Carbon-Transition Risk

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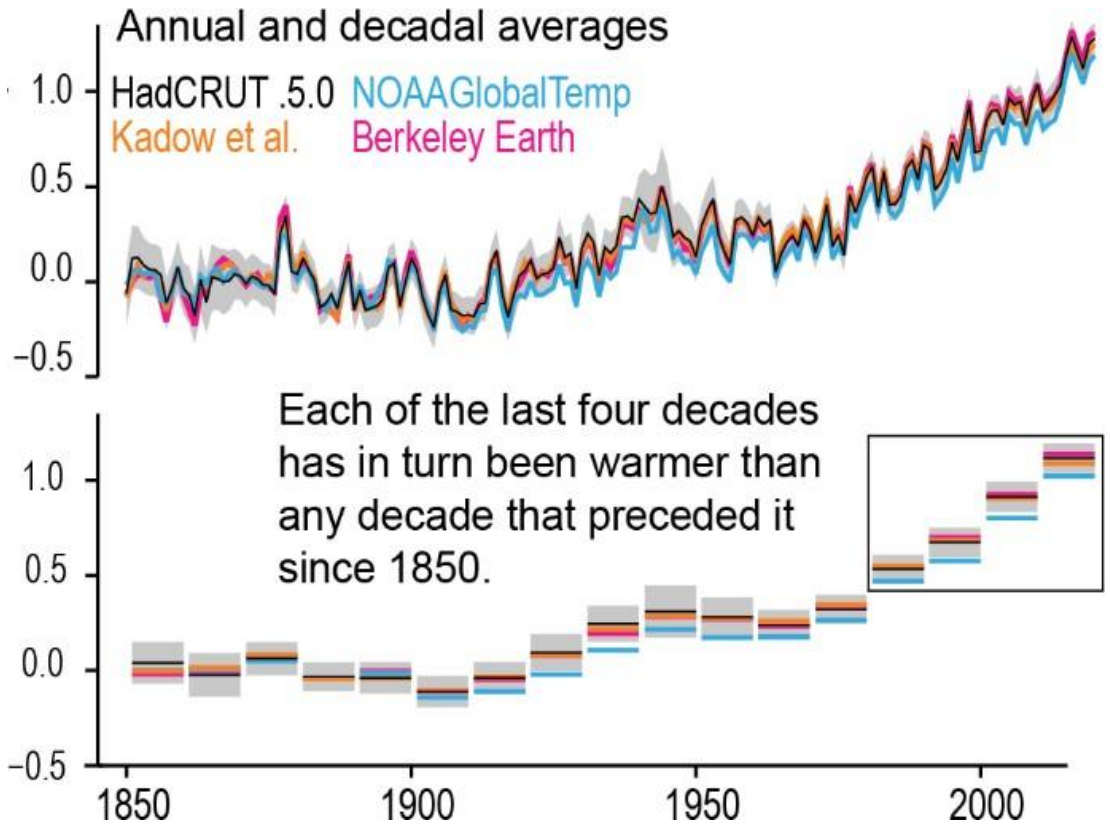
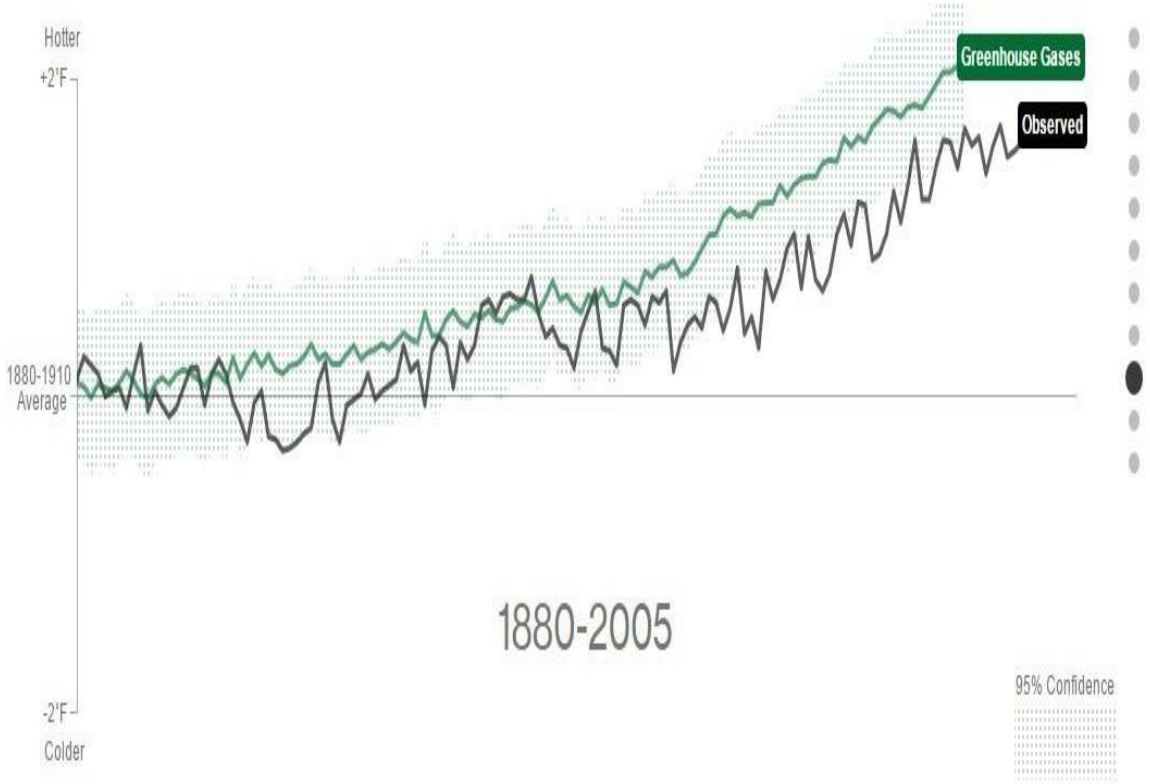
Reading Climate and Finance Conference

Climate Crisis is a First-order Issue





Motivation: Climate Crisis

- Tight link between emissions and temperature changes (K. Hasselmann/ S. Manabe, NP 2021)
  - Global decarbonization is necessary to address the climate crisis (curr. ~40GtCO2)
- Carbon pricing considered by many to be the best solution to the climate problem
  - High coordination costs stifle effective implementation (25% of emissions covered by carbon pricing)
  - Room for free riding and carbon leakage
  - Regulatory inertia is costly because time is critical (Carney, 2015)
- Market-based solutions have become a useful alternative/complement

Motivation: Transition Risk

- Global warming has been at the forefront of policy and social debates for some time now
  - Decarbonization commitments (COP21, COP26)
  - The stated objective is to reduce carbon emissions sufficiently to avoid an average temperature rise of more than 1.5 degrees Celsius by 2050
  - These commitments generate **transition risk** for corporations

- Investors require compensation for holding assets with greater transition risk

- **Two dimensions of transition risk:**
  1. At what **cost** will carbon emissions decline; will they decline fast enough?
  2. How do investors' perceptions and **expectations** about carbon risk evolve?

- Measuring the size of carbon premium is critical to assess the power of decarbonization incentives and the economic costs of transition (**CP** as an equivalent of carbon tax (Pedersen, 2024)

Sources of Transition Risk

1) Transition risk depends on:

- ➢Technological progress
- ➢Policy tightness

- Uncertainty about each element increases transition risk (the cash-flow effect)

2) Investors' **perceptions** about carbon risk depend on:

- ➢Socio-economic environment

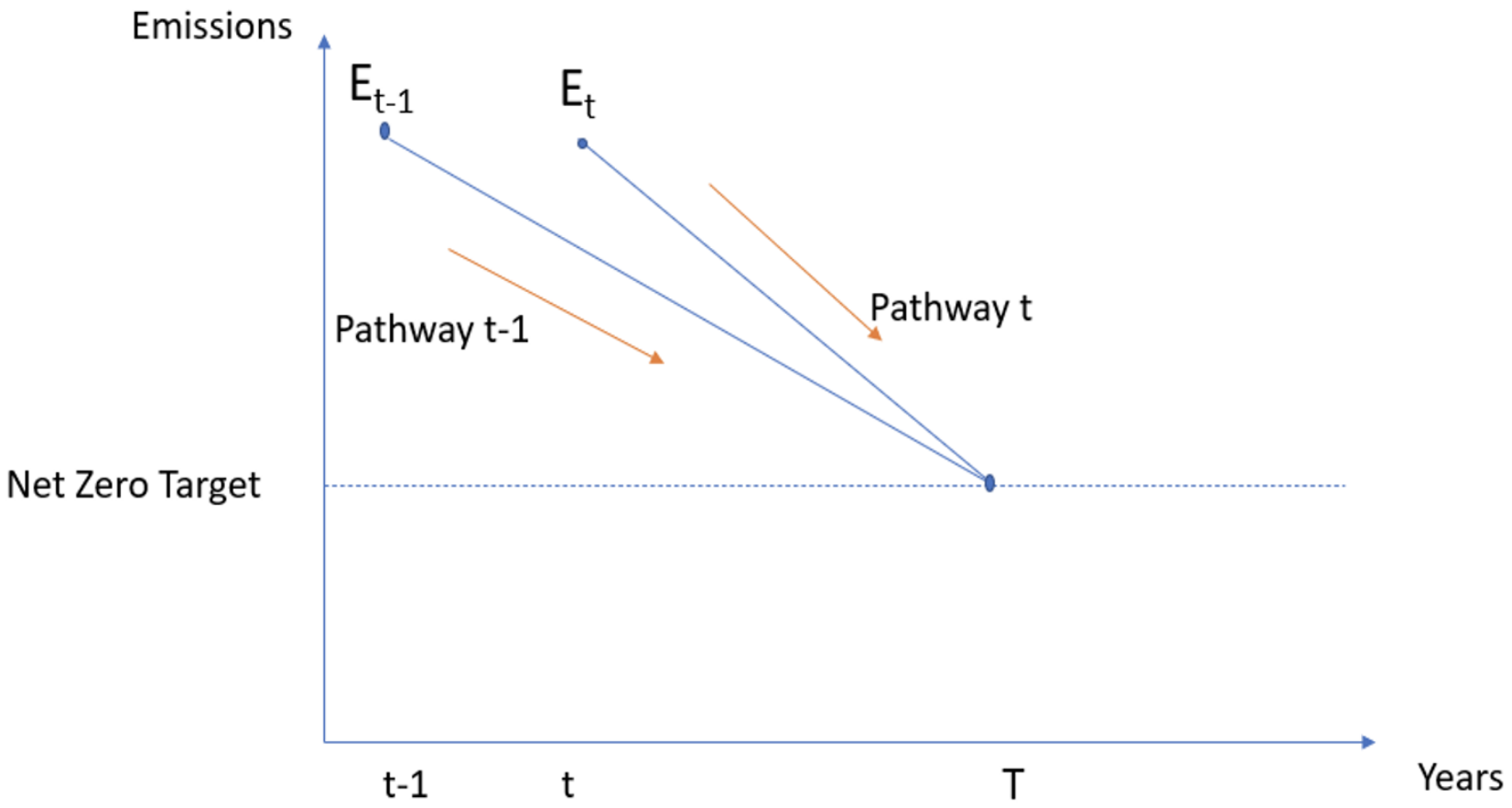
- Stronger preferences for greening the economy amplify transition risk (the discount rate effect)

Measuring Transition Risk: Traditional Approaches

- Approach 1: Bolton & Kacperczyk (2021, 2023)
- The **level** of firms' emissions determines their distance from net neutrality (size of transition)
  → **Long-term risk**
- Short-term **changes** in emissions determine firms' progress towards net neutrality
  → **Short-term risk**

- Strengths:
  - Easy to measure
  - Consistent with a well-defined objective function (NZ bound) => contrast with emission intensity
- Limitations:
  - Measures based on past emissions
  - Relies on availability of emission data (role of disclosure)
  - Forward-looking information is at the core of transition risk (role of commitments)

The Role of Time



Measuring Transition Risk (2)

- Approach 2: Sautner et al. (2021). Also, Alekseev et al. (2023)
- Use textual analysis to capture the process of transitioning to a green equilibrium
  - Decomposing content into regulatory risk, technological risk (opportunities) from conference call transcripts
  - Using word frequency as metric of climate sentiment
- Strengths:
  - Captures information owned by managers and firm analysts
  - Can be useful to isolate climate impact resulting in future emission reduction
- Limitations:
  - Not grounded in clear economic framework; lacks discipline in terms of null and alternative hypotheses
  - Subject to potential greenwashing
  - Computationally much more intensive

Evidence on Carbon Transition Risk from Global Markets

- Climate risk is a global problem
- Is there evidence that carbon transition risk is priced in financial assets?
- Most evidence comes from equity markets, limited evidence from bond markets, CDS, or mortgages
- General conclusions:
  - Transition risk is priced globally
  - Equity markets are the strongest evidence in the case

Estimating Carbon Premia (Levels): 2005-2020

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)
LOGS1TOT	0.027			0.063***		
	(0.021)			(0.015)		
LOGS2TOT		0.093***			0.113***	
		(0.029)			(0.027)	
LOGS3TOT			0.112***			0.164***
			(0.031)			(0.035)
LOGSIZE	-0.149***	-0.180***	-0.180***	-0.185***	-0.222***	-0.244***
	(0.041)	(0.042)	(0.043)	(0.041)	(0.042)	(0.044)
B/M	0.519**	0.512**	0.522**	0.630**	0.608**	0.597**
	(0.217)	(0.215)	(0.216)	(0.218)	(0.212)	(0.213)
LEVERAGE	-0.426**	-0.431**	-0.362**	-0.373**	-0.402**	-0.386**
	(0.180)	(0.167)	(0.165)	(0.158)	(0.146)	(0.150)
MOM	1.028**	1.035**	1.035**	1.021**	1.030**	1.033**
	(0.365)	(0.366)	(0.364)	(0.370)	(0.370)	(0.369)
INVEST/A	-0.741	-0.693	-0.392	-0.435	-0.275	0.006
	(1.102)	(1.157)	(1.215)	(1.064)	(1.090)	(1.103)
HHI	0.010	0.028	0.097	0.055	0.056	0.102
	(0.119)	(0.117)	(0.114)	(0.125)	(0.121)	(0.127)
LOGPPE	-0.002	-0.024	-0.039	0.009	-0.001	-0.020
	(0.018)	(0.022)	(0.023)	(0.017)	(0.017)	(0.018)
ROE	0.014***	0.013***	0.012***	0.013***	0.013***	0.013***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
VOLAT	0.129	-0.052	0.009	0.359	0.309	0.334
	(3.539)	(3.482)	(3.522)	(3.203)	(3.182)	(3.201)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	No	Yes	Yes	Yes
Observations	746,499	746,642	747,139	736,711	736,854	737,351
R-squared	0.150	0.150	0.150	0.151	0.151	0.151

Estimating Carbon Premia (Changes): 2005-2020

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)
S1CHG	0.437***			0.453***		
	(0.086)			(0.088)		
S2CHG		0.250***			0.255***	
		(0.067)			(0.069)	
S3CHG			1.157***			1.175***
			(0.278)			(0.288)
LOGSIZE	-0.156***	-0.153***	-0.170***	-0.170***	-0.166***	-0.183***
	(0.041)	(0.040)	(0.041)	(0.039)	(0.039)	(0.040)
B/M	0.506**	0.500**	0.537**	0.640**	0.633**	0.672**
	(0.217)	(0.216)	(0.217)	(0.221)	(0.220)	(0.220)
LEVERAGE	-0.459**	-0.444**	-0.492**	-0.393**	-0.379**	-0.421**
	(0.179)	(0.173)	(0.173)	(0.150)	(0.145)	(0.144)
MOM	0.958**	0.974**	0.880**	0.944**	0.961**	0.867**
	(0.362)	(0.363)	(0.350)	(0.368)	(0.369)	(0.356)
INVEST/A	-1.000	-0.870	-1.180	-0.785	-0.690	-0.963
	(1.180)	(1.194)	(1.204)	(1.059)	(1.058)	(1.058)
HHI	-0.046	-0.036	-0.064	-0.033	-0.022	-0.051
	(0.127)	(0.128)	(0.124)	(0.122)	(0.124)	(0.120)
LOGPPE	0.029	0.025	0.041*	0.047**	0.043**	0.060***
	(0.021)	(0.020)	(0.020)	(0.017)	(0.017)	(0.018)
ROE	0.014***	0.014***	0.014***	0.014***	0.014***	0.014***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
VOLAT	-0.146	-0.059	-0.175	0.182	0.252	0.169
	(3.602)	(3.619)	(3.670)	(3.258)	(3.274)	(3.308)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	No	Yes	Yes	Yes
Observations	735,359	735,362	735,903	725,745	725,748	726,289
R-squared	0.151	0.151	0.152	0.153	0.153	0.153

Consistency in the Objective Function

- Suppose we care about emission levels (e.g., because of transition risk). Optimizing along other measures is not necessarily consistent with *this* objective.

- Example: carbon intensity

- A large firm can be seen as more environmentally friendly than a small firm, even though its climate impact in terms of the size of its carbon emissions is much larger.

  - FT ranking of Europe's Climate Leaders (the 400 companies that achieved the greatest reduction in their Scope 1 and 2 emissions intensity over a five-year period—2015-20) includes some of the largest carbon emitters in the world, such as *Engie* with 40.9 million tons of CO2e for 2020, and *Holcim Group* with 117 million tons of CO2e (*Holcim Group* is one of the companies on the list of Climate Action 100+).

  - *Fortum:* a 29.8% reduction in emission intensity but an increase in carbon emissions by 157.2%.

  - *Axereal:* a 23.8% reduction in emission intensity but increase in total emissions by 236.2%.

Estimating Carbon Premia (Intensity): 2005-2020

Panel C: Emission Intensity

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)
S1INT	-0.007			-0.001		
	(0.007)			(0.004)		
S2INT		0.014			-0.001	
		(0.089)			(0.045)	
S3INT			0.019			0.013
			(0.018)			(0.017)
LOGSIZE	-0.157***	-0.152***	-0.145***	-0.164***	-0.164***	-0.163***
	(0.040)	(0.040)	(0.039)	(0.040)	(0.040)	(0.040)
B/M	0.505**	0.500**	0.506**	0.635**	0.635**	0.635**
	(0.214)	(0.214)	(0.218)	(0.218)	(0.217)	(0.218)
LEVERAGE	-0.405*	-0.426**	-0.417**	-0.341*	-0.342*	-0.342*
	(0.188)	(0.180)	(0.174)	(0.171)	(0.167)	(0.168)
MOM	0.830**	0.826**	0.823**	0.816**	0.816**	0.815**
	(0.325)	(0.327)	(0.327)	(0.331)	(0.331)	(0.331)
INVEST/A	-0.542	-0.640	-0.643	-0.519	-0.520	-0.524
	(1.155)	(1.082)	(1.170)	(1.052)	(1.046)	(1.055)
HHI	-0.072	-0.045	-0.023	-0.024	-0.023	-0.017
	(0.120)	(0.121)	(0.108)	(0.118)	(0.120)	(0.119)
LOGPPE	0.026	0.020	0.015	0.037**	0.037**	0.036**
	(0.019)	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)
ROE	0.014***	0.014***	0.014***	0.014***	0.014***	0.014***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
VOLAT	-0.392	-0.391	-0.384	-0.188	-0.187	-0.186
	(3.457)	(3.440)	(3.460)	(3.243)	(3.242)	(3.243)
Constant	2.089***	2.050***	1.969***	1.916***	1.914***	1.883**
	(0.592)	(0.609)	(0.616)	(0.617)	(0.625)	(0.620)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	No	Yes	Yes	Yes
Observations	747,290	747,290	747,290	737,499	737,499	737,499
R-squared	0.150	0.150	0.150	0.151	0.151	0.151

(Dis)similarities in Measures

	Log Emissions	Emissions Growth	Emissions Intensity	ESG (LSEG)	E score (LSEG)	Emissions Score	ESG score (MSCI)	E score (MSCI)
Log Emissions	1							
Emissions Growth	**0.0068**	1						
Emissions Intensity	**0.5223**	0.0529	1					
ESG (LSEG)	**0.3659**	-0.1059	0.0362	1				
E-score (LSEG)	**0.4674**	-0.1102	0.1063	0.8492	1			
Emissions Score	**0.4453**	-0.1062	0.1228	0.7968	0.8871	1		
ESG score (MSCI)	**0.0187**	-0.0697	-0.1507	0.387	0.3336	0.3181	1	
E-score (MSCI)	**0.0388**	-0.0444	-0.1619	0.3143	0.2881	0.2994	0.5269	1

Remarks on Disclosure

- Some studies suggest that estimated emissions are noisy and carbon premium disappears for disclosed emissions (Aswani et al., 2023)
  - Disclosure is endogenous (disclosing information reduce informational asymmetry)
  - If emissions are noisy, why does not noise reduce significance of estimates?
  - Disclosure rates have been growing up over time and so is the carbon premium (inconsistent with the view that disclosed emissions attract no premium)
  - Disclosure rates vary greatly across countries but carbon premia not so much

Data Timing is Key

- Some research claims that "the emission data timing needs to be aligned with the date the data is reported by the provider" (Zhang, JF 2024)

- This seems sensible (in theory) but:

  - We do not necessarily know which data investors use and when they are available to them (e.g., we have at least 10 different providers of emissions data)

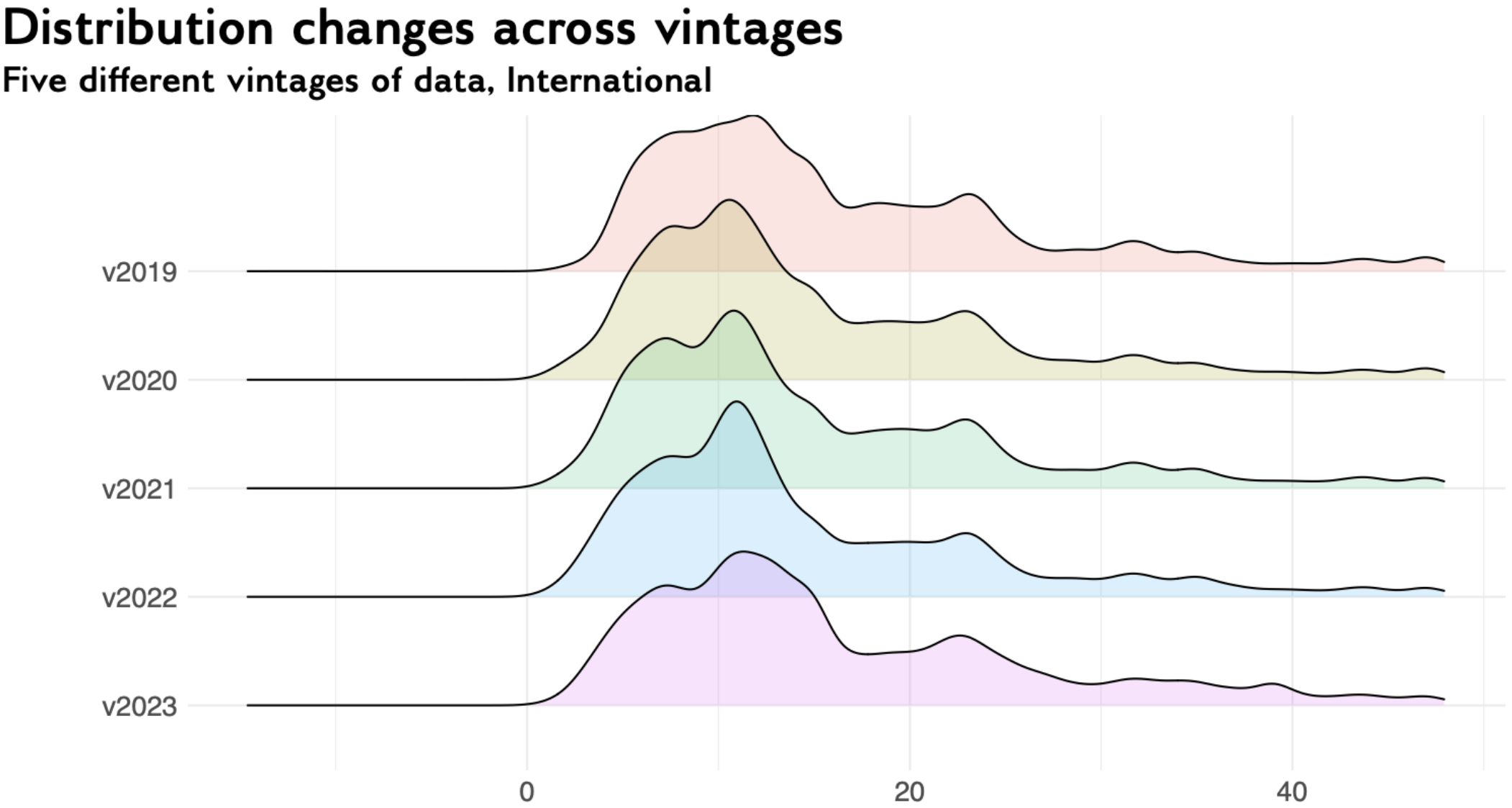
  - Investors may predict emissions on a continuous basis (would they wait one year to get the next update?)

Timing Trucost (from EFA 2023)

Example: Amazon.com Inc, 2019 vs 2023 vintages

Accounting Year End	Effective Date v2019	Reporting lag v 2019	Effective Date v2023	Reporting lag v2023
2008-12-31	2009-06-18	5	2020-02-24	133
2009-12-31	2010-06-14	5	2020-02-24	121
2010-12-31	2011-07-06	6	2020-02-24	109
2011-12-31	2012-04-24	3	2020-02-24	97
2012-12-31	2013-07-19	6	2020-02-24	85
2013-12-31	2014-08-27	7	2020-02-24	73
2014-12-31	2015-03-04	2	2020-02-24	61
2015-12-31	2017-04-26	15	2020-02-24	49
2016-12-31	2017-06-07	5	2020-02-24	37
2017-12-31	2018-06-26	5	2020-02-24	25

Timing Trucost (from EFA 2023)



Taking the Mechanism Forward

- What explains asset prices due to transition risk?
- Literature tends to associate transition pricing with divestment (like in Hong and Kacperczyk, 2009)
- Some arguments that divestment is too small to justify equity prices (Berk and van Binsbergen, 2022)
- Divestment may be forward looking in nature => asset prices discount the future

Net-Zero Portfolios: Bringing Climate Finance Closer to Science

- Cenedese, Han, and Kacperczyk (2023) use a net-zero portfolio (NZP) framework to measure transition risk as a **forward-looking phenomenon**

- NZP mimic science-based decarbonization paths (Bolton, Kacperczyk, and Samama, FAJ 2022)

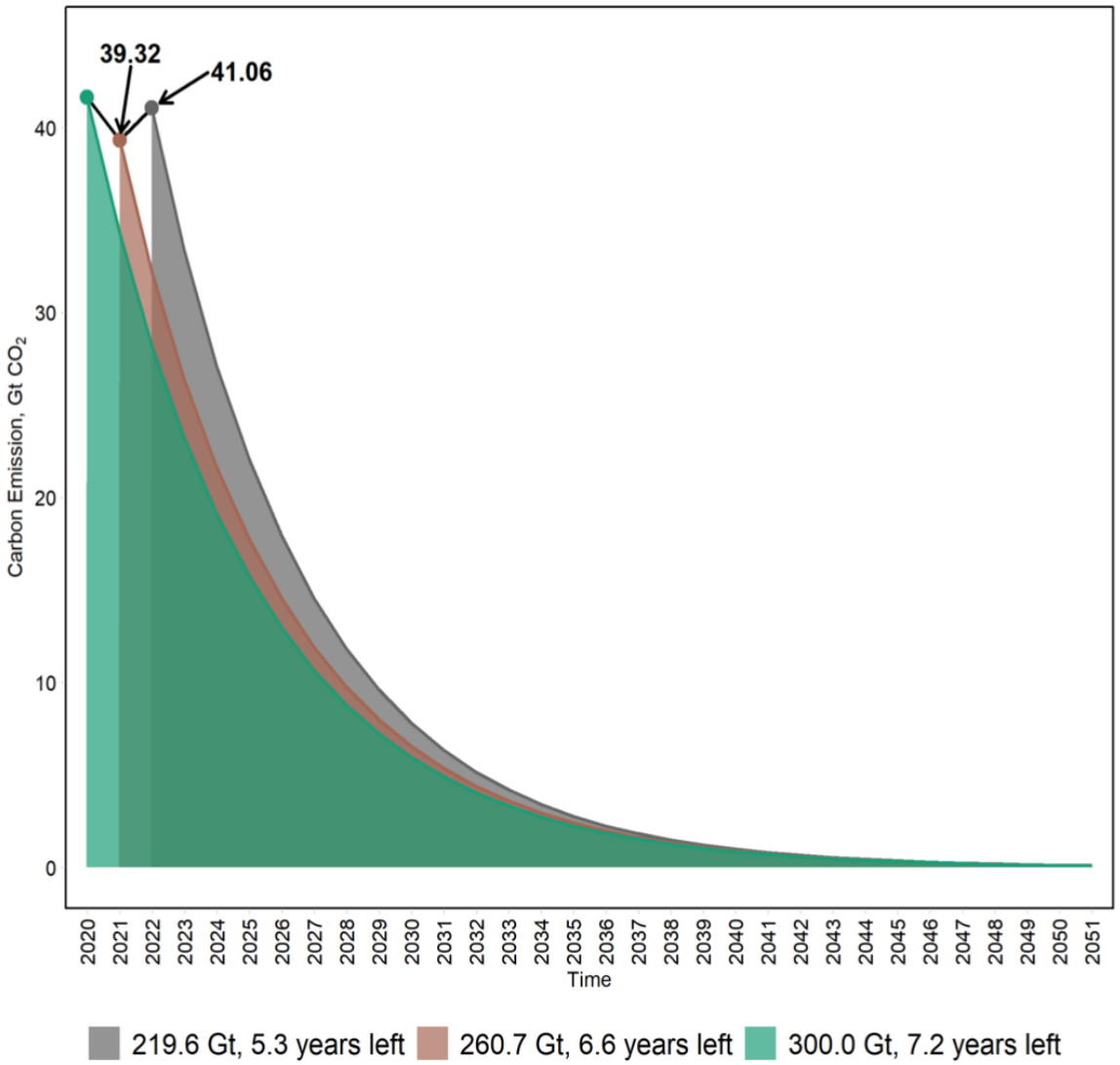
- NZP generate paths of **expected divestment + forward looking risk**

- NZP introduces a combination of **divestment and engagement** forces

Net-Zero Portfolios: Economic Significance

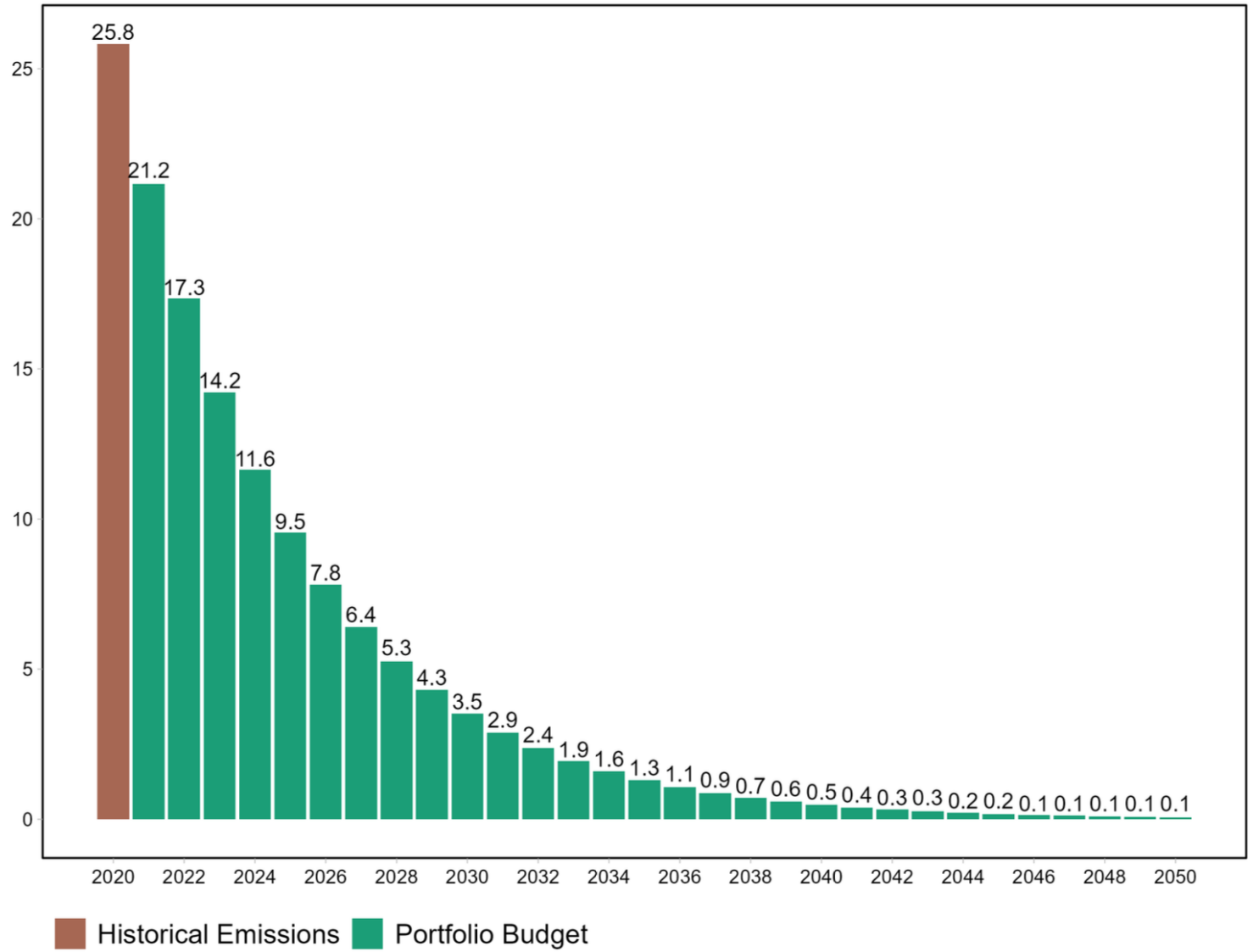
- NZP attracts a significant interest of investors
  - Net-Zero Asset Managers Initiative: $59 trillion pledged to carbon neutrality by asset managers
  - Net-Zero Asset Owners: $10 trillion
  - Net-Zero Banking Alliance: $67 trillion
  - Net-Zero Engagement Initiative (launched in March 2023)

Net-Zero Portfolios: Dynamic Carbon Budget (2020-2022)



- Global emissions 39.3 GtCO_2 in 2020.
- Global net-zero target:
  - Not to exceed the overall budget 260.7 GtCO_2 (from beginning of 2021).
  - Reduce global emissions to zero by 2050.
- Decarbonization from 2021 onwards implies:
  - Constant yearly 18.1% emission reduction until 2050.
  - Emissions drop to 0.1 GtCO_2 in 2050.
  - Total emissions from 2021 to 2050 sum up to 178.0 GtCO_2 (within 260.7 budget limit).

NZP: Portfolio Carbon Budget (2021)



Ambition Score Measure: Apple (2020)

Category	Category Weight	Data Source	Variables	Reported Value	Score Input	Standardized Value
Historical hard data	33.33%	Trucost	Carbon emission	39,453,087.42	39,453,087.42	165.24
			Emission growth	0.14	0.14	0.68
Historical soft data	33.33%	Trucost	Carbon Intensity	143.72	143.72	-0.56
			Intensity growth	0.06	0.06	1.61
Forward-looking soft data	33.33%	CSR Report	Decarbonization target existence	Yes	0.00	-2.63
			Decarbonization policy existence	Yes	0.00	-1.75
			Emission disclosure	Reported	0.00	-1.91
			Sustainability committee existence	Yes	0.00	-2.05
			UNPRI signatory	No	1.00	NA
			SDG13 climate action	Yes	0.00	-2.62
		Orbis Patent	Green patent number	23	-23.00	-2.10
			Brown efficiency patent number	0	0.00	0.10
			Green patent citation number	264	-264.00	-16.47
			Brown efficiency patent citation number	0	0.00	0.11
			Green patent ratio	0.04	-0.04	-0.03
			Brown efficiency patent ratio	0	0.00	0.08
		CDP Survey	SBTi participation	Submitted	1.00	-2.76
			Greenwashing indicator	0	0.00	-0.04
			Abatement rate	5	-5.00	-6.36
			Target underperformance	18.96	18.96	-3.08
			Target impracticability	18.00	18.00	-3.13
					Final Score	28.28

Distance-to-Exit (DTE):Construction

Cumulative sum of constant emissions

Company	Industry	Ambition Score	Rank	Emission	Cumulative Sum	DTE-ACE
				Constant Carbon Emission at *t*		
GlycoNex	Pharma	1417.61	1	766.49	25,824,357,750.72	0
Metro Pacific	Financial	287.21	2	4,742,804.79	25,824,356,984.23	0
Berkshire Hathaway	Financial	249.54	3	96,466,704.66	25,819,614,179.44	0
...						
Apple Inc.	Technology	28.28	24	39,453,087.42	25,391,269,074.17	0
...						
BP p.l.c.	Energy	7.31	187	124,243,014.60	21,358,975,283.01	0
Huaneng Power	Utilities	7.31	188	352,402,872.93	21,234,732,268.41	0
				Budget Cutoff 2021 21,161,609,768		
Wuchan Zhongda	Consr. Disc.	7.29	189	13,393,304.98	20,882,329,395.48	1
LG Display	Technology	7.26	190	10,035,133.68	20,868,936,090.50	1
...						
Baidu, Inc.	Media	3.71	407	1,421,440.52	17,376,909,255.76	1
Hindalco Industries	Materials	3.70	408	51,911,995.83	17,375,487,815.24	1
				Budget Cutoff 2022 17,340,749,856		
National Arts	Media	3.70	409	2,501.89	17,323,575,819.41	2
EVRAZ plc	Materials	3.69	410	49,095,855.65	17,323,573,317.52	2
Magnit	Consr. Stpl.	3.68	411	5,991,870.24	17,274,477,461.87	2
Japan Post	Insurance	3.68	412	5,554,199.79	17,268,485,591.63	2
...						
Bupa Arabia	Insurance	-5.75	14676	78,252.12	78,252.12	30

DTE and Stock Returns

Dependent variable: RET	(1)	(2)	(3)	(4)
DTE-ACE	-0.013***		-0.017***	
	(0.004)		(0.004)	
DTE-AFE		-0.013***		-0.016***
		(0.003)		(0.004)
Controls	No	No	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes
Industry-year-month-fixed effects	Yes	Yes	Yes	Yes
Observations	995,505	995,505	995,505	995,505
R-squared	0.230	0.230	0.231	0.231

Decomposing Transition Risk

- Which aspects of transition risk matter for asset prices?
  - The short-term and long-term premium is present in most geographic locations globally. Some cross-sectional variation in magnitudes
  - The level of a country's development does (not) differentially affect short (long)-term transition risk
  - technological (energy mix) changes: production mix matters for ST Risk (supporting Bolton, Kacperczyk, Wiedemann, 2023)
  - political environment matters for ST Risk
  - climate-related policy tightness: domestic policy matters for LT Risk
  - investor awareness matters for LT Risk (based on COP 21 shock)

Summary

- Transition risk is one of the key factors underlying decarbonization process and a way to estimate the financial cost of carbon
- Financial cost of carbon can be thought of as a market-based measure of carbon tax
- Consistency between objective function and measurement is key
- Useful to think about risk as a forward-looking object
- More work remains to be done to understand how transition risk interacts with financial markets and real changes in the economy
- Thinking more about the role of transition risk beyond equity markets and its underlying drivers are fruitful areas for future research