Virtual Seminar on Climate Economics

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Carbon-Transition Risk and Net-Zero Portfolios

Virtual Seminar on Climate Economics

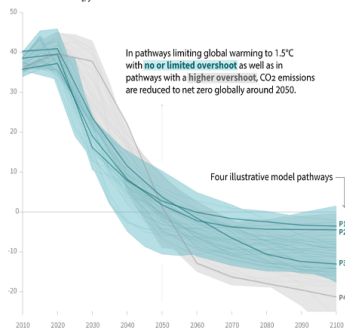**Marcin Kacperczyk (Imperial College London)**

Joint with
Gino Cenedese (Fulcrum Asset Management)
Shangqi Han (Fulcrum Asset Management)

What is carbon-transition risk?

Global total net CO₂ emissions

Billion tonnes of CO₂/yr

In pathways limiting global warming to 1.5°C with **no or limited overshoot** as well as in pathways with a **higher overshoot**, CO₂ emissions are reduced to net zero globally around 2050.

Four illustrative model pathways

Timing of net zero CO₂
Line widths depict the 5-95th percentile and the 25-75th percentile of scenarios

Pathways limiting global warming to 1.5°C with **no or limited** overshoot
Pathways with **higher overshoot**
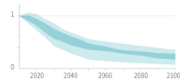Pathways limiting global warming below 2°C (Not shown above)

Non-CO₂ emissions relative to 2010
Emissions of non-CO₂ forcers are also reduced or limited in pathways limiting global warming to 1.5°C with **no or limited overshoot**, but they do not reach zero globally.
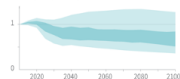
Methane emissions
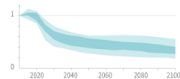
Black carbon emissions

Nitrous oxide emissions

Source: IPCC Special Report on Global Warming of 1.5°C

- ▶ Global warming is at the forefront of policy and social debates

- ▶ Decarbonization commitments

- ▶ 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
  - ▶ Uncertainty about the cost of transition
  - ▶ Uncertainty about the evolution of investors' beliefs

Carbon-transition risk and institutional pressure

▶ Investor/consumer pressure has been touted as one of the most important forces behind transition risk

▶ Measuring stakeholder pressure, especially its dynamics, is empirically difficult

▶ **This paper**:
  ▶ Propose a quantitative framework to measure investors' response to a growing pressure to decarbonize
  ▶ Derive new measure of transition risk, distance-to-exit (*DTE*)

Research context: net-zero portfolios

▶ Link portfolio decisions to climate science through Net-Zero Portfolios (NZP)

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

▶ 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)

▶ S&P has recently signed in the third largest client in its history ($6 billion under NZP)

Institutional investors and transition risk: economic mechanism

▶ Institutional investors may affect transition risk of corporates

  ▶ Divestment (Merton, 1987; Hong and Kacperczyk, 2009)

  ▶ Engagement/voice (e.g., Krueger, Sautner, and Starks, 2020)

  ▶ Active debate on the relative importance of these channels

▶ Innovation

  ▶ Allow for a dynamic force of a portfolio divestment/engagement

  ▶ Feedback effects between divestment and engagement + G.E. effects

  ▶ Link climate asset pricing *directly* to climate science

Carbon budget for net neutrality

▶ Intergovernmental Panel on Climate Change (IPCC) simulates global temperature changes under different emission paths

  ▶ Most paths imply increasing decarbonization pressure

▶ Our focus: limit global warming below $1.5°C$ from pre-industrial levels with an 83% probability

▶ Implied carbon budget: emit maximum total of 260.7 GtCO_2 (as of beginning 2021)

▶ 39.3 GtCO_2 global emissions in 2020 (Global Carbon Project)

▶ Assuming **constant** emissions, remaining budget would be used up in **6.6** years (260.7/39.3)

Net-zero portfolios

▶ Net-zero portfolios aim to align with the global decarbonization objectives

  ▶ NZAMI: "ambition to reach net zero emissions by 2050 or sooner across all assets under management"

▶ Main steps to construct a net-zero portfolio:

  1. Define the investable stock universe (all Trucost stocks)

  2. Add up all firms' scope 1–3 emissions in a given year (25.8 GtCO_2 in 2020)

  3. Multiply the sum by the number of years left (**6.6** years $\times 25.8 = 170.3$ GtCO_2 beginning of 2021)

  4. Select companies so that total emissions cumulatively do not exceed the yearly emission budget

Dynamic carbon budget for carbon neutrality: 2020-2022
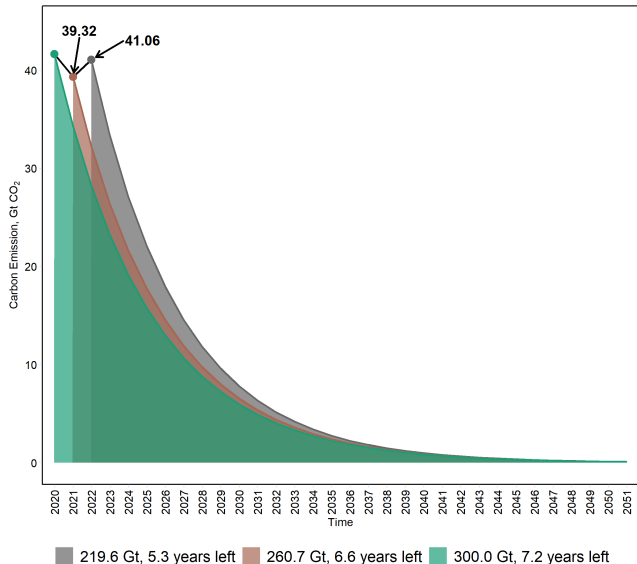
- ► Global emissions 39.3 GtCO_2 in 2020

- ► 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)

Corresponding portfolio carbon budget 2021
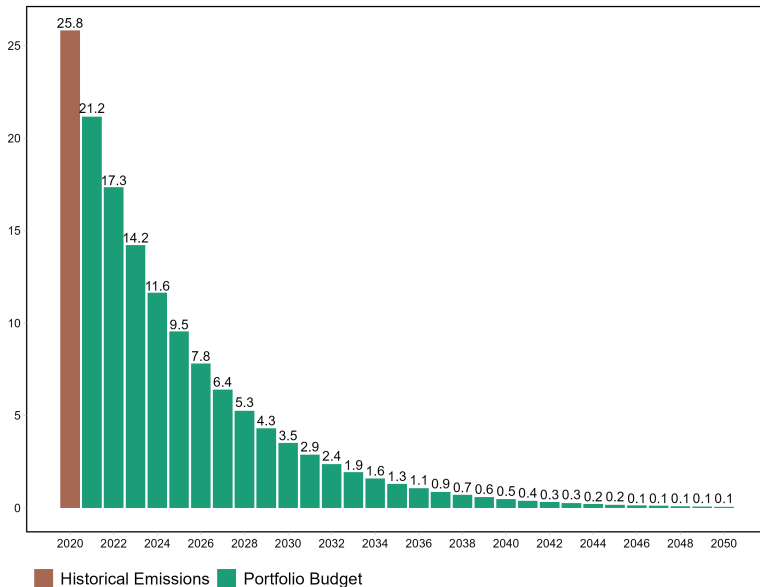
Distance-to-exit (DTE) concept

1. Budget: set yearly carbon budget (of absolute emissions) at a *portfolio level* based on alignment path

2. Rank companies by the metric of decarbonization efforts from worst to best, assuming *constant or estimated* future emissions

3. Exclude first *k* companies until total emissions of remaining companies are within yearly carbon budget

4. Distance-to-exit (DTE): number of years a stock is not excluded from the portfolio. Exit year is assumed to be 2051 for companies that never get excluded

Measuring decarbonization efforts: Ambition Score

▶ **Novel forward-looking approach:** Ambition Score based on the following three categories:

1. Historical emissions data: emissions levels and a 3-year moving average emission growth rate

2. Historical intensity data: emissions intensity and a 3-year moving average intensity growth rate

3. Forward-looking data:
   ▶ Decarbonization policy, target information, and sustainability effort from CSR reports
   ▶ Green and brown patents data
   ▶ CDP targets and the level of target achievement
   ▶ SBTi commitment information
   ▶ Greenwashing indicator

▶ Best-in-class: variables standardized within industry

▶ Simple average within category, then weighted average across categories

▶ Less aligned firms have higher score values

Ambition Score: Apple Inc.

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

DTE with constant emissions (2020)

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 with forecasted emissions (2020)

Cumulative sum of forecasted emissions

Company	Rank	Emission	Cumulative Sum	Inclusion	Emission	Cumulative Sum	Inclusion	…	Emission	Cumulative Sum	Inclusion	DTE-AFE
		Forecasted Carbon Emission at $t+1$			Forecasted Carbon Emission at $t+2$			…	Forecasted Carbon Emission at $t+30$			
GlycoNex	1	650.08	26,196,034,754.43	0	551.35	26,917,601,217.75	0		100.69	35,627,155,540.16	0	0
Metro Pacific	2	4,977,899.08	26,196,034,104.36	0	5,224,646.66	26,917,600,666.41	0		4,339,081.43	35,627,155,439.47	0	0
Berkshire Hathaway	3	85,585,349.93	26,191,056,205.28	0	75,931,401.90	26,912,376,019.75	0		17,932,132.28	35,622,816,358.04	0	0
…												
Apple Inc.	24	40,913,753.19	25,750,791,406.70	0	42,550,265.73	26,454,970,807.25	0		45,911,139.40	35,072,595,493.30	0	0
…												
BP p.l.c.	187	119,973,019.20	21,586,914,255.59	0	115,849,775.40	22,080,319,470.76	0		55,132,551.02	27,247,482,057.21	0	0
Huaneng Power	188	349,365,173.70	21,466,941,236.39	0	346,353,659.33	21,964,469,695.35	0		163,650,617.65	27,192,349,506.19	0	0
		Budget Cutoff 2021 21,161,609,768										
Wuchan Zhongda	189	13,613,251.38	21,117,576,062.69	1	13,836,809.76	21,618,116,036.02	0		9,469,136.04	27,028,698,888.54	0	1
LG Display	190	9,608,640.84	21,103,962,811.31	1	9,189,978.51	21,604,279,226.26	0		5,206,760.84	27,019,229,752.50	0	1
…												
Fiserv	434	851,761.73	17,106,665,354.66	1	876,386.48	17,347,334,058.39	0		797,647.44	19,798,001,418.84	0	1
Asia Cement	435	21,780,114.28	17,105,813,592.93	1	21,508,521.56	17,346,457,671.91	0		11,921,813.63	19,797,203,771.40	0	1
		Budget Cutoff 2022 17,340,749,856										
Valero Energy	436	59,655,889.16	17,084,033,478.65	1	61,431,135.99	17,324,949,150.36	1		47,478,779.04	19,785,281,957.77	0	2
Samsung Biologics	437	232,831.10	17,024,377,589.49	1	272,504.98	17,263,518,014.36	1		592,096.97	19,737,803,178.73	0	2
…												
Centrica plc	14194	2,751,619.58	113,499,916.74	1	2,878,277.13	107,200,634.82	1		2,708,671.04	69,791,662.70	0	29
HelloFresh	14195	394,914.44	110,748,297.16	1	488,532.59	104,322,357.69	1		1,402,905.41	67,082,991.66	0	29
		Budget Cutoff 2050 65,705,949										
CTS Eventim	14196	13,547.70	110,353,382.72	1	7,976.97	103,833,825.09	1		118.51	65,680,086.25	1	30
Eltel AB	14197	48,671.88	110,339,835.02	1	33,108.69	103,825,848.12	1		1,258.00	65,679,967.73	1	30
…												
Jefferies Financial	14674	203,458.10	300,157.46	1	194,437.15	284,507.03	1		79,514.87	112,868.02	1	30
Anadolu Sigorta	14675	23,812.02	96,699.35	1	22,179.52	90,069.88	1		8,213.15	33,353.15	1	30
Bupa Arabia	14676	72,887.34	72,887.34	1	67,890.35	67,890.35	1		25,140.01	25,140.01	1	30

DTE of Apple: time series

Estimation Year		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ambition Score	Percentile Ranks	25.89	43.10	47.99	36.48	30.62	7.64	3.71	4.19	4.01	2.45	2.40	0.43	0.23	0.15	0.16	0.09	0.11
ACE	Exit Year	2014	2018	2019	2018	2018	2014	2014	2015	2016	2017	2018	2018	2019	2020	2021	2022	2023
	Distance-to Exit	7	10	10	8	7	2	1	1	1	1	1	0	0	0	0	0	0
AFE	Exit Year	2012	2014	2017	2017	2017	2014	2013	2015	2016	2017	2018	2018	2019	2020	2021	2022	2023
	Distance-to Exit	5	6	8	7	6	2	0	1	1	1	1	0	0	0	0	0	0

▶ The ambition-based DTE changes over time due to a changing **budget** and ambition score **ranking**

Data sources

▶ Primary database combines several datasets.

  ▶ Firm-level corporate carbon and other greenhouse gas emissions globally from Trucost

  ▶ Disclosures from Corporate Social Responsibility reports via Refinitiv

  ▶ Commitments collected from CDP

  ▶ Patents from Orbis IP Financial

  ▶ Stock returns and corporate fundamentals from Compustat

▶ 13,373 unique publicly listed companies (about 90% of total market cap) representing 92 countries and spanning all industries over the period 2006-2022.

Anatomy of DTEs: industry exposure (2020)
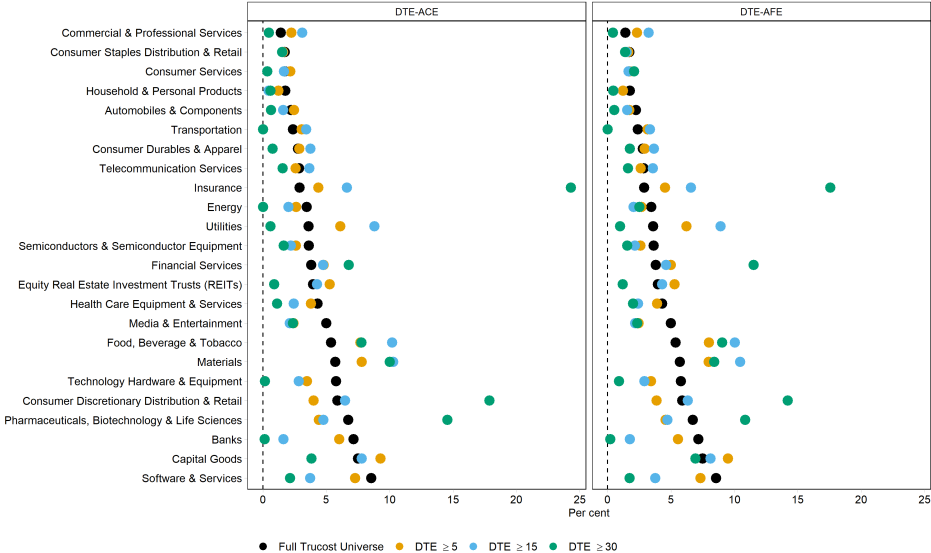
Anatomy of DTEs: DTE-investable stock characteristics (2020)
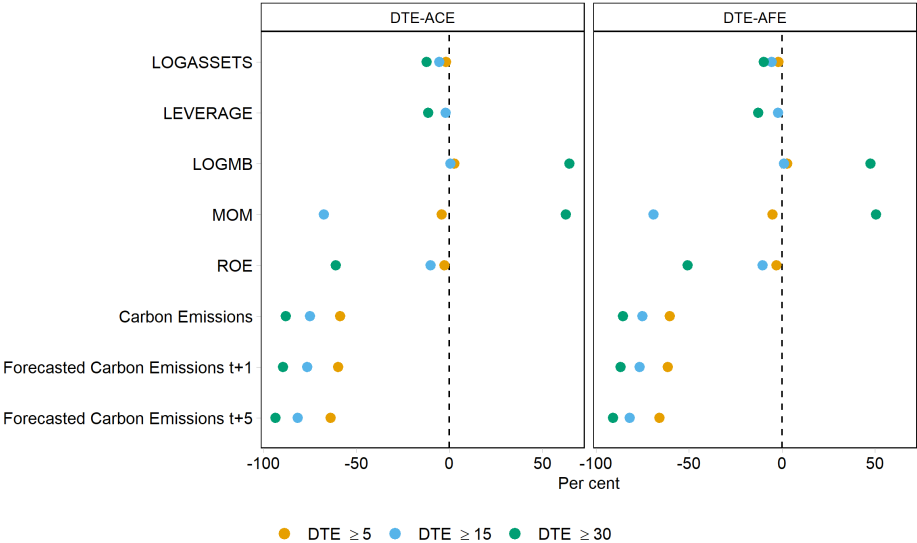
DTE and stock returns

- ▶ Estimate a pooled regression model (a la Daniel and Titman, 1998):
  - ▶ Monthly future stock returns as a dependent variable
  - ▶ DTE as a main explanatory variable (observed on an annual basis)
  - ▶ Various firm-level characteristics as controls
  - ▶ Include year-month×(Trucost) industry and country fixed effects
  - ▶ Double cluster standard errors at industry and year dimensions
  - ▶ Coefficient of DTE identifies average risk premium

Basic results

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

Economic significance: 1.2-2.5% annualized return difference per one st. dev. of DTE

Robustness tests

- Explore additional tests to check the robustness of our results

  - The relative role of sorting variable and carbon budget
  - Alternative decarbonization pathways
  - Changes in investors' perception
  - Alternative weights in Ambition Score
  - Controlling for alternative measures of climate change exposure
  - Valuation effects
  - Extensive margin
  - DTE based on scope 1 and 2 emissions
  - The role of emissions disclosure

Controlling for Ambition Score

Dependent variable: RET	(1)	(2)	(3)
Ambition Score	0.119***	0.032	0.039
	(0.037)	(0.034)	(0.030)
DTE-ACE		-0.014***	
		(0.003)	
DTE-AFE			-0.013***
			(0.003)
Controls	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes
Industry-year-month-fixed effects	Yes	Yes	Yes
Observations	995,505	995,505	995,505
R-squared	0.231	0.231	0.231

Alternative decarbonization pathways
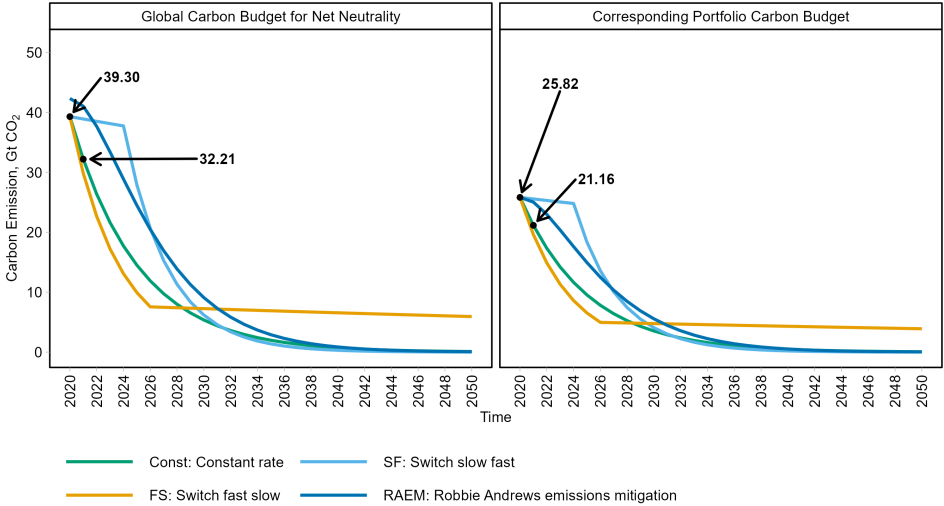
Alternative decarbonization pathways

Dependent variable: returns	(1)	(2)	(3)	(4)	(5)	(6)
Pathway RAEM: DTE-ACE	-0.016*** (0.004)					
Pathway RAEM: DTE-AFE		-0.013*** (0.004)				
Pathway FS: DTE-ACE			-0.010*** (0.003)			
Pathway FS: DTE-AFE				-0.009*** (0.002)		
Pathway SF: DTE-ACE					-0.026*** (0.007)	
Pathway SF: DTE-AFE						-0.019*** (0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year-month-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	995,505	995,505	995,505	995,505	995,505	995,505
R-squared	0.231	0.231	0.231	0.231	0.231	0.231

Controlling for other climate change exposure variables

Dependent variable: RET	(1)	(2)	(3)	(4)	(5)	(6)
DTE-ACE	-0.009**		-0.009*		-0.009*	
	(0.003)		(0.005)		(0.005)	
DTE-AFE		-0.009***		-0.009*		-0.009*
		(0.003)		(0.004)		(0.004)
Ambition Score	-0.011	-0.008				
	(0.032)	(0.028)				
Log Emissions	0.257***	0.258***				
	(0.052)	(0.052)				
Log Cumulative Forecasted Emissions	0.056	0.055				
	(0.044)	(0.043)				
CCExposure			7.957	7.967		
			(19.490)	(19.494)		
$CCExposure^{Opp}$					9.492	9.517
					(26.539)	(26.539)
$CCExposure^{Reg}$					-11.007	-11.073
					(46.399)	(46.424)
$CCExposure^{Phy}$					142.913	143.044
					(83.408)	(83.392)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year-month-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	995,505	995,505	325,757	325,757	325,757	325,757
R-squared	0.231	0.231	0.383	0.383	0.383	0.383

Paris agreement

Dependent variable:	RET		LOGPE	
	(1)	(2)	(3)	(4)
DTE-ACE	-0.009*		0.003***	
	(0.005)		(0.001)	
DTE-AFE		-0.008**		0.003***
		(0.004)		(0.001)
DTE-ACE × Paris	-0.014	-0.014*	0.002*	0.002*
	(0.009)	(0.008)	(0.001)	(0.001)
Controls	Yes	Yes	Yes	Yes
Country-fixed effects	Yes	Yes	Yes	Yes
Industry-year-month-fixed effects	Yes	Yes	Yes	Yes
Observations	995,505	995,505	633,015	633,015
R-squared	0.231	0.231	0.429	0.429

Time-series effects

Dependent variable: RET	(1)	(2)
DTE-ACE	-0.012***	
	(0.003)	
DTE-AFE		-0.011***
		(0.003)
Controls	Yes	Yes
Country-fixed effects	Yes	Yes
Industry-fixed effects	Yes	Yes
Time trend	-0.006	-0.005
	(0.004)	(0.003)
Observations	203	203
Time trend (ex 2022)	-0.009**	-0.008**
	(0.004)	(0.004)
Observations	191	191

Conclusions

▶ Transition risk is an important factor in setting incentives to decarbonize

▶ Pressure from institutional investors is an important source of the risk

▶ Distance-to-exit framework links transition risk and the pressure from institutional investors

▶ Growing importance of NZP will likely amplify the economic significance of the effect on asset prices