues Classification System (GRCS) 2.0 data model [disclosed + company-specific estimates + sector estimates]; backfill point estimates from 2015 going back to 2008. 16,000 listed firms (min market cap USD $100 mln) from 48 developed + emerging markets (3,321 firms with revenues from green products and services)
  - Alternative: Min/Max midpoint estimates, Tier 1 green revenues, MSCI ESG Sustainable Impact Metrics - Environmental Impact
- **Additional variables:**
  - FactSet: financial variables, institutional ownership
  - Global Corporate Patent Dataset: Bena, Ferreira, Matos & Pires (2017) https://patents.darden.virginia.edu/ and mapping of green patents based on Hascic & Migotto - OECD, 2015 [used by Cohen et al. (2023), Hege et al. (2022), Atta-Darkua et al. (2022)]
  - IBES: analyst earnings estimates

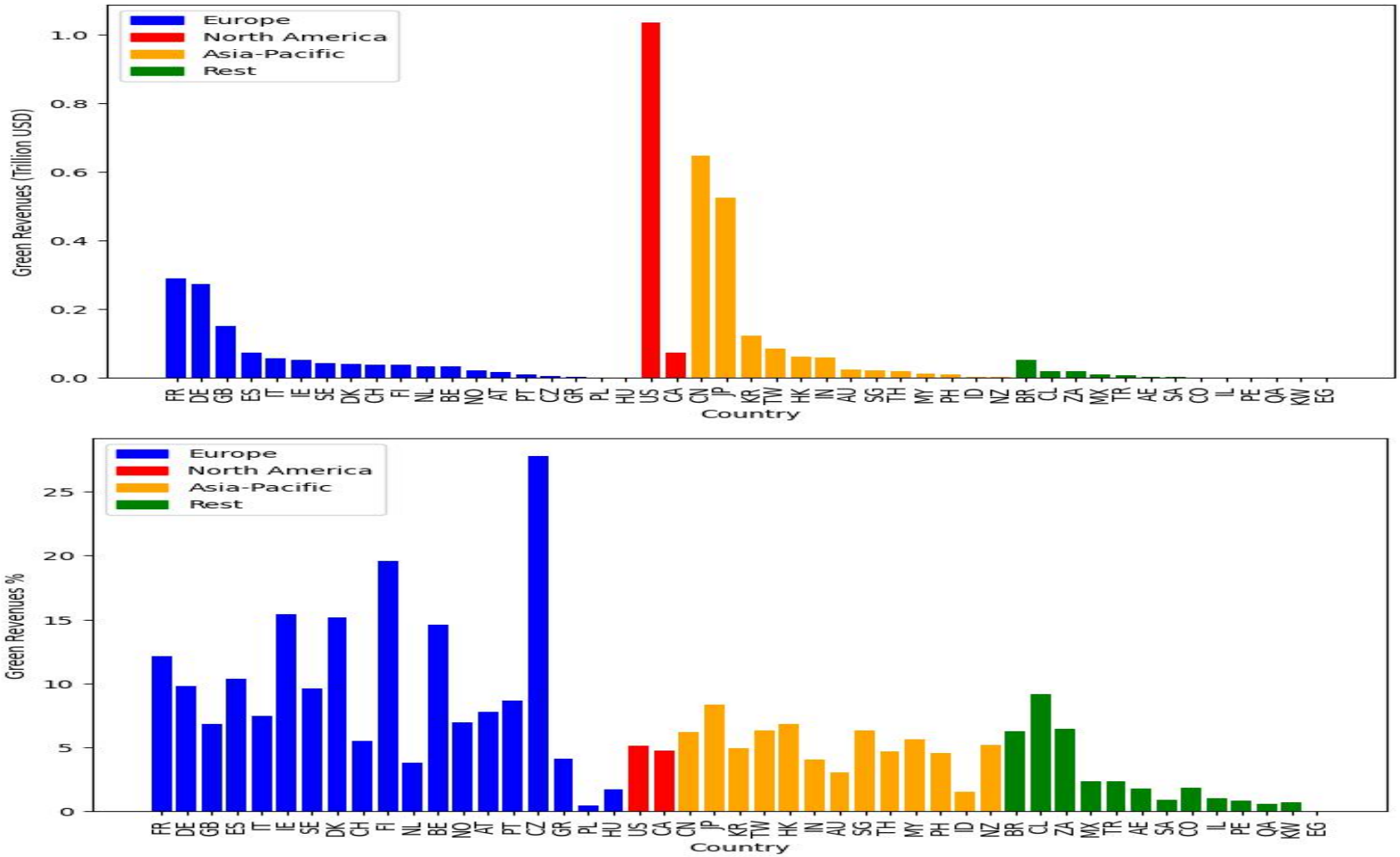
Q1: How Big is the Green Economy? (by "greenness")

- **Tier 1**: with significant and clear environmental benefits
- **Tier 2**: more limited but net-positive environmental benefits
- **Tier 3**: some environmental benefits but overall net-neutral or negative



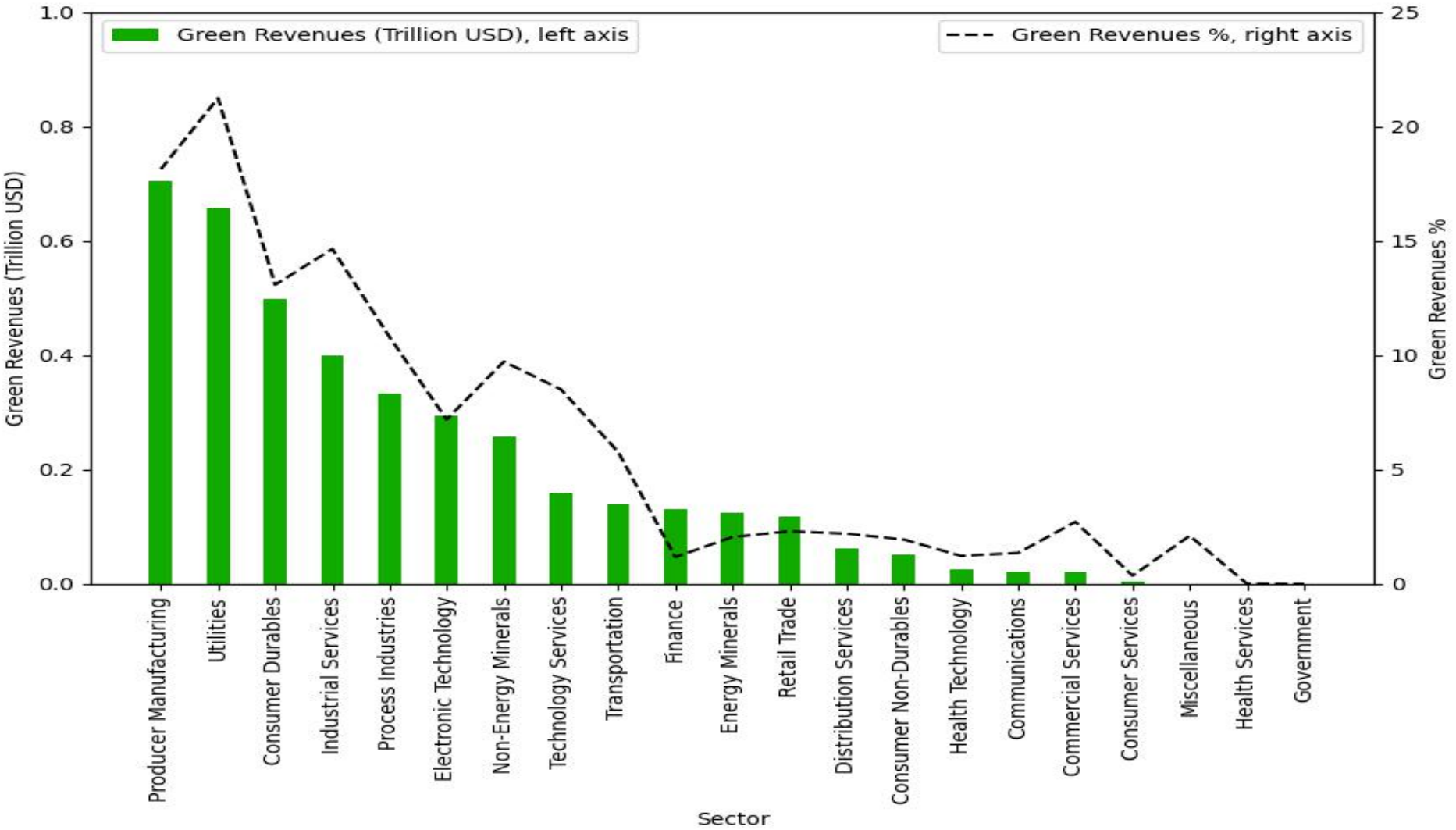
Q1: How Big is the Green Economy? (by geography)

Figure: Green Revenues by Country



Q1: How Big is the Green Economy? (by industry)

Figure: Green Revenues by Industry



Q2: Do Firms Successfully Commercialize Green Innovations?

- **Question:** Do firms with more green patents (GP) take these to market?

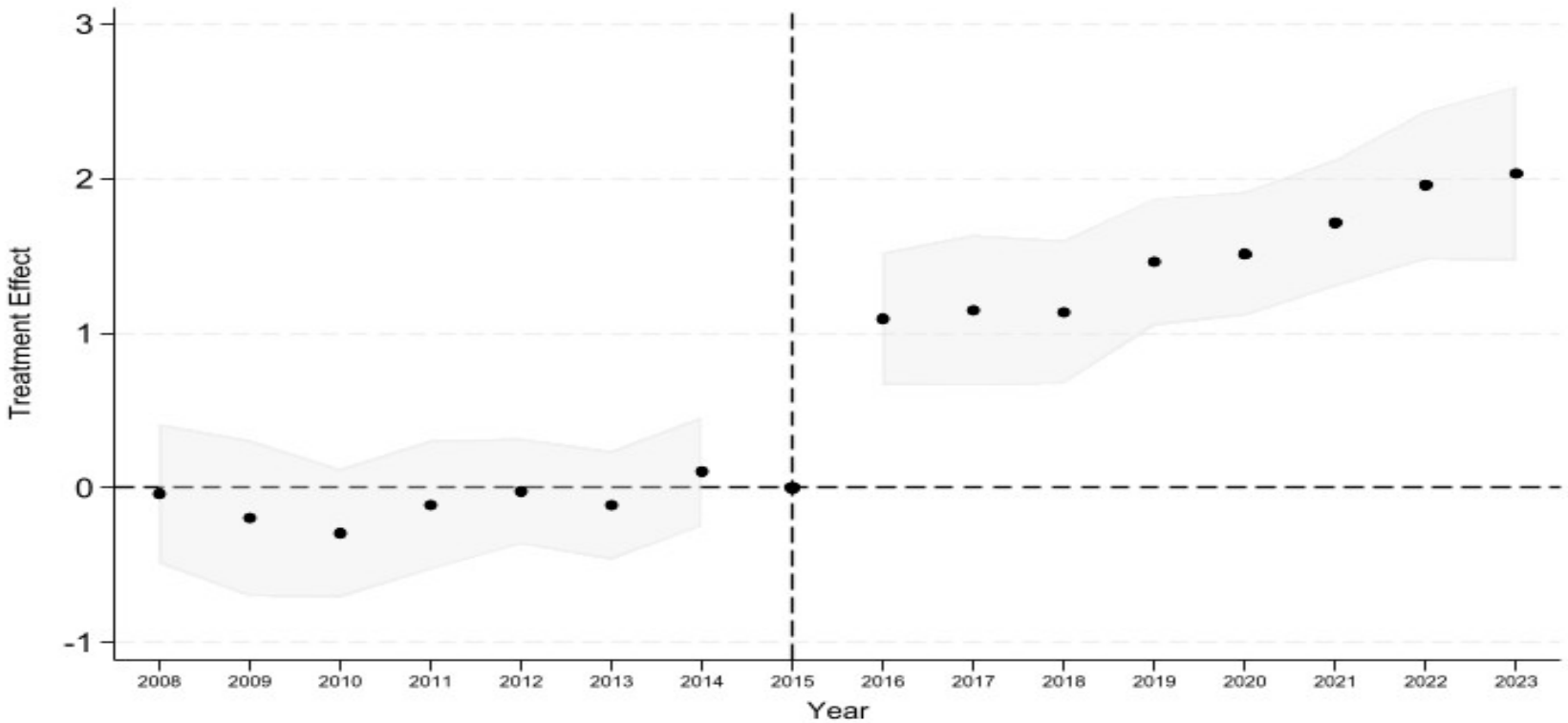
$$GR_{i,t} = \alpha + \beta_1 PostParis_t + \beta_2 GP_{i,preParis} + \beta_3 PostParis_t \times GP_{i,preParis} + \beta_n X_{i,t} + \mu_j + \theta_r + \tau_t + \epsilon_{i,t},$$

Dep. Variable	Green Revenues %	Midpoint Green Revenues %	Tier 1 Green Revenues %
Regressions	(1)	(2)	(3)
GP Indicator × Post Paris	1.558***	2.308***	1.209***
	(0.107)	(0.187)	(0.116)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes
Observations	264,658	264,658	264,658
Adjusted R^2	0.856	0.845	0.852

- **Economic magnitude:** firms with green patents *pre Paris* experienced a 1.6% larger increase in green revenues *post Paris*

Q2: Do Firms Successfully Commercialize Green Innovations? (**Trends**)

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



Intensive Margin USD Green Revenues Determinants of Green Revenues

Q2: Do Firms Successfully Commercialize Green Innovations? (**Regions & Energy**)

- **Questions:** How are green patents linked to green revenues in different regions? How does the energy sector react?

Dep. Variable	Green Revenues %			
Regressions	(1)	(2)	(3)	(4)
GP Indicator × Post Paris	1.476***	0.0109	1.862***	-1.002**
	(0.208)	(0.312)	(0.176)	(0.435)
Sample	USA	Europe	Asia-Pacific	Energy
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes	No
Country x Year FE	No	Yes	Yes	Yes
Observations	47,709	44,171	141,746	7,313
Adjusted R^2	0.911	0.840	0.838	0.673

Q2: Do Firms Successfully Commercialize Green Innovations? (**Product vs. Process Patents**)

- **Question:** Do product or process patents drive the results?

Dep. Variable	Green Revenues %	Midpoint %	Tier 1 %
Regressions	(1)	(2)	(3)
GP Process × Post Paris	-0.999***	-0.316	-1.141***
	(0.181)	(0.294)	(0.190)
GP Product × Post Paris	2.232***	2.534***	1.980***
	(0.157)	(0.224)	(0.160)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes
Observations	264,658	264,658	264,658
Adjusted R^2	0.856	0.845	0.852

Q2: Do Firms Successfully Commercialize Green Innovations? (**Placebo Test**)

- **Question:** Are results driven by green (or any type of) innovation?

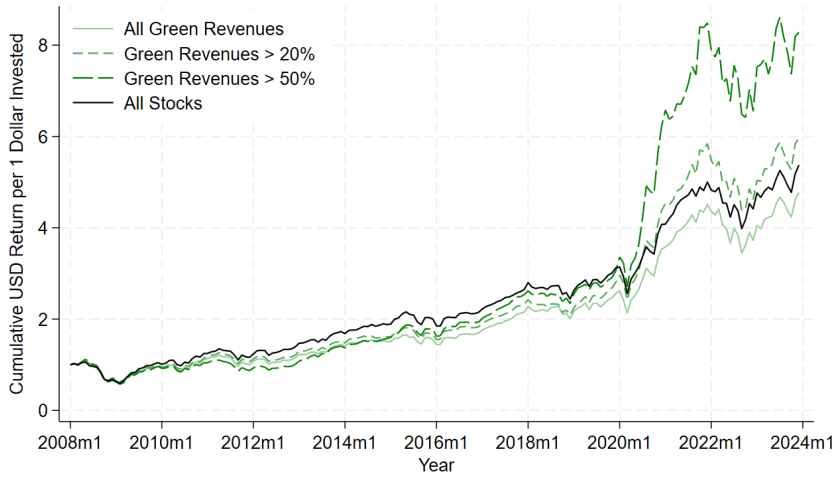
Dep. Variable	Green Revenues %	Midpoint Green Revenues %	Tier 1 Green Revenues %
Regressions	(1)	(2)	(3)
GP Indicator × Post Paris	2.052***	2.558***	1.702***
	(0.128)	(0.198)	(0.134)
Any Patent Indicator × Post Paris	-0.601***	-0.304***	-0.598***
	(0.0963)	(0.117)	(0.0659)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes
Observations	264,658	264,658	264,658
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- Green innovation (not any type of patents) drives green revenues

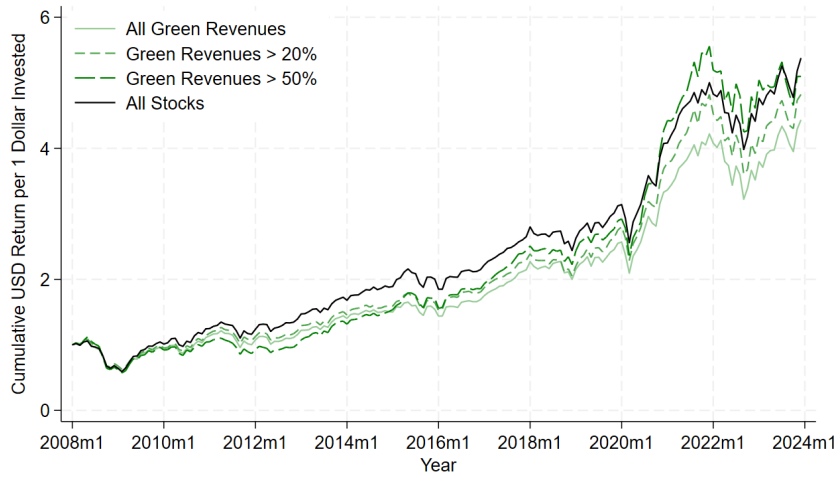
Q2: Do Firms Successfully Commercialize Green Innovations? (**Robustness**)

- **Alternative green revenue measures**
  - Midpoint Green Revenues and Tier 1 Green Revenues
  - EU Taxonomy-eligible green revenues
  - EU Taxonomy-aligned reported revenues MSCI green revenues
- **Alternative measures of green innovation**
  - Number and share of green patents
  - Patent influence based on green patent citations
- **Extensive vs. intensive margin**
  - Green innovators are more likely to enter green-revenue activities post Paris
  - Green revenues in USD also increase while legacy revenues do not decrease
- **Sample and specification robustness**
  - Balanced panel and alternative FTSE coverage restrictions
  - Intensive margin including only firms that already have some green revenues pre Paris
  - Results robust to alternative fixed effects and controls

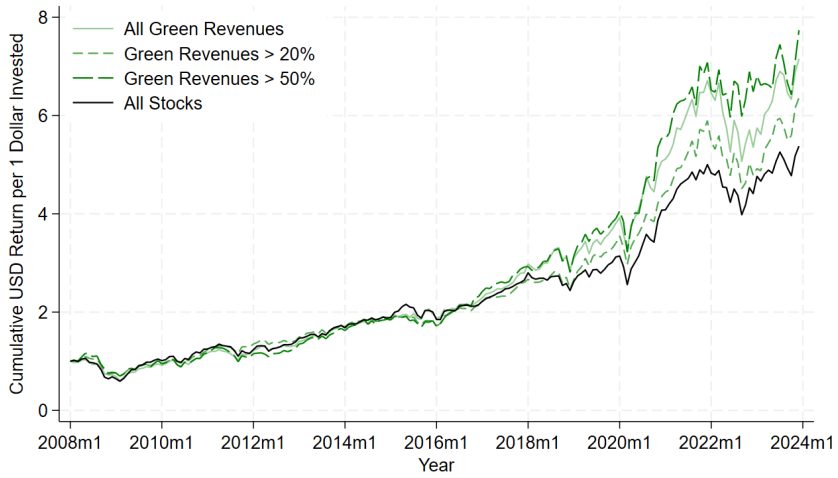
Do Investors Value Green Revenues?



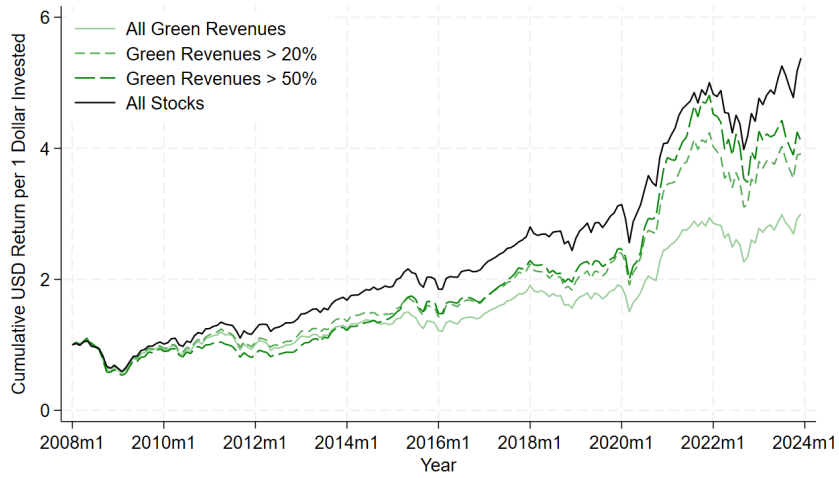
(a) Global



(b) Global ex. Tesla



(c) US ex. Tesla



(d) Rest of the World

Q3: Do Investors Value Green Revenues? (**U.S. Event Study Around Paris**)

- **Question:** Is any potential green alpha driven by Covid (2020) or did investor revalue green relative to legacy stocks around Paris (Dec 12, 2015)?

Event window	$[-1, +1]$	$[-3, +3]$	$[-5, +5]$	$[-10, +10]$
Green revenue share $>$ 0% **and green patent**				
Non-green CAR	-1.87***	-1.80***	-4.04***	-2.74***
	(0.10)	(0.15)	(0.21)	(0.25)
High-green + patent CAR	-1.61***	-1.91***	-4.41***	-1.77**
	(0.29)	(0.54)	(0.69)	(0.75)
High minus low	0.26	-0.10	-0.37	0.97
	(0.31)	(0.56)	(0.72)	(0.79)
Green revenue share $>$ 20% **and green patent**				
High-green + patent CAR	-0.63	0.57	-1.82	1.26
	(0.58)	(1.20)	(1.57)	(1.61)
High minus low	1.25**	2.37**	2.22	4.00**
	(0.59)	(1.21)	(1.58)	(1.63)
Green revenue share $>$ 50% **and green patent**				
High-green + patent CAR	-0.32	2.95	1.44	5.10*
	(1.12)	(2.34)	(3.04)	(3.01)
High minus low	1.56	4.76**	5.48*	7.84***
	(1.12)	(2.35)	(3.05)	(3.02)
Green revenue share $>$ 80% **and green patent**				
High-green + patent CAR	0.84	5.76*	5.75	7.70*
	(1.56)	(3.23)	(4.11)	(4.25)
High minus low	2.71*	7.56**	9.79**	10.44**
	(1.57)	(3.24)	(4.11)	(4.26)

Q3: Do Investors Value Green Revenues? (Calendar-Time Portfolio Tests)

Panel A: Green Minus Legacy (GML)				
Portfolio	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
Alpha	-0.199**	-0.0219	0.135	0.595*
	(0.0941)	(0.120)	(0.191)	(0.302)
Pre Paris	-0.409***	-0.292*	-0.286	-0.0426
	(0.129)	(0.151)	(0.192)	(0.283)
Post Paris	0.00602	0.242	0.546*	1.218***
	(0.120)	(0.169)	(0.297)	(0.463)
2008: Nr firms	1,462	493	221	129
Total USD trln	$7.79	$2.00	$0.70	$0.25
2023: Nr firms	2,687	985	496	290
Total USD trln	$32.60	$10.60	$4.27	$2.41
Panel B: Midpoint Green Minus Legacy (GML)				
Portfolio	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
Alpha	-0.191**	-0.165	0.289	0.679*
	(0.0928)	(0.107)	(0.200)	(0.349)
Pre Paris	-0.382***	-0.394***	-0.148	0.125
	(0.125)	(0.146)	(0.246)	(0.328)
Post Paris	-0.00333	0.0583	0.715**	1.219**
	(0.120)	(0.142)	(0.299)	(0.550)
Panel C: Tier 1 Green Minus Legacy (GML)				
Portfolio	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
Alpha	-0.266**	0.0844	0.446	1.082**
	(0.103)	(0.182)	(0.277)	(0.482)
Pre Paris	-0.503***	-0.279	-0.0204	0.202
	(0.142)	(0.199)	(0.259)	(0.457)
Post Paris	-0.0355	0.439	0.901**	1.942***
	(0.133)	(0.275)	(0.445)	(0.743)

Q3: Do Investors Value Green Revenues (**Calendar-Time Portfolio Tests: Sub-Samples**)?

- **Questions:** Is "green alpha" concentrated in certain regions? How does the energy sector react?

GR Portfolio	$>$ 0%	$>$ 20%	$>$ 50%	$>$ 80%
Sample		Panel A: United States		
Pre Paris	-0.308*	-0.380**	-0.331	0.0575
	(0.159)	(0.173)	(0.318)	(0.417)
Post Paris	0.126	0.394	1.319**	1.859**
	(0.183)	(0.252)	(0.538)	(0.716)
Sample		Panel B: Europe		
Pre Paris	-0.575***	-0.589***	-0.821***	-0.251
	(0.158)	(0.180)	(0.276)	(0.334)
Post Paris	-0.130	-0.0152	0.117	0.0518
	(0.124)	(0.171)	(0.210)	(0.268)
Sample		Panel C: Asia-Pacific		
Pre Paris	-0.423**	-0.0586	0.0589	0.347
	(0.187)	(0.215)	(0.214)	(0.389)
Post Paris	-0.0870	0.0950	0.0913	0.555
	(0.167)	(0.248)	(0.309)	(0.339)
Sample		Panel D: Energy		
Pre Paris	-0.220	-0.0574	-	-
	(0.306)	(0.630)	-	-
Post Paris	-0.443	0.429	-	-
	(0.278)	(0.876)	-	-

Q3: Do Investors Value Green Revenues (Calendar-Time Portfolio Tests: GP Indicator = 1)?

- **Questions:** Is "green alpha" stronger when firms commercialize pre-existing green innovations when their relative value increases?

	Firms with Pre-Paris GP Indicator = 1			
Variable	Green Revenue Threshold			
Portfolio	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
	Panel A: Global			
Pre Paris	-0.428**	-0.319	-0.195	0.0917
	(0.193)	(0.219)	(0.335)	(0.542)
Post Paris	0.0986	0.399	1.026**	2.177***
	(0.190)	(0.254)	(0.518)	(0.797)
	Panel B: United States			
Pre Paris	-0.311*	-0.288	-0.180	0.221
	(0.179)	(0.204)	(0.381)	(0.493)
Post Paris	0.181	0.477*	1.596**	2.014**
	(0.212)	(0.284)	(0.659)	(0.796)

Q3: Do Investors Value Green Revenues? (**Channels: Cash flows vs. Discount rates**)

Q3.a) Cash flows: Is the market surprised by earnings of green revenues?

Q3.b) Discount rates: What are the expected green excess returns?

Dep. Variable	Earnings Surprise		Implied Cost of Capital		Alternative ICC	
Sample	Global	US	Global	US	Global	US
Regression	(1)	(2)	(3)	(4)	(5)	(6)
Lagged Green Revenues %	-0.0139	-0.0168**	-0.108	0.223	-0.149	-0.0969
	(0.00863)	(0.00743)	(0.685)	(0.622)	(0.525)	(0.569)
Lagged Green Revenues % × Post Paris	0.0147**	0.0136***	-0.0894	-0.301	-0.0980	-0.303
	(0.00678)	(0.00523)	(0.277)	(0.341)	(0.258)	(0.330)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	24375	15628	16485	11327	24375	15628
Adjusted R^2	0.196	0.176	0.586	0.593	0.545	0.546

Answer Q3.a): Some evidence of mispricing in stocks with high green revenues (as in Atilgan, Edmans, Gunaydin & Gunaydin (2023))

Answer Q3.b): No shift post Paris in implied cost of capital

Q3: Do Investors Value Green Revenues? (**Channels: Shocks to Climate Concerns**)

Q3.c) Are green returns driven by unexpected shocks to environmental concerns (using the Media Climate Change Concerns Index proposed by Ardia et al. (2022)?

Variable	Green Minus Legacy %			
Portfolio	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
Prediction Error	0.708**	1.020***	2.105***	2.803***
	(0.318)	(0.384)	(0.576)	(0.856)
Observations	192	192	192	192
Adjusted R^2	0.029	0.038	0.074	0.063

Answer Q3.c): Positive abnormal green returns when investors are more concerned about the environment (consistent with Pastor, Stambaugh & Taylor (2022))

Before I conclude ;-) ... join the Principles for Responsible Investments (PRI) Academic Network

PRI PRINCIPLES FOR RESPONSIBLE INVESTMENT

https://www.unpri.org/about-PRI/academic-network



Date	Topic	Speaker/moderator
13 January 2026 (9-10.30pm SGT/1-2.30pm GMT) Online	Carbon transition risk	Marcin Kacperczyk, Professor of Finance, Imperial College London Moderator tbc
10 February 2026 (9-10.30pm SGT/1-2.30pm GMT) Online	Nature and biodiversity loss: Economic and financial implications	Johannes Stroebel, David S Loe Professor of Finance, New York University Moderator tbc
10 March 2026 (7.30-9pm SGT) Hybrid	TBC	Adriana Robertson, Donald N Pritzker Professor of Business Law, University of Chicago Moderator tbc
14 April 2026 (9-10.30pm SGT/1-2.30pm GMT) Online	TBC	Jeffrey York, Professor of Strategy and Entrepreneurship, University of Colorado Moderator tbc
11 August 2026 (6.30-8pm SGT) Hybrid	TBC	Shivaram Rajgopal, Roy Bernard Kester and TW Burnes Professor of Accounting and Auditing, Columbia University Moderator tbc
8 September 2026 (6.30-8pm SGT) Online	TBC	Witold Henisz, Deloitte & Touche Professor of Management in Honor of Russell E Palmer, University of Pennsylvania Moderator tbc
13 October 2026 (9-10.30pm SGT) Online	TBC	Renee Adams, Professor of Finance, University of Oxford Moderator tbc
10 November 2026 (6.30-8pm SGT) Hybrid	TBC	Caroline Flammer, A Barton Hepburn Professor of Economics, Columbia University Moderator tbc

NBS-PRI-ECGI
Public Lecture series



https://www.ecgi.global/events/series/nbs-pri-ecgi-public-lecture-series

One free ticket left! ... anyone interested in attending PRI in Person (Amsterdam, Oct 12-15)? Let Me Know!



Academic Network Conference at PRI in Person
Thu, 15 Oct (8:00-10:00 am)
Co-chairs: **Pedro Matos** (U of Virginia) and **Laura Starks** (UT Austin)

1 ***Investor Democracy***
Presenter: **Rob Bauer** (Maastricht U, co-authored with Emmeline Cooper, Bram van der Kroft and Paul Smeets)
Academic discussant: **Ayako Yasuda** (UC Davis)
Practitioner discussant: **Barbara Zvan** (CEO, University Pension Plan Ontario)

2 ***What is the Carbon Premium a Premium On?***
Presenter: **Marcin Kacperczyk** (Imperial College)
Academic discussant: **Zacharias Sautner** (U of Zurich)
Practitioner discussant: **Jason Mitchell** (CIO for Responsible Investment. Man Group)

3 **Lucian Peppelenbos** (Robeco) will be awarding the winners of our research awards
- Best Paper: ***Powering AI: How Do Data Centers Affect Renewable Energy Investment?***
Presenter: **Alexander Heiss** (TMU, co-authored with Zacharias Sautner and Thomas Schmid)
- Best Ph.D Paper: ***Can Investor Coalitions Drive Corporate Climate Action?***
Presenter: **Nikolaus Hastreiter** (Imperial)
Discussant: **Marie Brière** (Head of Investor Intelligence & Academic Partnerships, Amundi Investment Institute)

Conclusions

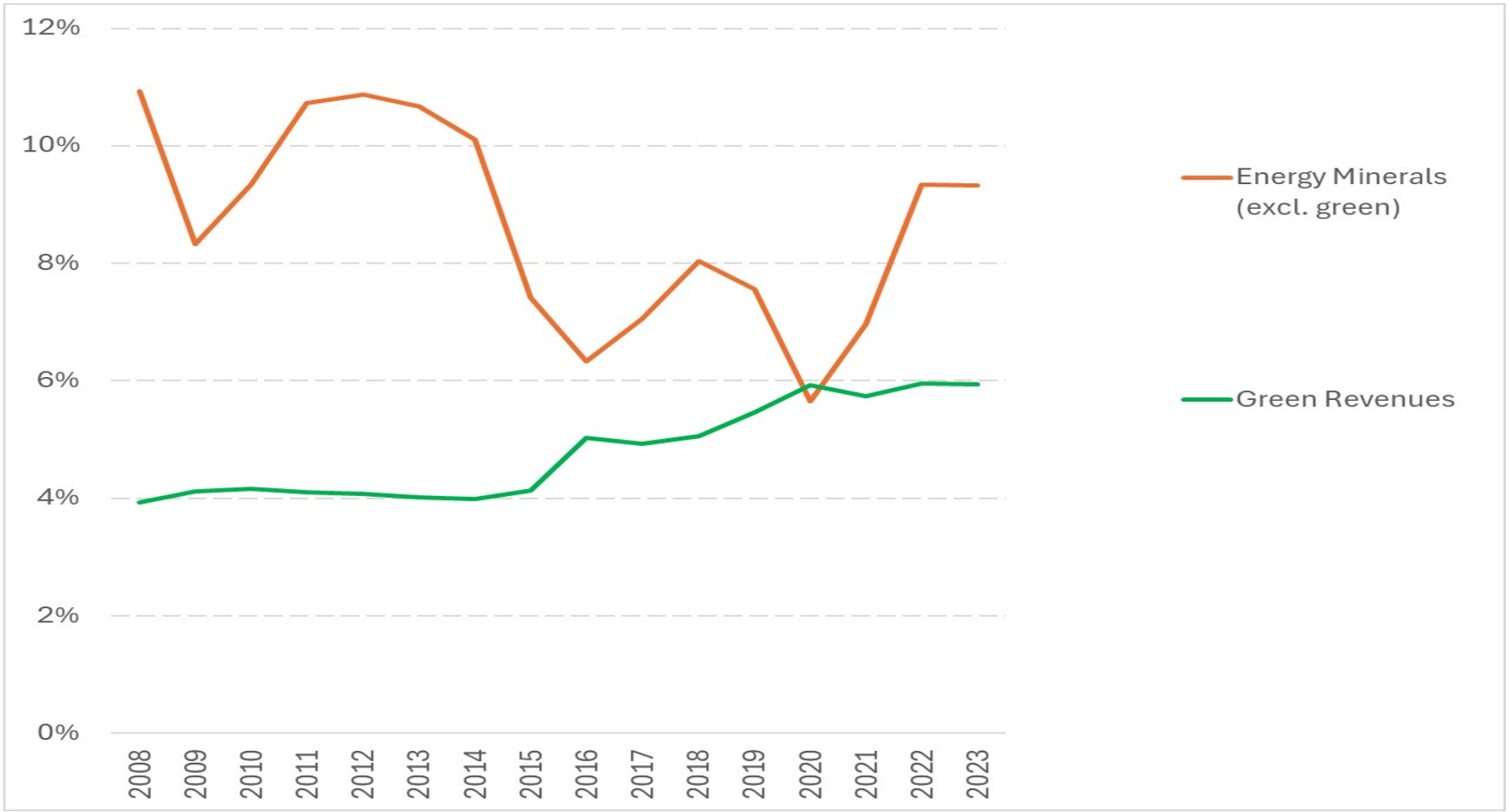
- **Green economy accelerating post 2015 Paris Agreement**
- Innovative **(US) firms with green patents** can effectively translate these patents into tangible green revenues
- Evidence of **"green alpha"** limited to US firms with high green revenues in the post Paris period

Appendix

Data (cont.): FTSE Russell GRCS Top Green Revenue Firms by Region

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	EDF $ 97 bln 64% (52% in EG - Nuclear)	VEOLIA $ 42 bln 93% (33 % in WI - Water Utilities)	Schneider Electric $ 26 bln 72% (23% in EM - Industrial 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-EQ $ 30 bln 19% (15% in TE - Electrified Road Vehides & 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 Vehides & Devices)	Johnson Matthey $ 21 bln 94% (76% in ER - Platinum)	bp $ 9 bln 4% (4% in TE - Electrified Road Vehicles & Devices)	AngloAmerican $ 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 INC $ 28 bln 10% (7% in TS - Railways Operator)	Ford $ 21 bln 13% (13 % in TE - Electrified Road Vehicles & Devices)
	Canada	450	$ 0.026	2.3	457	$ 0.073	4.7	CN $ 12 bln 91 % (91 % in TS - General Railways)	Ellert Fraser $ 9 bln 92% (92% in FA - Sustainable Forestry)	CanadianSolar $ 7 bln 100% (83% in EQ - Solar)	$ 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	中国国家铁路集团有限公司 CHINA RAILWAY $ 60 bln 35% (35% in TE - Railway)	中国中车 $ 34 bln 21% (20% in TE - Railway)	中国华能 $ 25 bln 30% (8% in EQ - Hydro)	BYD $ 24 bln 38% (14% in TE - Electrified Road Vehicles & Devices)	CGNPC $ 23 bln 43% (5% in EQ - Solar)
	Japan	1,808	$ 0.370	5.7	1,956	$ 0.526	8.4	TOYOTA $ 71 bln 30% (30% in TE - Electrified Road Vehides & 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 Vehides & Devices)	HYUNDAI $ 12 bln 11% (11% in TE - Electrified Road Vehicles & Devices)	SK Hynix $ 10 bln 28% (28% in EM - Efficient IT)	Samsung $ 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	$ 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)	Eletrobras $ 4 bln 56% (53% in EG - Hydro)	GERDAU $ 3 bln 20% (20% in WP - Recyding Services)
	Chile	165	$ 0.011	6.8	160	$ 0.020	9.2	SQM $ 4 bln 41% (33% in ER - Lithium)	CC $ 4 bln 12% (12% in EA - Sustainable Forestry)	enel $ 3 bln 17% (10% in EG - Hydro)	enel $ 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					

What is the Size of the Non-Green Energy Sector?



Green Business Activities

How Does FTSE Russell Evaluate Corporate (Green) Revenues? (1/2)

Green Revenue Breakdown

Company X categorizes its business into eight segments – some of which are green in their entirety and others which combine green and non-green activities and reports revenues.

Green segments include Renewable Energy, Energy Efficient Lighting, and Locomotive Manufacturing, providing 9.7% of company revenues and the minimum green revenue. Additional Power and Transportation segments contain green and non-green activities and account for 24.2% of company revenues.

By adding all revenue from these segments to the fully green segments already identified, the maximum green revenue is established as 33.9%. Company X therefore has a minimum and maximum green revenue range of 9.7% and 33.9%.

Green Business Activities

How Does FTSE Russell Evaluate Corporate (Green) Revenues? (2/2)

Green Revenue Breakdown

Information such as technology types, numbers of product lines, and revenues at acquisition are then used to estimate green revenues from the power and transportation segments at 5.9% and 0.8%, respectively. Adding this to the revenue from the fully green segments yields the more precise company-specific green revenue estimate of 16.4%.

Because all of Company X's activities that qualify under the GRCS are also eligible under the EU Taxonomy, this also represents the estimate of Company X's EU taxonomy-aligned revenue.

Green Business Activities

Expectations before the Paris Agreement

Figure: Source: BBC (Sep 16, 2015)

Paris climate summit: Don't mention Copenhagen

Figure: Source: Forbes (Nov 30, 2015)

FORBES > BUSINESS > POLICY

The Paris Climate Summit Will Fail, For A Pretty Simple Reason

Paris Shock

Regulatory and Consumer-Demand Evidence

- **Question:** Is the post Paris growth in green revenues driven by more stringent regulation or higher consumer demand?

Regressions	(1)	(2)	(3)	(4)	(5)
			Green Revenues		
EPI	0.0352***	0.0672***			
	(0.0135)	(0.0145)			
EPI × Post Paris		0.0186***			
		(0.00288)			
IVS			-0.0277	-3.814**	-1.660
			(0.970)	(1.553)	(1.531)
Domestic Sales				-0.0423***	-0.0285***
				(0.00677)	(0.00671)
IVS × Domestic Sales				0.0493***	0.0263*
				(0.0152)	(0.0148)
IVS × Post Paris					-7.511***
					(2.301)
Domestic Sales × Post Paris					-0.0441***
					(0.0124)
IVS × Dom. Sales × Post Paris					0.0777***
					(0.0274)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	216,232	216,232	233,171	227,420	227,420
Adjusted R^2	0.069	0.069	0.069	0.070	0.070

The Paris Regime Shift

Supply Side: European Evidence

- **Question:** Did the regulatory push in Europe lead to more green revenues?
- Post Paris ($\geq$ 2016); Post TEG ($\geq$ 2018: creation of Technical Expert Group); Post EUTSF ($\geq$ 2020: roll out of EUTSF)

Regressions	(1)	(2)	(3)	(4)
		Green Revenues %		
Europe × Post Paris	0.983***			0.477***
	(0.128)			(0.138)
Europe × Post TEG		1.063***		0.459***
		(0.141)		(0.154)
Europe × Post EUTSF			1.042***	0.355*
			(0.184)	(0.201)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	267,576	267,576	267,576	267,576
Adjusted R^2	0.072	0.072	0.072	0.072

- **Economic magnitude:** *Europe* × *Post Paris*, firms based in Europe exhibit on average 1% higher green revenues *post Paris*
- **Robustness:** EU only, propensity score matching, green revenues tiers, EPI measuring a country's stringency of its environmental policies

The Paris Regime Shift

Market Demand: Institutional Ownership

- **Question:** Is (green) institutional ownership linked to green revenues?

Dep. Variable	Green Revenues %			
Regressions	(1)	(2)	(3)	(4)
IO Total Pre Paris × Post Paris	2.334***			
	(0.254)			
IO PRI Pre Paris × Post Paris		3.706***		
		(0.437)		
IO CDP Pre Paris × Post Paris			4.237***	
			(0.534)	
Turnover Pre Paris × Post Paris				-2.235***
				(0.343)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes	Yes
Observations	202,930	202,930	202,930	208,992
Adjusted R^2	0.860	0.860	0.860	0.853

- Responsible (IO PRI, Gibson et al. (2022)), Climate-aware (IO CDP, Atta-Darkua et al. (2024)) and Longer-term (Starks et al. (2024))

The Paris Regime Shift

Summary Statistics

Variable	N	Mean	SD	Min	Median	Max
Green Revenues %	267,576	3.3666	13.8646	0.0000	0.0000	100.0000
Green Revenues Dummy	267,576	0.1373	0.3441	0.0000	0.0000	1.0000
Tier 1 Green Revenues %	267,576	2.1078	10.4023	0.0000	0.0000	100.0000
Tier 2 Green Revenues %	267,576	0.9828	7.0425	0.0000	0.0000	100.0000
Tier 3 Green Revenues %	267,576	0.2362	3.4485	0.0000	0.0000	100.0000
EUTSF Green Revenues %	267,576	2.5576	11.7089	0.0000	0.0000	100.0000
Post 2016	267,576	0.5306	0.4991	0.0000	1.0000	1.0000
Post 2018	267,576	0.3923	0.4883	0.0000	0.0000	1.0000
Post 2020	267,576	0.2570	0.4370	0.0000	0.0000	1.0000
All Patents	267,576	1.9515	9.5517	0.0000	0.0000	65.5000
Green Patents	267,576	0.0948	0.5176	0.0000	0.0000	3.6667
Green Patents / All Patents	267,576	0.0056	0.0302	0.0000	0.0000	0.2222
Green Patents Dummy	267,576	0.0554	0.2287	0.0000	0.0000	1.0000
Total Assets USD	267,576	12.4658	109.2394	0.0000	0.8245	12822.25
Total Sales USD	267,576	3.1190	13.4602	0.0000	0.4323	592.46
Green Revenues USD	267,576	0.1550	1.4778	0.0000	0.0000	102.55
Market Value USD	267,576	3.7128	21.7784	0.1000	0.6045	2490.54
Tobin's Q	267,576	1.8913	1.7600	0.5450	1.2903	17.0187
Leverage	267,576	0.2278	0.1937	0.0000	0.1972	0.8445
ROA	267,576	0.0627	0.0956	-0.4682	0.0596	0.4022
Cash	267,576	0.1750	0.1730	0.0003	0.1203	0.8717
CAPEX	267,576	0.0396	0.0478	0.0000	0.0241	0.3426
R&D	267,576	0.0143	0.0378	0.0000	0.0000	0.2825
Europe	267,576	0.1670	0.3730	0.0000	0.0000	1.0000
North America	267,576	0.2125	0.4091	0.0000	0.0000	1.0000
Asia-Pacific	267,576	0.5345	0.4988	0.0000	1.0000	1.0000
Rest of the World	267,576	0.0860	0.2803	0.0000	0.0000	1.0000
Pre-Paris IO	220,241	0.2180	0.2834	0.0000	0.0909	1.0000
Pre-Paris IO CDP	220,241	0.0787	0.1077	0.0000	0.0281	0.5774
Pre-Paris IO PRI	220,241	0.1031	0.1402	0.0000	0.0405	0.7584
Pre-Paris IO Climate 100+	220,241	0.0787	0.1077	0.0000	0.0281	0.5774
Pre-Paris Turnover	209,056	0.2740	0.1673	0.0202	0.2089	1.4532

Determinants of Green Revenues

Regressions	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln(Sales)	0.820***	0.818***	0.816***	0.787***	0.736***	0.794***	0.744***
	(0.0324)	(0.0311)	(0.0313)	(0.0330)	(0.0375)	(0.0315)	(0.0359)
Tobin's Q		0.176***	0.131***	0.167***	0.196***	0.118***	0.142***
		(0.0241)	(0.0250)	(0.0258)	(0.0227)	(0.0239)	(0.0235)
Leverage		2.214***	2.044***	0.933***	0.975***	2.070***	0.894***
		(0.216)	(0.212)	(0.158)	(0.167)	(0.221)	(0.161)
ROA		-2.542***	-2.592***	-2.644***	-2.882***	-2.462***	-2.574***
		(0.331)	(0.341)	(0.376)	(0.367)	(0.346)	(0.360)
Cash		-1.737***	-1.737***	-1.252***	-1.009***	-1.518***	-0.846***
		(0.186)	(0.189)	(0.173)	(0.220)	(0.194)	(0.188)
CAPEX			9.786***	9.826***	11.37***	10.17***	10.48***
			(1.153)	(1.064)	(1.093)	(1.144)	(1.099)
R&D			4.660***	6.481***	1.091	3.089***	3.121**
			(0.966)	(1.159)	(1.226)	(1.042)	(1.239)
Europe						2.160***	2.414***
						(0.193)	(0.138)
Asia-Pacific						1.211***	1.078***
						(0.150)	(0.104)
North America						1.500***	2.018***
						(0.227)	(0.0940)
Constant	-1.676***	-2.036***	-2.352***	-2.098***	-1.857***	-3.560***	-3.238***
	(0.191)	(0.233)	(0.239)	(0.260)	(0.261)	(0.257)	(0.252)
Year FE	No	No	No	Yes	Yes	No	Yes
Sector FE	No	No	No	Yes	Yes	No	Yes
Country FE	No	No	No	No	Yes	No	No
Observations	267,576	267,576	267,576	267,576	267,576	267,576	267,576
Adjusted R^2	0.013	0.015	0.016	0.065	0.072	0.018	0.068

Green Innovation

Correlations (Intensive Margin)

- **Question:** What are the correlations when we restrict to firms that have green revenues?

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Green Revenues %	1							
(2) Midpoint %	0.718***	1						
(3) Tier 1 %	0.776***	0.530***	1					
(4) CO2 Int. Scope 1	-0.054***	-0.044**	-0.085***	1				
(5) CO2 Int. Scope 2	0.0098	0.0059	-0.0042	0.0919***	1			
(6) CO2 Int. Scope 3	-0.0348*	-0.0353*	0.0657***	0.326***	0.0787***	1		
(7) E-Score PST	-0.00421	-0.0103	0.0510**	-0.416***	-0.117***	-0.439***	1	
(8) Adj. ESG Score	0.0118	-0.0267	0.0509**	-0.179***	-0.0364*	-0.154***	0.386***	1

Correlations

Do Green Revenues Substitute Legacy Revenues?

- **Question:** Do green revenues increase in firms with already existing green revenues?

Dep. Variable	Green Revenues %	Midpoint Green Revenues %	Tier 1 Green Revenues %
Regressions	(1)	(2)	(3)
GP Indicator × Post Paris	1.686***	2.051***	0.912***
	(0.239)	(0.391)	(0.241)
Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes
Observations	36,646	36,646	36,646
Adjusted R^2	0.914	0.808	0.915

Green Innovation

Do Green Revenues Substitute Legacy Revenues?

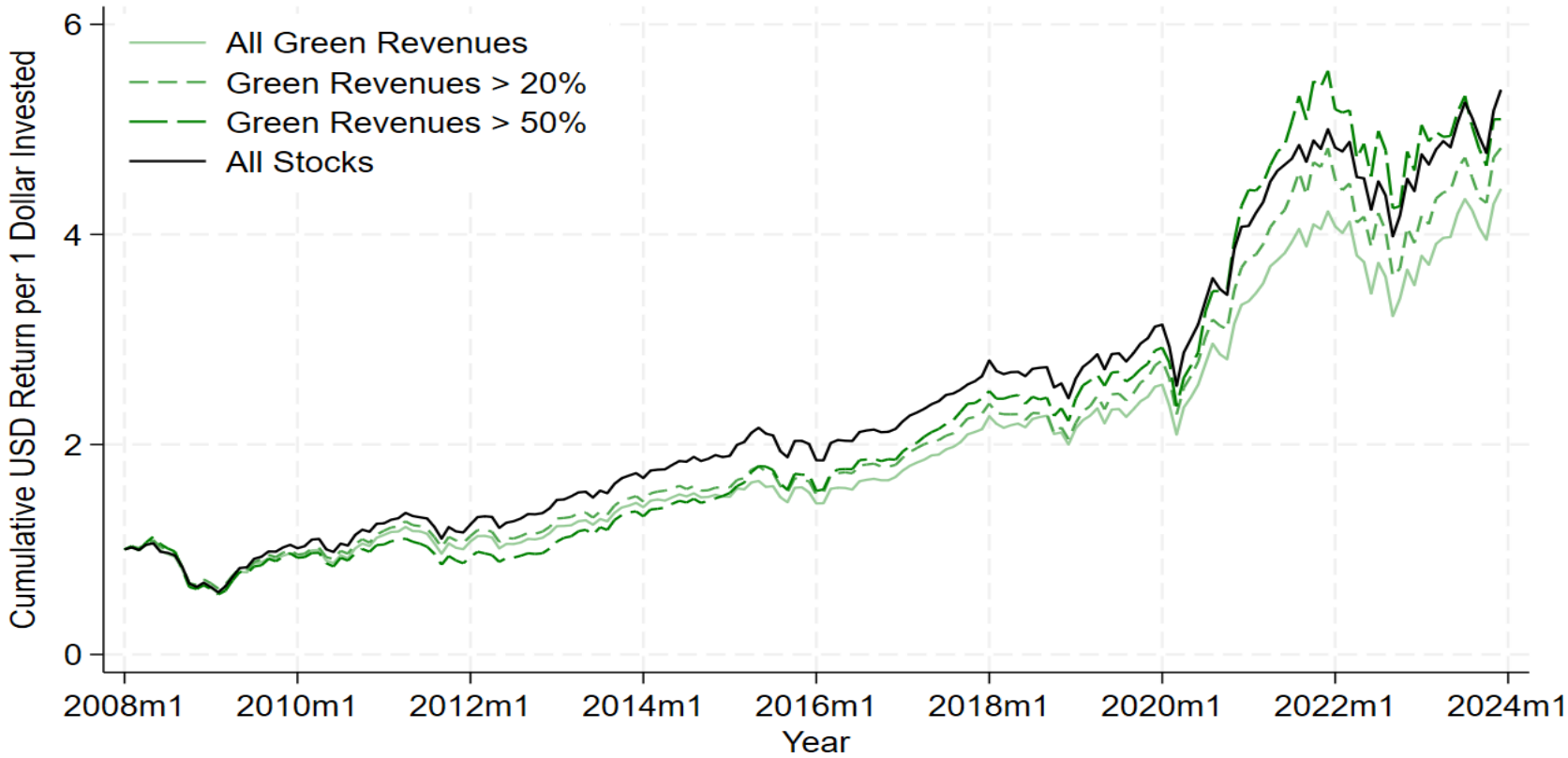
- **Question:** Do brown revenues decrease when green revenues ramp up?

Dep. Variable	USD Green Revenues		USD Brown Revenues	
Regression	(1)	(2)	(3)	(4)
GP Indicator × Post Paris	460.9***		1069.5***	
	(60.75)		(366.7)	
GP Ratio × Post Paris		1041.0***		-424.9
		(199.4)		(693.6)
Firm FE	Yes	Yes	Yes	Yes
Sector x Year FE	Yes	Yes	Yes	Yes
Country x Year FE	Yes	Yes	Yes	Yes
Observations	264,658	264,658	264,658	264,658
Adjusted R^2	0.717	0.716	0.893	0.893

Green Innovation

Excluding Tesla? (Global)

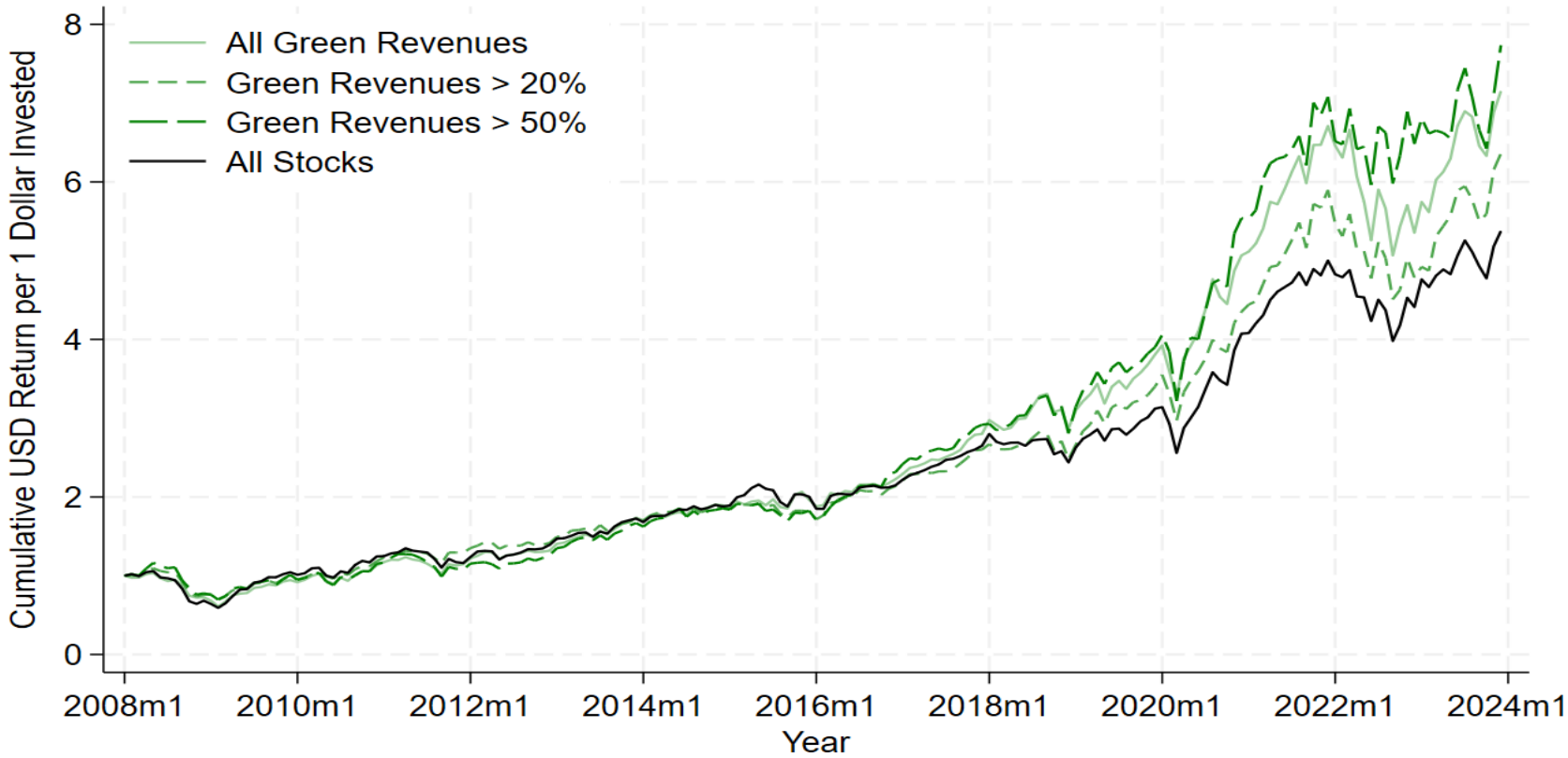
- **Question:** What are the portfolio returns excluding Tesla from the global sample?



Returns

Excluding Tesla? (USA)

- **Question:** What are the portfolio returns excluding Tesla from the US sample?



Returns

Q3: Do Investors Value Green Revenues (Excluding Tesla)?

Regression	(1)	(2)	(3)	(4)
Variable		Green Minus Legacy (GML)		
Portfolio	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
		Panel A: All Firms without Tesla Value-Weighted		
Alpha (Pre Paris)	-0.412***	-0.302**	-0.323**	-0.126
	(0.125)	(0.139)	(0.160)	(0.227)
Alpha (Post Paris)	-0.0746	0.00995	0.00794	0.289
	(0.108)	(0.126)	(0.172)	(0.209)
		Panel B: US Firms without Tesla Value-Weighted		
Alpha (Pre Paris)	-0.302*	-0.385**	-0.422*	-0.171
	(0.155)	(0.162)	(0.252)	(0.291)
Alpha (Post Paris)	0.000520	0.0162	0.192	0.454*
	(0.169)	(0.192)	(0.205)	(0.268)
		Panel C: All Firms Equally-Weighted		
Alpha (Pre Paris)	-0.234*	-0.102	-0.112	-0.0298
	(0.119)	(0.128)	(0.174)	(0.226)
Alpha (Post Paris)	-0.169*	-0.0406	0.0839	0.310
	(0.0977)	(0.125)	(0.162)	(0.205)
		Panel D: US Firms Equally-Weighted		
Alpha (Pre Paris)	-0.280**	-0.282*	-0.260	-0.243
	(0.135)	(0.152)	(0.240)	(0.286)
Alpha (Post Paris)	-0.0650	0.0195	0.345	0.646**
	(0.137)	(0.164)	(0.216)	(0.274)

Weights Tesla (Global) Weights Tesla (US)

Portfolio Weights of Tesla (Global)

Panel A: Tesla Weight in Global Portfolios (%)				
Year	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
2010	0.022	0.083	0.293	0.646
2011	0.030	0.116	0.421	1.066
2012	0.035	0.136	0.488	1.316
2013	0.141	0.572	1.858	4.837
2014	0.204	0.852	2.647	6.848
2015	0.225	0.931	2.698	6.315
2016	0.198	0.772	1.876	4.143
2017	0.236	0.909	2.118	4.826
2018	0.273	1.078	2.744	5.413
2019	0.308	1.010	2.853	5.378
2020	2.300	6.764	15.482	28.930
2021	3.067	8.520	19.660	34.221
2022	1.291	3.943	9.757	18.250
2023	2.332	7.107	17.560	32.386

Returns

Portfolio Weights of Tesla (US)

Panel B: Tesla Weight in US Portfolios (%)				
Year	$> 0\%$	$> 20\%$	$> 50\%$	$> 80\%$
2010	0.072	0.312	1.378	2.374
2011	0.091	0.370	1.839	3.554
2012	0.099	0.417	2.013	4.028
2013	0.358	1.803	7.791	14.543
2014	0.509	2.488	9.351	19.680
2015	0.548	2.969	11.324	21.118
2016	0.456	2.023	5.516	10.573
2017	0.551	2.478	7.175	13.038
2018	0.601	2.928	8.581	13.362
2019	0.657	2.178	8.519	13.002
2020	4.409	13.118	39.798	54.164
2021	5.727	16.557	48.424	62.055
2022	2.448	7.991	28.609	41.245
2023	4.186	13.340	42.251	56.284

Returns