Global Pricing of Carbon-Transition Risk

Patrick Bolton (Columbia University/Imperial College)
Marcin Kacperczyk (Imperial College)

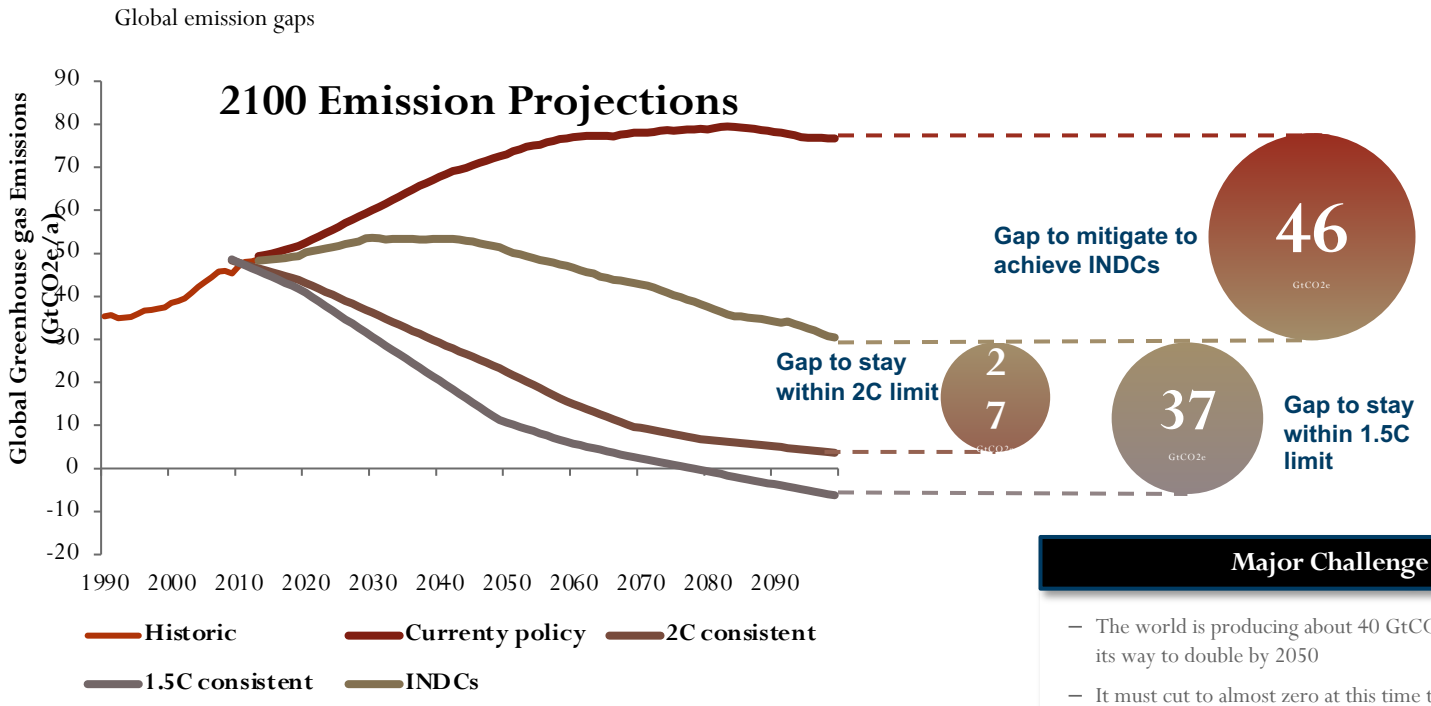
NBER LTAM Meetings

January 21, 2021

Motivation

- Global warming at the forefront of policy and social debates for some time now
  - COP21 and "Net Neutral" 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

The Climate Change Mitigation Challenge



Major Challenge

- The world is producing about 40 GtCO2/year and is on its way to double by 2050
- It must cut to almost zero at this time to achieve the 1.5 degree increase objective

Source: Climate Action Tracker Database, Global emissions time series, updated November 2017. Time series data for INDCs, 2C consistent, 1.5C consistent time series are computed as medians of highest and lowest potential global emission level results.

Motivation

- Global warming at the forefront of policy and social debates for some time now
  - COP21 and "Net Neutral" 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 to reduce carbon emissions generate **transition risk** for corporations
  - Two dimensions of transition risk:
    1. At what rate will carbon emissions decline; will they decline fast enough?
    2. How do investors' perceptions and expectations about carbon risk evolve?

This Paper

- Looks at a large panel of over 14,400 firms from 77 countries over the **2005-2018** time period

Main Questions:

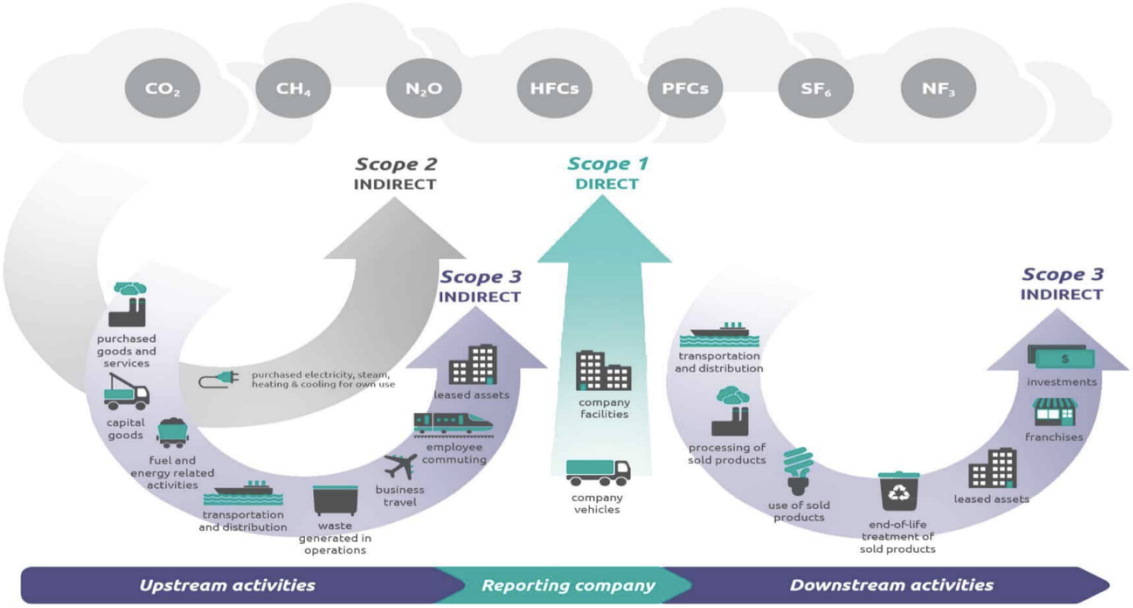
- Do we observe systematic differences in returns between firms with different exposures to carbon-transition risk?
- How is carbon-transition risk priced across countries?
- What are the key drivers of carbon-transition risk?

Data: Sources

- Our primary database is largely a result of matching two data sets, by Trucost and FactSet
  - Trucost provides information on firm-level corporate carbon and other greenhouse gas emissions globally. Follows the Greenhouse Gas Protocol that sets the standards for measuring corporate emissions
  - FactSet provides data on stock returns and corporate fundamentals globally
- The matching produced 14,468 unique companies out of approx. 16,000 companies available in Trucost (about 99% of total market cap)
- Representing 77 countries and spanning all industries

Primer on Carbon Emissions

- Three different basic sources of carbon emissions from a company's operations and economic activity



Source: GHG Protocol

- Data on scope 1 and scope 2 emissions have been more systematically reported
- Although scope 3 emissions are the most important component of companies' emissions in a number of industries (e.g., automobile manufacturing) they are the hardest to measure and assemble

Data: Firm-Level Emissions (Risk Quantity)

- We consider two different measures of emissions across three scopes:
  - Firm-level **total emissions** (in logs of tons of CO2): long-term risk
  - **Percentage changes in firm-level emissions**: short-term risk

	logscope1	logscope2	logscope3	scope1chg	scope2chg	scope3chg
logscope1	1					
logscope2	0.736	1				
logscope3	0.808	0.824	1			
scope1chg	0.040	-0.020	-0.047	1		
scope2chg	-0.004	0.045	-0.046	0.485	1	
scope3chg	-0.045	-0.061	-0.059	0.555	0.503	1

Determinants of Carbon Emissions (Levels)

Panel A: Levels

VARIABLES	(1) LOGS1TOT	(2) LOGS2TOT	(3) LOGS3TOT	(4) LOGS1TOT	(5) LOGS2TOT	(6) LOGS3TOT
LOGSIZE	-0.246***	-0.165***	-0.163***	0.329***	0.472***	0.453***
	(0.018)	(0.017)	(0.016)	(0.020)	(0.027)	(0.023)
B/M	-0.154***	-0.106**	-0.148***	0.371***	0.451***	0.381***
	(0.042)	(0.043)	(0.035)	(0.044)	(0.051)	(0.047)
ROE	0.015***	0.015***	0.016***	0.008***	0.008***	0.009***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
LEVERAGE	1.103***	1.096***	0.822***	0.669***	0.671***	0.370***
	(0.124)	(0.156)	(0.120)	(0.099)	(0.127)	(0.097)
INVEST/A	-2.196***	-3.081***	-4.251***	-1.136***	-1.928***	-3.089***
	(0.321)	(0.279)	(0.241)	(0.371)	(0.322)	(0.287)
HHI	-1.597***	-1.117***	-1.147***	-1.216***	-0.660***	-0.722***
	(0.094)	(0.089)	(0.090)	(0.074)	(0.059)	(0.062)
LOGPPE	0.395***	0.300***	0.311***	0.428***	0.336***	0.346***
	(0.016)	(0.014)	(0.012)	(0.015)	(0.016)	(0.016)
MSCI	1.246***	1.438***	1.359***	0.176***	0.256***	0.218***
	(0.111)	(0.133)	(0.130)	(0.040)	(0.049)	(0.042)
Constant	10.597***	9.854***	11.728***	3.902***	2.415***	4.555***
	(0.158)	(0.201)	(0.134)	(0.215)	(0.260)	(0.212)
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	874,592	874,736	875,270	874,592	874,736	875,270
R-squared	0.696	0.551	0.629	0.779	0.715	0.793

Carbon Premia Measurement

- We estimate a pooled regression model á la Daniel & Titman (1997) with:
  - monthly stock returns as a dependent variable
  - carbon emissions as a main explanatory variable (observed on an annual basis)
  - various firm-level characteristics as controls
  - industry and firm fixed effects
- We include year-month and country fixed effects
- We double cluster standard errors at firm and year dimensions
- Coefficient of carbon emission measure identifies average carbon premium

Estimating Carbon Premia (Levels)

Panel A: Levels

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LOGS1TOT	0.029			0.066***			0.140***		
	(0.022)			(0.016)			(0.044)		
LOGS2TOT		0.096***			0.118***			0.154**	
		(0.030)			(0.027)			(0.056)	
LOGS3TOT			0.118***			0.174***			0.620***
			(0.032)			(0.037)			(0.180)
LOGSIZE	-0.150***	-0.182***	-0.182***	-0.186***	-0.225***	-0.249***	-2.557***	-2.568***	-2.718***
	(0.040)	(0.042)	(0.042)	(0.041)	(0.042)	(0.045)	(0.341)	(0.345)	(0.391)
B/M	0.501**	0.496**	0.505**	0.610**	0.588**	0.576**	0.458	0.455	0.390
	(0.216)	(0.214)	(0.215)	(0.216)	(0.210)	(0.211)	(0.268)	(0.271)	(0.282)
LEVERAGE	-0.439**	-0.443**	-0.371**	-0.387**	-0.417**	-0.401**	-1.108**	-1.110**	-1.330**
	(0.182)	(0.170)	(0.168)	(0.163)	(0.151)	(0.154)	(0.455)	(0.455)	(0.489)
MOM	0.823**	0.830**	0.828**	0.815**	0.824**	0.825**	0.557	0.561	0.594
	(0.325)	(0.325)	(0.324)	(0.330)	(0.330)	(0.329)	(0.458)	(0.457)	(0.455)
INVEST/A	-0.775	-0.724	-0.409	-0.466	-0.303	-0.003	1.047	0.907	1.295
	(1.115)	(1.176)	(1.236)	(1.065)	(1.093)	(1.111)	(1.789)	(1.812)	(1.806)
HHI	0.014	0.031	0.104	0.059	0.059	0.108	-0.099	-0.087	0.069
	(0.120)	(0.118)	(0.115)	(0.126)	(0.122)	(0.128)	(0.283)	(0.283)	(0.289)
LOGPPE	-0.003	-0.025	-0.042	0.008	-0.003	-0.023	-0.183*	-0.176*	-0.256***
	(0.018)	(0.022)	(0.024)	(0.017)	(0.018)	(0.019)	(0.090)	(0.088)	(0.081)
ROE	0.013***	0.013***	0.012***	0.013***	0.013***	0.012***	0.015**	0.015**	0.014**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
VOLAT	-0.404	-0.560	-0.494	-0.182	-0.231	-0.202	-0.606	-0.633	-0.489
	(3.465)	(3.415)	(3.451)	(3.244)	(3.222)	(3.238)	(3.647)	(3.628)	(3.633)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	746,642	746,797	747,290	736,851	737,006	737,499	746,615	746,770	747,263
R-squared	0.150	0.150	0.150	0.151	0.151	0.151	0.176	0.176	0.177

Estimating Carbon Premia (Changes)

Panel B: Percentage Changes

DEP. VARIABLE: RET	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
S1CHG	0.500***			0.515***			0.586***		
	(0.089)			(0.091)			(0.086)		
S2CHG		0.301***			0.307***			0.354***	
		(0.062)			(0.065)			(0.071)	
S3CHG			1.342***			1.364***			1.628***
			(0.257)			(0.266)			(0.230)
LOGSIZE	-0.162***	-0.159***	-0.178***	-0.174***	-0.170***	-0.189***	-2.539***	-2.537***	-2.576***
	(0.042)	(0.041)	(0.042)	(0.041)	(0.041)	(0.041)	(0.327)	(0.328)	(0.328)
B/M	0.519**	0.513**	0.557**	0.657**	0.650**	0.696***	0.512*	0.500*	0.580**
	(0.215)	(0.214)	(0.217)	(0.219)	(0.218)	(0.221)	(0.265)	(0.266)	(0.260)
LEVERAGE	-0.455**	-0.441**	-0.492**	-0.372**	-0.357*	-0.403**	-1.051**	-1.048**	-1.060**
	(0.185)	(0.179)	(0.180)	(0.170)	(0.166)	(0.165)	(0.445)	(0.448)	(0.433)
MOM	0.785**	0.800**	0.705**	0.773**	0.789**	0.694*	0.517	0.530	0.452
	(0.321)	(0.321)	(0.314)	(0.327)	(0.327)	(0.320)	(0.452)	(0.454)	(0.449)
INVEST/A	-0.908	-0.768	-1.115	-0.758	-0.661	-0.961	0.732	0.811	0.638
	(1.187)	(1.205)	(1.204)	(1.065)	(1.065)	(1.058)	(1.815)	(1.836)	(1.802)
HHI	-0.050	-0.040	-0.071	-0.028	-0.018	-0.050	-0.145	-0.138	-0.130
	(0.124)	(0.126)	(0.121)	(0.122)	(0.124)	(0.120)	(0.280)	(0.283)	(0.278)
LOGPPE	0.030	0.026	0.045**	0.048**	0.043**	0.063***	-0.133	-0.140	-0.104
	(0.021)	(0.020)	(0.021)	(0.016)	(0.016)	(0.017)	(0.092)	(0.094)	(0.094)
ROE	0.014***	0.014***	0.015***	0.014***	0.014***	0.015***	0.016**	0.016**	0.016**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)
VOLAT	-0.500	-0.434	-0.450	-0.289	-0.239	-0.222	-0.593	-0.560	-0.330
	(3.461)	(3.477)	(3.524)	(3.241)	(3.256)	(3.286)	(3.646)	(3.640)	(3.678)
Yr/mo fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Industry fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Firm fixed effects	No	No	No	No	No	No	Yes	Yes	Yes
Observations	746,738	746,749	747,290	736,947	736,958	737,499	746,711	746,722	747,263
R-squared	0.150	0.150	0.151	0.152	0.151	0.152	0.177	0.177	0.177

Country-level Determinants

- Does the geographic location matter for transition risk? Are markets for carbon risk segmented?
  - The short-term and long-term premium is **present in most geographic locations** globally. Some cross-sectional variation in magnitudes
  - Weaker results for countries from Africa and the Southern Hemisphere (Argentina, Australia, Brazil, Chile, Nigeria, South Africa)
  - Firm-level **international (sectoral) diversification** is less relevant for the risk

- Does the degree of a country's development matter? Is carbon-transition risk mainly a developed country issue?
  - The degree of a country's development does not differentially affect **long-term** transition risk
  - Firms located in countries with better development are exposed to smaller **short-term** transition risk

Decomposing Transition Risk

- Which elements of transition risk matter for asset prices?
  - technological (energy mix) changes
  - political environment/voice
  - climate-related policy tightness

- Our state variables observed at the country level only. To strengthen identification, we follow Rajan & Zingales (1998) and interact country-level variables with firm-level measures of emissions (levels and changes)
  - Empirical identification allows us to introduce country, industry, and firm fixed effects
  - Typical country-level omitted variables are less of an issue

Decomposing Transition Risk: Results

- Energy mix and political environment matter for **short-term transition risk**
  - Firms in countries with a greater transition advancement to green energy face significantly lower transition risk
  - Firms located in countries with more equal society are exposed to less risk
  - Results consistent with: (a) technological risk being largely transitory; (b) political environment's cyclical nature

- Carbon policy tightness matters for **long-term transition risk**
  - Firms in countries with greater policy tightness are exposed to more risk
  - The effect significant for **domestic** policies and not international policy tightness
  - Results consistent with: (a) policies' lasting effects; (b) high coordination costs of global policies (see, carbon tax discussion)

Additional Tests: The Role of Salience

- Carbon-transition risk depends on investors' awareness/beliefs about it. Look at shocks to investors' awareness:
  - (1) Global-level (Paris Agreement)
  - (2) Country-level (investors' beliefs)
  - (3) Industry-level (headline risk)

- ad. (1) Paris Agreement increases the average **long-term transition risk**
  - consistent with PA driving climate policy framework
- ad. (2) Countries in Europe react less to Paris shock than do countries in North America and Asia
  - consistent with the view that Europe is ahead of other countries in the transition
- ad. (3) Results similar or slightly stronger if we exclude industries exposed to headline risk (energy, utilities, and transportation)

Conclusions

- Transition risk is already a material risk for investors & corporations
  - Transition risk is difficult to measure: Focus on carbon footprint
  - It is reflected both as a long-term and short-term risk
  - The long-term premium is unrelated to economic development, energy mix, or social environment; more related to **domestic** policy implementation
  - The short-term premium is related to technology risk and social environment, less so to policy implementation
  - Importance of changing investor awareness/beliefs (especially post Paris)
- Carbon premium acts like a carbon tax
  - Easier to leverage capital markets than political coalitions