

Carbon-Transition Risk and Net-Zero Portfolios

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Marcin Kacperczyk (Imperial College London)

Joint with

Gino Cenedese (Fulcrum Asset Management)

Shangqi Han (Fulcrum Asset Management)

Carbon-transition risk and institutional pressure

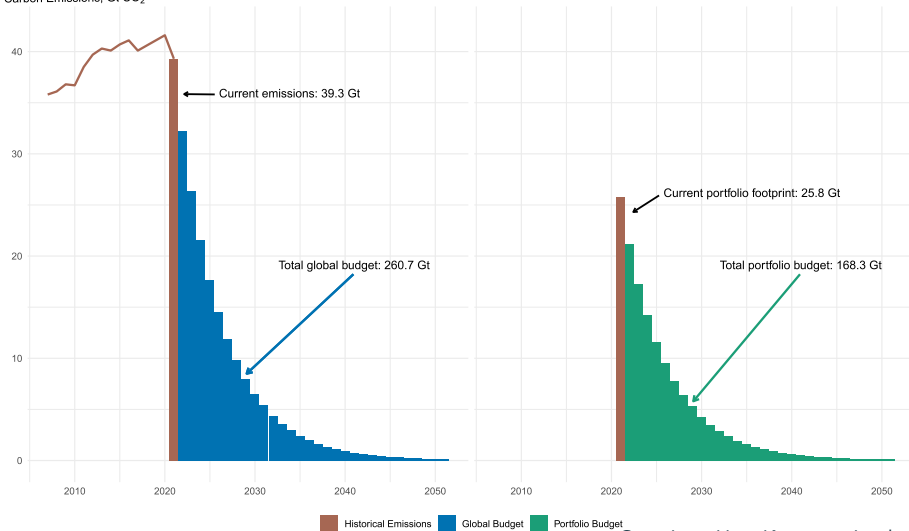
- ▶ Investor pressure to decarbonize is an important source of transition risk
 - ▶ Divestment
 - ▶ Engagement
- ▶ Measuring shareholder pressure is difficult
- ▶ **This paper:**
 - ▶ Quantitative framework to measure investors' pressure
 - ▶ Derive a new measure of transition risk, distance-to-exit (*DTE*)
 - ▶ Is investor pressure reflected in asset prices?

Institutional investors and transition risk: traditional view

- ▶ Institutional investors may affect transition risk of corporates
 - ▶ Divestment (Merton, 1987; Heinkel et al, 2001; Hong and Kacperczyk, 2009)
 - ▶ Engagement/voice (e.g., Krueger, Sautner, and Starks, 2020)
 - ▶ Active debate on the relative importance of these channels
 - ▶ Current literature focuses on *realized* divestment
 - ▶ Disagreement on quantitative effect

Investor pressure to decarbonize

Carbon Emissions, Gt CO₂



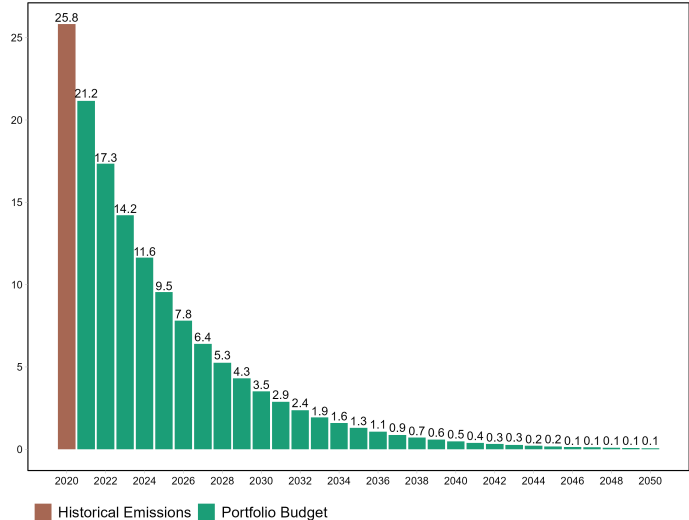
Institutional investors and transition risk: new economic insights

- ▶ Dynamic force incorporating both realized and *expected* portfolio divestment
- ▶ Feedback effects between divestment and engagement
- ▶ Climate asset pricing *directly* linked to climate science via explicit carbon budget

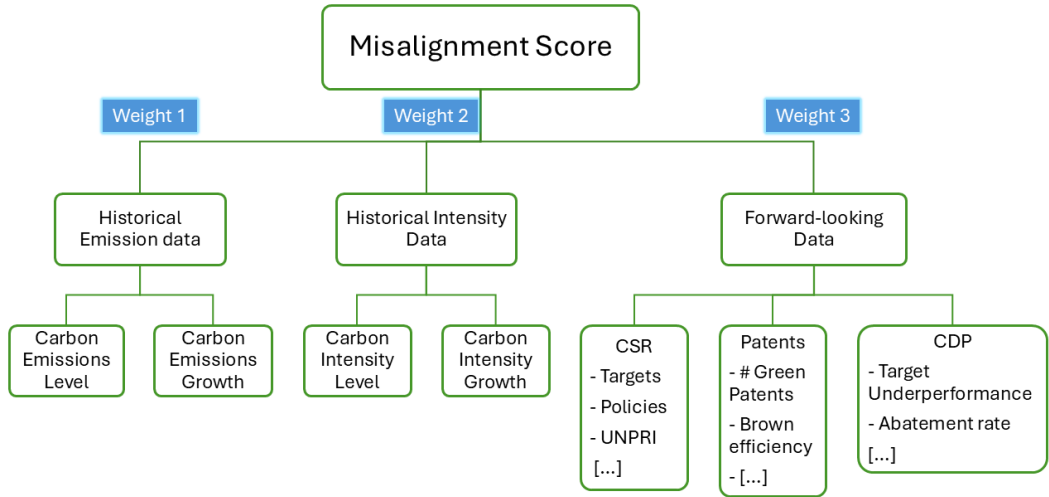
Distance-to-exit (DTE): a new measure of transition risk

- 1 **Set carbon budget** based on predetermined decarbonization path
- 2 **Rank** companies by a **metric of decarbonization efforts** from worst to best
 - ▶ Introduce a metric of **misalignment score**
 - ▶ Alignment is a key consideration in discussion of decarbonization
- 3 **Exclude** first k companies until total emissions are within annual carbon budget
 - ▶ **Distance-to-exit (DTE)**: number of years before a stock is expected to be excluded

Step 1. Carbon budget (end of 2020)



Step 2. Ranking by Misalignment Score



Step 2. Ranking by Misalignment Score (example: Apple Inc.)

Category	Category Weight	Data Source	Variables	Reported Value	Score Input	Standardized Value
Historical emission 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 intensity data	33.33%	Trucost	Carbon Intensity	143.72	143.72	-0.56
			Intensity growth	0.06	0.06	1.61
Forward-looking company 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	

Step 3. DTE: an outcome of exclusion process

Exclusions as of 2020, assuming constant emissions

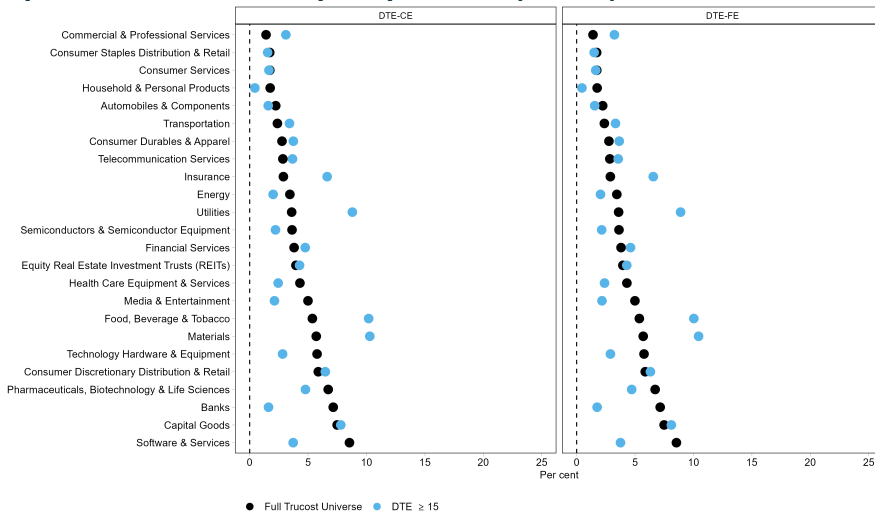
Company	Industry	Misalignment Score	Rank	Emission	Cumulative Sum	DTE-CE
Constant Carbon Emission at <i>t</i>						
GlycoNex	Pharma	1417.61	1	766.49	25,824,357,750.72	0
Metro Pacific	Financial	287.21	2	4,742,804.79	25,824,356,984.23	0
Berkshire Hathaway	Financial	249.54	3	96,466,704.66	25,819,614,179.44	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 Future Emissions

Cumulative sum of forecasted emissions

Company	Rank	Emission	Cumulative Sum	Inclusion	Emission	Cumulative Sum	Inclusion ...	Emission	Cumulative Sum	Inclusion	DTE-FE
		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	
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

Anatomy of DTE: industry exposure (2020)



Greater DTE associated with lower future average returns

Two flavours of DTE:

- 1 DTE-CE assumes constant future firm-level emissions
- 2 DTE-FE uses a forecast of future firm-level emissions

Dependent variable: RET	(1)	(2)	(3)	(4)
DTE-CE	-0.013*** (0.004)		-0.017*** (0.004)	
DTE-FE		-0.013*** (0.003)		-0.016*** (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

Controlling for other climate change exposure variables

Dependent variable: RET	(1)	(2)	(3)	(4)	(5)	(6)
DTE-CE	-0.009** (0.003)		-0.009* (0.005)		-0.009* (0.005)	
DTE-FE		-0.009*** (0.003)		-0.009* (0.004)		-0.009* (0.004)
Misalignment Score	-0.011 (0.032)	-0.008 (0.028)				
Log Emissions	0.257*** (0.052)	0.258*** (0.052)				
Log Cumulative Forecasted Emissions	0.056 (0.044)	0.055 (0.043)				
CCExposure			7.957 (19.490)	7.967 (19.494)		
CCExposure ^{Opp}					9.492 (26.539)	9.517 (26.539)
CCExposure ^{Reg}					-11.007 (46.399)	-11.073 (46.424)
CCExposure ^{Phy}					142.913 (83.408)	143.044 (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

Time-series effects

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

Conclusions

- ▶ Transition risk is an important factor in setting incentives to decarbonize
- ▶ Institutional investor pressure is an important source of the risk
- ▶ Distance-to-exit framework links transition risk and the pressure from institutional investors
- ▶ Current approach is particularly relevant for passive investors and asset owners

Appendix

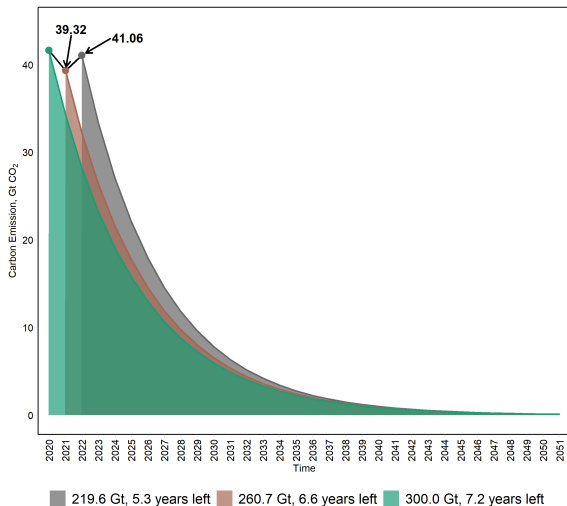
Carbon budget for net neutrality

- ▶ 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** GtCO₂ (as of beginning 2021)
- ▶ **39.3** GtCO₂ 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 GtCO₂ in 2020)
 - 3 Multiply the sum by the number of years left (6.6 years × 25.8 = 170.3 GtCO₂ 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** GtCO₂ in 2020
- ▶ Global net-zero target:
 - ▶ Not to exceed the overall budget **260.7** GtCO₂ (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** GtCO₂ in 2050
 - ▶ Total emissions from 2021 to 2050 sum up to **178.0** GtCO₂ (within **260.7** budget limit)

Measuring decarbonization efforts: Misalignment Score

- ▶ **Novel forward-looking approach:** **Misalignment 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

Assumptions on future emissions

- ▶ NZP-framework requires modeling future company emissions
- ▶ Assumption 1: Emissions stay constant until 2050
- ▶ Assumption 2: Forecast emissions based on:
 - (a) CDP commitments: aggregating targets with different ambitions and horizons at the firm level
 - (b) Past emissions trends: use a 3-year moving-average emissions growth rate for 3 periods, then converge to an industry long-term growth rate until 2050
- ▶ Weighted-average of (a) and (b) following the GFANZ target credibility framework
 - 1 0% (a) + 100% (b): no long-term target (> 4 years)
 - 2 25% (a) + 75% (b): long-term target only but not SBTi validated
 - 3 50% (a) + 50% (b): long-term and short-term target but not SBTi validated
 - 4 50% (a) + 50% (b): long-term target only and SBTi validated
 - 5 75% (a) + 25% (b): long-term and short-term target and SBTi validated

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-FE
		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
Eitel 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

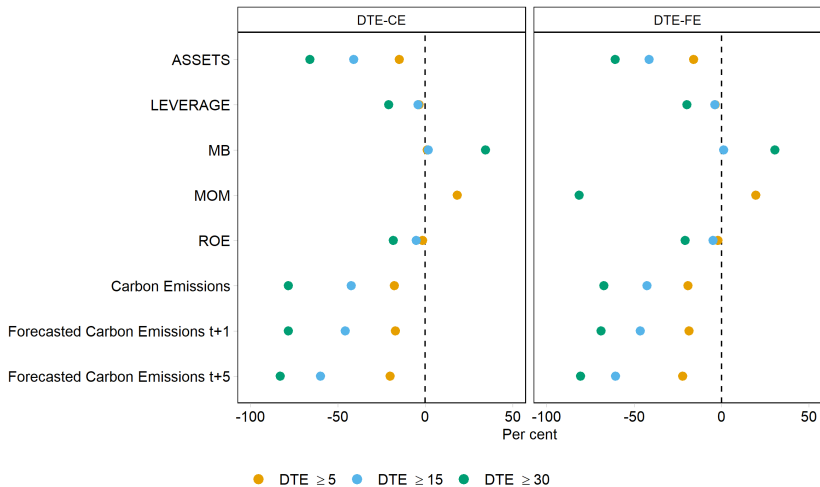
Estimation Year		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Misalignment Score	Percentile Ranks	25.89	43.10	47.99	36.48	30.62	7.64	3.71	4.19	4.01	2.45	2.40	0.43	0.23	0.15	0.16	0.09	0.11
ACE	Exit Year	2014	2018	2019	2018	2018	2014	2014	2015	2016	2017	2018	2018	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 Misalignment 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: DTE-investable stock characteristics (2020)



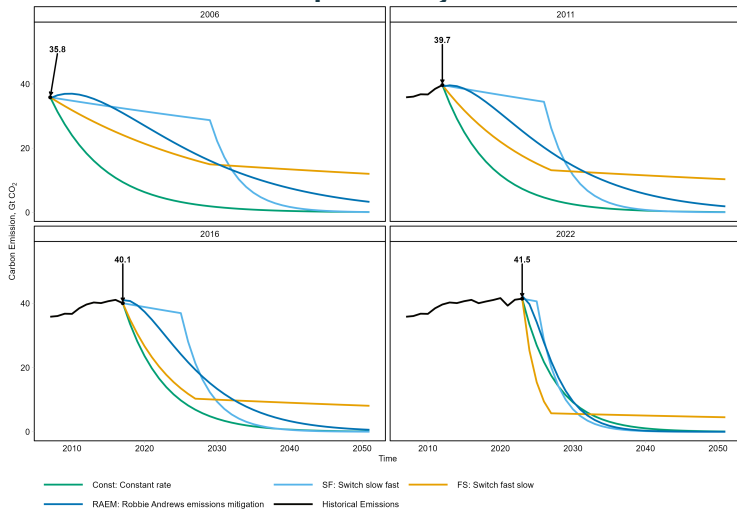
Robustness tests

- ▶ 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 Misalignment 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

Results are robust when controlling for Misalignment Score

Dependent variable: RET	(1)	(2)	(3)
Misalignment Score	0.119*** (0.037)	0.032 (0.034)	0.039 (0.030)
DTE-CE		-0.014*** (0.003)	
DTE-FE			-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 (cont'd)

Dependent variable: returns	(1)	(2)	(3)	(4)	(5)	(6)
Pathway RAEM : DTE-CE	-0.016*** (0.004)					
Pathway RAEM : DTE-FE		-0.013*** (0.004)				
Pathway FS : DTE-CE			-0.010*** (0.003)			
Pathway FS : DTE-FE				-0.009*** (0.002)		
Pathway SF : DTE-CE					-0.026*** (0.007)	
Pathway SF : DTE-FE						-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

Effect is stronger after 2015 Paris agreement

Dependent variable:	RET		LOGPE	
	(1)	(2)	(3)	(4)
DTE-CE	-0.009* (0.005)		0.003*** (0.001)	
DTE-FE		-0.008** (0.004)		0.003*** (0.001)
DTE-CE × Paris	-0.014 (0.009)		0.002* (0.001)	
DTE-FE × Paris		-0.015* (0.008)		0.002* (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