



Carbon Risk

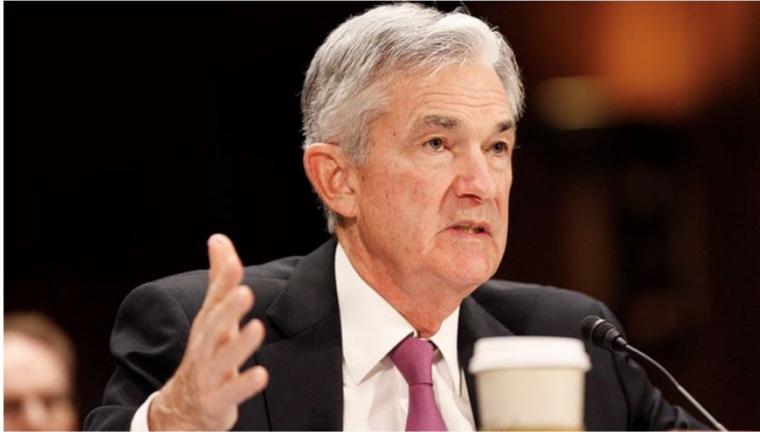
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Powell told Congress Fed is preparing for economic 'damage' from climate change

BY JOHN BOWDEN - 05/07/19 02:14 PM EDT

 187 COMMENTS



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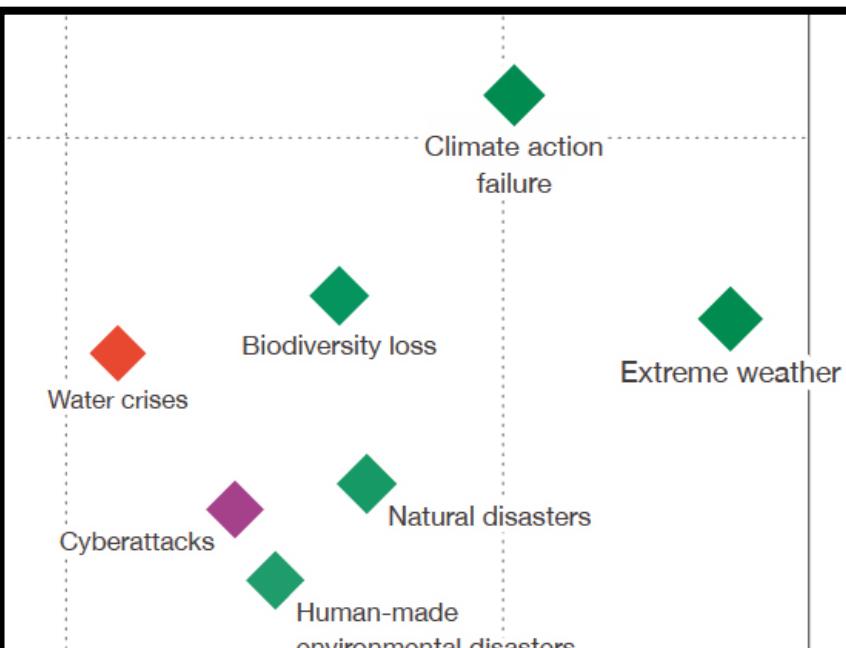
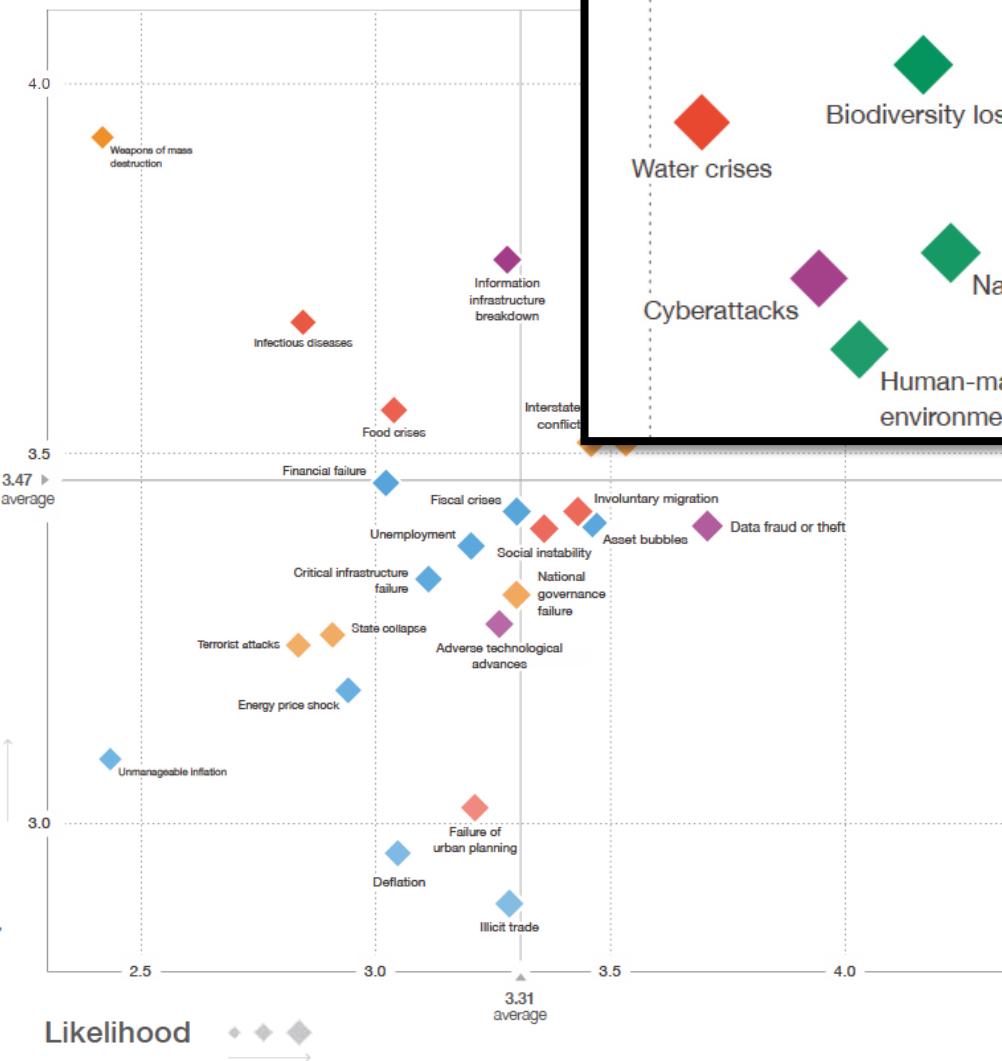
The Federal Reserve has taken steps to ensure that banks and other financial institutions affected by a changing global climate will be protected from undue financial burden, Chairman Jerome Powell says.

In a letter to Sen. Brian Schatz (D-Hawaii), Powell wrote last month that the central bank stood ready to protect financial institutions affected by severe weather events that result from temperatures rising around the world, according to [The Wall Street Journal](#).

"Although addressing climate change is a responsibility that Congress has entrusted to other agencies, the Federal Reserve does use its authorities and tools to prepare financial institutions for severe weather events," Powell wrote, according to the Journal.

"As such, these events may affect economic conditions, which we take into account in our assessment of the outlook for the economy," he added.

Global Risk Report 2020

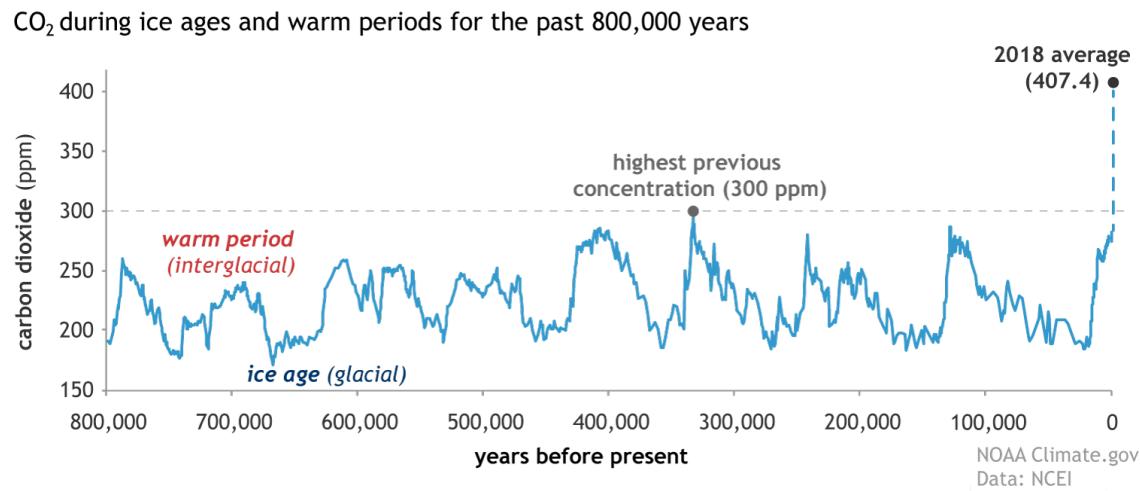


Outline

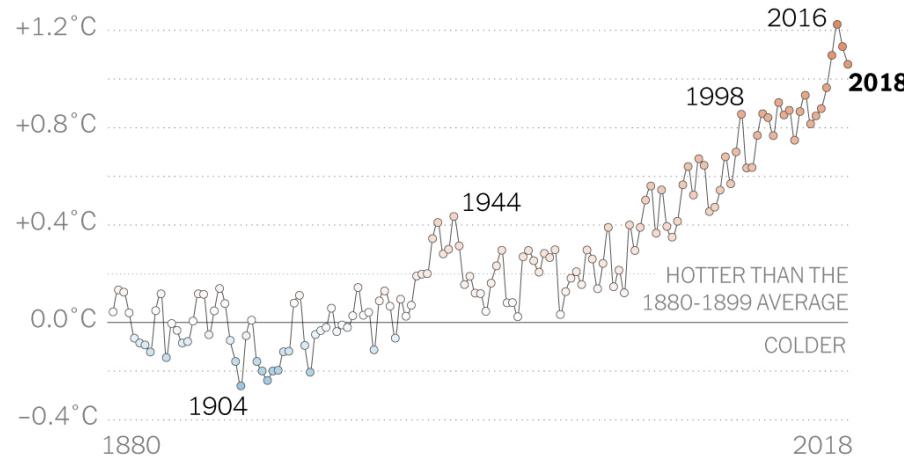
1. Motivation
2. Carbon Risk in Equity Prices
3. Carbon Risk Factor Construction
4. The Missing Carbon Risk Premium
5. Summary

Motivation - Climate Change

Atmospheric CO₂ emissions are rising rapidly



Temperature is continually increasing



Source: climate.nasa.gov (2019)

Motivation - Transition Process

New agreements



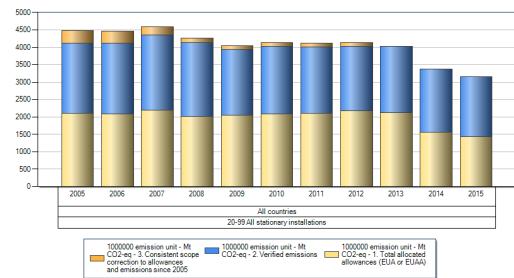
e.g. Paris Agreement

Change in taste



e.g. Divestment movement, \$11 trn.

Changing market dynamics



e.g. Emission certificates, carbon prices and taxes

Definition: Carbon Risk results from the transition process from a carbon-intensive brown economy to a low-carbon green economy.

Motivation - Academic Literature

A growing literature on the relationship between climate change and asset prices

Review of Financial Studies – Special Issue “Climate Finance” (Hong et al., 2020)

- Paper studying the **pricing of physical risks** induced by **climate change**
(e.g. Engle et al., 2020; Barnett et al., 2020)
- Studies analyzing the overall **impact of climate change** on **firm returns**
(e.g. Monasterolo et al., 2020; Choi et al., 2020; Hong et al., 2017; Oestreich and Tsiakas, 2015)
- Papers conducting research on the **influence of climate change risk in bonds and loans**
(e.g. Baker et al., 2020; Delis et al., 2020; Rainforest Action Network et al., 2019)
- Studies reporting a link between **climate change** and **property values**
(e.g. Bakkensen and Barrage, 2018; Baldauf et al., 2020; Bernstein et al., 2019; Giglio et al., 2018; Ortega and Taspinar, 2018; Rehse et al., 2019)
- Further studies focusing on downside risks in **options** (Ilhan et al., 2019), firm-value effects of **carbon disclosure** (Matsumara et al., 2014), **fund managers** (Alok et al., 2020), **investors** (Krüger et al., 2020), or a firm’s **cost of capital** (e.g. Chava, 2014; El Ghoul et al., 2011) and related ESG factor risk (Pástor et al., 2019)

Motivation - Contribution

Challenges measuring Carbon Risk

- Little and low quality Carbon data
- Short and volatile time series
- Transition of economies/industries is uncertain

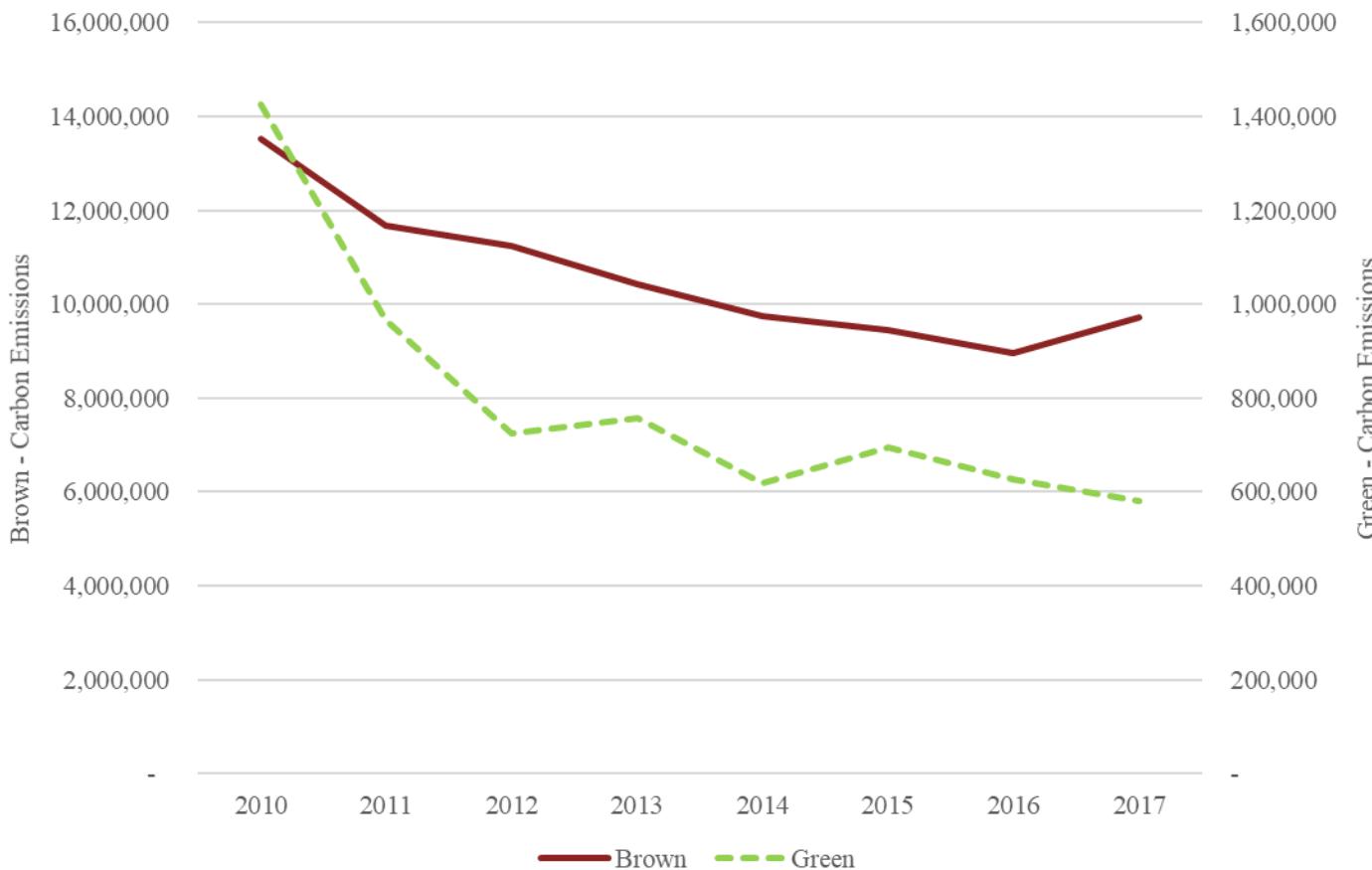
Our Contribution

- Determine the greenness or brownness of a firm
- Development of a Carbon Risk Factor
- Quantify Carbon Risk using the tools of asset pricing
- Present a plausible explanation and prediction about carbon risk premium

Outline

1. Motivation
2. **Carbon Risk in Equity Prices**
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Emissions of Brown and Green firms



→ Green firms are becoming greener than Brown firms

Expected and Unexpected Carbon Risk

	(1)	(2)	(3)	(4)
BGS	0.044*** (3.18)	0.062*** (4.55)	0.054*** (3.69)	0.068* (1.67)
BGS Difference	-0.040 (-1.55)	-0.070*** (-2.90)	-0.064*** (-2.63)	-0.065** (-2.05)
Log Total Assets	0.063*** (10.83)	0.059*** (10.50)	0.065*** (11.26)	0.36*** (21.56)
Book-to-market Ratio	34.1*** (2.76)	4.69 (0.38)	10.5 (0.89)	179.5*** (7.79)
Country fixed effects	no	yes	no	no
Industry fixed effects	no	no	yes	no
Firm fixed effects	no	no	no	yes
Time fixed effects	no	yes	yes	yes
Controls	yes	yes	yes	yes
R ²	0.040	0.17	0.17	0.35
N	6,055	6,053	6,055	5,871

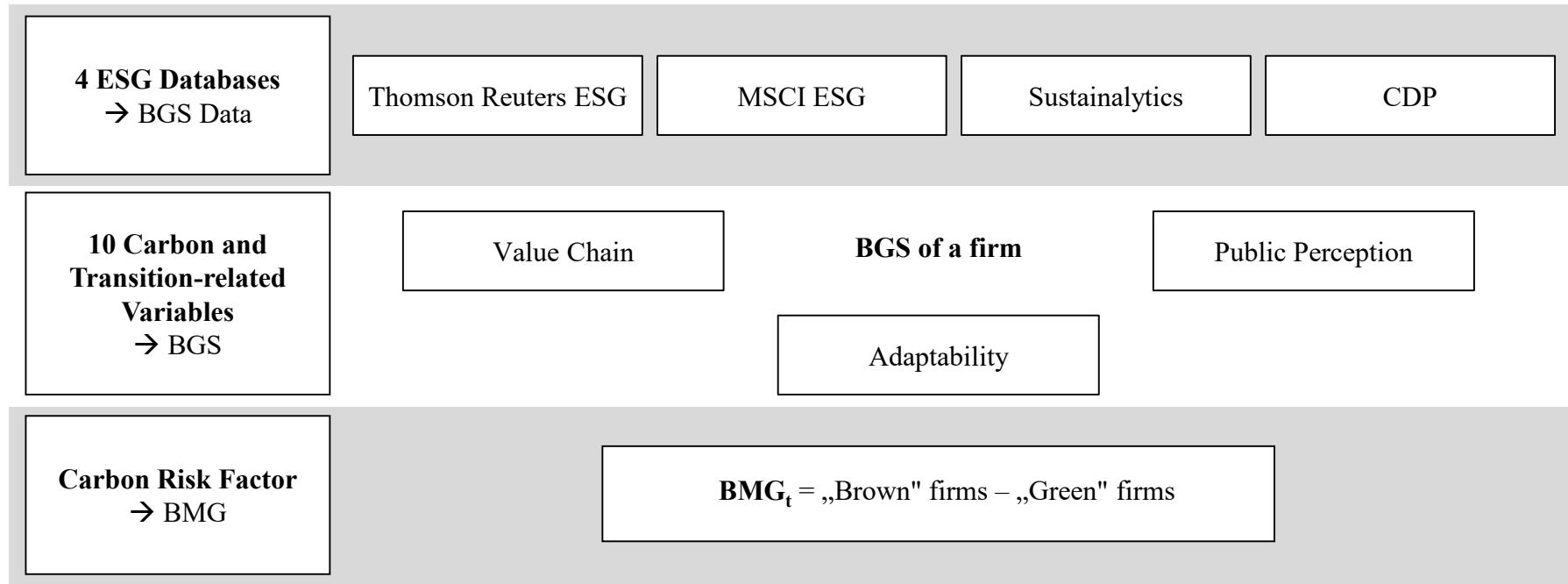
→ BGS level is associated with a positive, change in BGS with a negative return

Outline

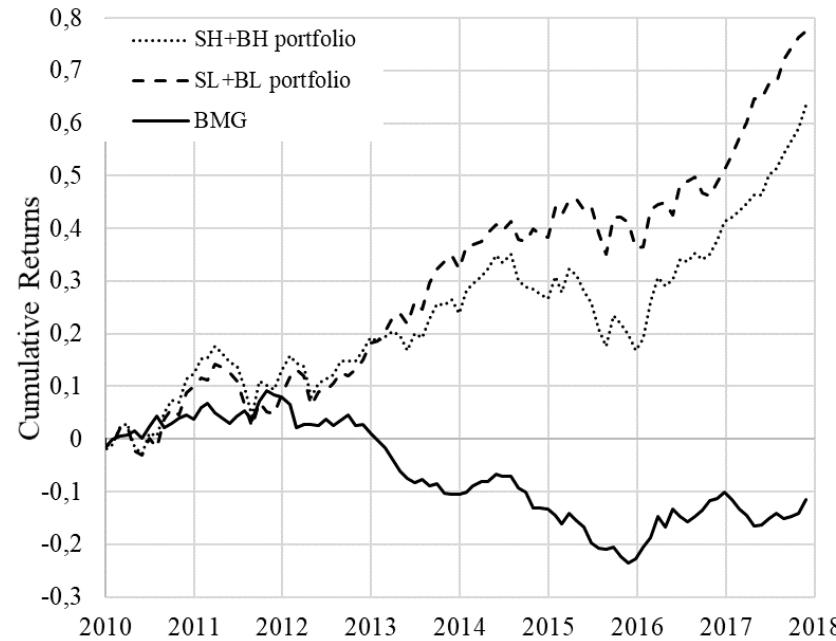
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Carbon risk measurement methodology

Carbon risk measurement methodology



BMG – A mimicking factor portfolio for carbon risk



Fama/French and BMG

Factor	Mean return (%)	SD (%)	t-stat.	Correlations				
				BMG	er_M	SMB	HML	WML
BMG	-0.11	1.70	-0.65	1.00				
er_M	0.89	3.78	2.30	0.05	1.00			
SMB	0.07	1.33	0.55	0.06	-0.02	1.00		
HML	-0.07	1.65	-0.41	0.29	0.17	-0.02	1.00	
WML	0.51	2.37	2.09	-0.17	-0.20	0.00	-0.38	1.00

BMG is a relevant factor in asset pricing models

Significance tests for explanatory power of various models

	Avg. Δ adj. R ² (%)	Significant at 5% F-test (%)
(1) CAPM – Fama/French 3F	1.32	15.00
(2) CAPM – CAPM + BMG	0.86	13.54
(3) Fama/French 3F – Carhart	0.29	7.20
(4) Fama/French 3F – Fama/French 3F + BMG	0.90	14.43

→ BMG factor adds explanatory power to common factor models

Significance levels for factor candidates (Pukthuanthong et al., 2019)

	er _M	SMB	HML	WML	BMG
mean absolute t-stat	5.44	2.93	3.03	2.20	4.13
mean absolute t-stat of significant canonical correlation	6.69	3.54	3.33	2.05	5.03

→ BMG factor is related to the covariance matrix of returns

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Cross-sectional regressions

Fama and MacBeth (1973) regressions

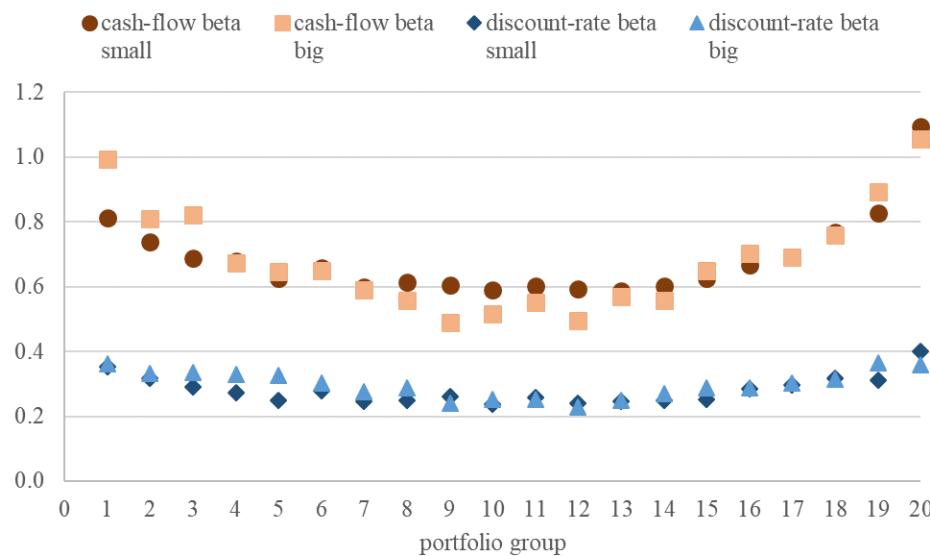
	(1)	(2)
BMG	-0.097	-0.062
er _M	-0.240	-0.232
SMB	-0.115**	-0.115**
HML	0.085	0.094
WML	-0.062	-0.076
Constant	2.713***	2.204***
Industry fixed effects	no	yes
Controls	yes	yes
R ²	3.57	4.58
N	792,352	792,352

→ BMG factor does **not** command a significant risk premium

A risk decomposition of BMG factor and beta portfolios

	Variance Components			
	Var(N_{CF})	Var(N_{DR})	-2 Cov(N_{CF}, N_{DR})	Corr(N_{CF}, N_{DR})
Absolute (%)	0.0428 (0.00)	0.0040 (0.00)	-0.0183 (0.00)	70.05 (0.00)
Normalized (%)	150.32 (0.21)	14.04 (0.02)	-64.36 (0.06)	70.05 (0.00)

→ BMG factor is mainly driven by cash-flow news



→ Market beta of extreme (carbon risk) portfolios mainly driven by cash-flow news

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Main contribution

Construct a Carbon Risk Factor and measure Carbon Risk

- Show that **green firms** getting **greener** and BGS is related to **stock returns**
- Construct a measure of **carbon risk** that explains **systematic returns**
- **BMG factor** robust to asset pricing tests
- We find no **risk premium**
- Show that this is to **cash-flow driven BMG betas**

Implications

- Markets are not in an **equilibrium** wrt. carbon risk (Pástor et al., 2019)
- Results point towards a **positive future risk premium**
- Need better **data** and **financial models** of carbon risk

Provide a “politically” neutral assessment of what markets think about carbon risk!

APPENDIX

Descriptive statistics of variables

Variable	N	Mean	SD	Median
Panel A. Raw BGS Data				
Emissions Intensity (Combined)	6,968	368.88	883.01	58.31
Environmental Score	7,130	16.78	20.54	7.47
Environmental Pillar Score	7,170	4.34	1.98	4.40
Performance Band	5,681	4.28	2.02	4.17
Environmental Score	6,875	36.32	12.10	36.00
Environmental Innovation Score	7,141	38.66	25.84	35.29
Carbon Emissions Score	6,385	2.77	2.36	2.50
Preparedness	6,875	4.55	0.57	4.67
Panel B. Scored BGS Data				
Value Chain Score	7,195	0.50	0.50	0.50
Public Perception Score	7,195	0.56	0.28	0.54
Adaptability Scores	7,195	0.51	0.34	0.50
Brown-Green-Score BGS	7,195	0.51	0.37	0.54
Panel C. Financial Data				
Returns	7,171	0.12	0.35	0.10
Market Capitalization	7,195	19,771.43	38,513.42	7,862.32
Net Sales	7,195	17,228.58	32,721.70	7,084.00
Total Assets	7,195	24,369.15	46,441.11	9,248.30
Book-to-Market Ratio	7,195	5.59	4.46	4.64
Leverage Ratio	7,194	25.88	16.06	24.46
Invest/Total Assets Ratio	7,189	0.15	0.73	0.10
Property, Plant, and Equipment	7,194	8,288.05	18,910.92	2,383.65
Market Beta	7,165	0.98	0.50	0.95
Idiosyncratic Volatility	7,167	1.71	0.72	1.57

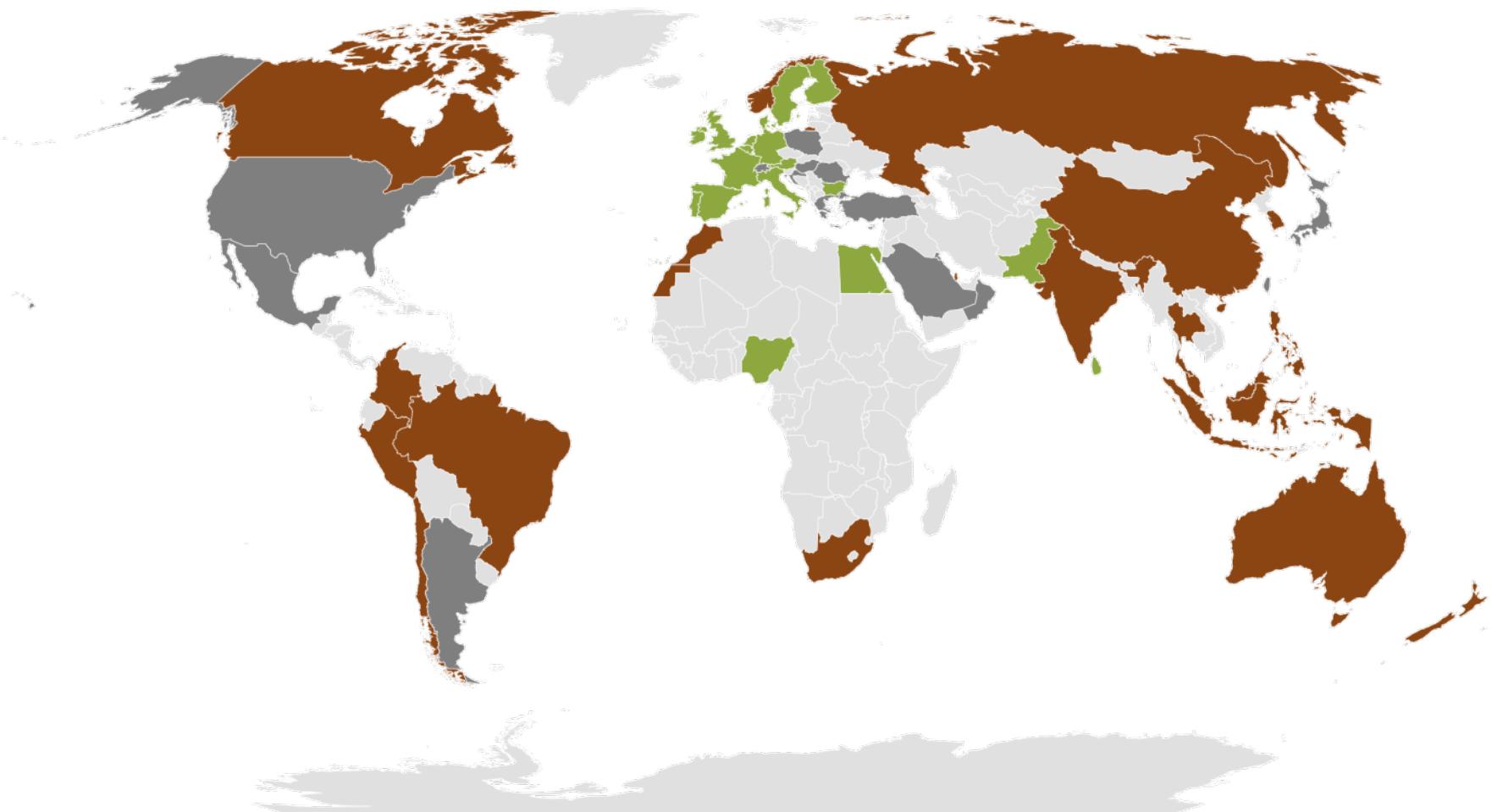
BGS quintile portfolio performance

Quintile	Median BGS	Coefficient						Adj. R ² (%)	Δ Coefficient					Δ Adj. R ² (%)
		Alpha	er _M	SMB	HML	WML	BMG		Δ Alpha	Δ er _M	Δ SMB	Δ HML	Δ WML	
Low	0.07	0.00 (-0.36)	1.04*** (39.50)	0.18** (2.46)	0.00 (-0.04)	-0.14*** (-3.14)	-0.30*** (-5.06)	94.74%	0.000 ^a	0.000 ^{a***}	0.030 ^{a*}	0.090 ^a	-0.020 ^{a**}	1.42***
2	0.18	0.00 (1.50)	0.99*** (34.20)	0.27*** (3.40)	-0.09 (-1.21)	-0.06 (-1.29)	-0.10 (-1.58)	92.88%	0.000 ^a	0.000 ^{a***}	0.010 ^{a***}	0.030 ^a	0.000 ^a	0.12
3	0.57	0.00 (-0.60)	1.09*** (38.56)	0.20** (2.55)	0.02 (0.31)	-0.08* (-1.69)	0.00 (-0.06)	94.41%	0.000 ^a	0.000 ^{a***}	0.000 ^{a**}	0.000 ^a	0.000 ^{a*}	-0.06
4	0.87	0.00 (-1.39)	1.05*** (32.15)	0.21** (2.29)	0.03 (0.34)	-0.18*** (-3.16)	0.47*** (6.27)	92.80%	0.000 ^a	0.010 ^{a***}	-0.040 ^{a**}	-0.130 ^a	0.020 ^{a***}	3.03***
High	0.96	0.00 (-0.52)	1.06*** (32.04)	0.34*** (3.77)	-0.19** (-2.35)	-0.14** (-2.52)	0.98*** (13.03)	93.34%	0.000 ^a	0.010 ^{a***}	-0.09 ^{a***}	-0.260 ^a	0.050 ^{a**}	12.36***
High-Low	0.89	0.00 (-0.32)	0.02 (0.69)	0.17** (2.39)	-0.19*** (-3.06)	0.00 (-0.02)	1.28*** (22.56)	84.94%						

Asset pricing tests

Factor model	GRS	p-value	Mean Alpha	Mean adj. R ²	SR ²
Panel A. 5x5 Size/Value Portfolios					
CAPM	4.454	0.000	0.001	0.859	1.678
CAPM + BMG	4.351	0.000	0.001	0.862	1.673
Fama/French	4.399	0.000	0.001	0.928	1.723
Fama/French + BMG	4.314	0.000	0.001	0.929	1.721
Carhart	4.055	0.000	0.001	0.931	1.710
Carhart + BMG	3.985	0.000	0.001	0.932	1.708
Fama/French 5F	3.295	0.000	0.001	0.928	1.629
Fama/French 5F + BMG	3.186	0.000	0.001	0.929	1.616
Fama/French 6F	3.238	0.000	0.001	0.931	1.644
Fama/French 6F + BMG	3.142	0.000	0.001	0.932	1.633
Panel B. 5x5 Size/Momentum Portfolios					
CAPM	4.452	0.000	0.003	0.842	1.678
CAPM + BMG	4.410	0.000	0.003	0.844	1.696
Fama/French	4.327	0.000	0.003	0.900	1.695
Fama/French + BMG	4.285	0.000	0.003	0.901	1.710
Carhart	3.883	0.000	0.002	0.933	1.637
Carhart + BMG	3.854	0.000	0.002	0.934	1.652
Fama/French 5F	3.057	0.000	0.002	0.905	1.511
Fama/French 5F + BMG	2.965	0.000	0.002	0.906	1.504
Fama/French 6F	2.969	0.000	0.002	0.934	1.508
Fama/French 6F + BMG	2.889	0.000	0.002	0.935	1.502

Global breakdown of BMG beta



Unterstützt von Bing

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BMG beta in major countries

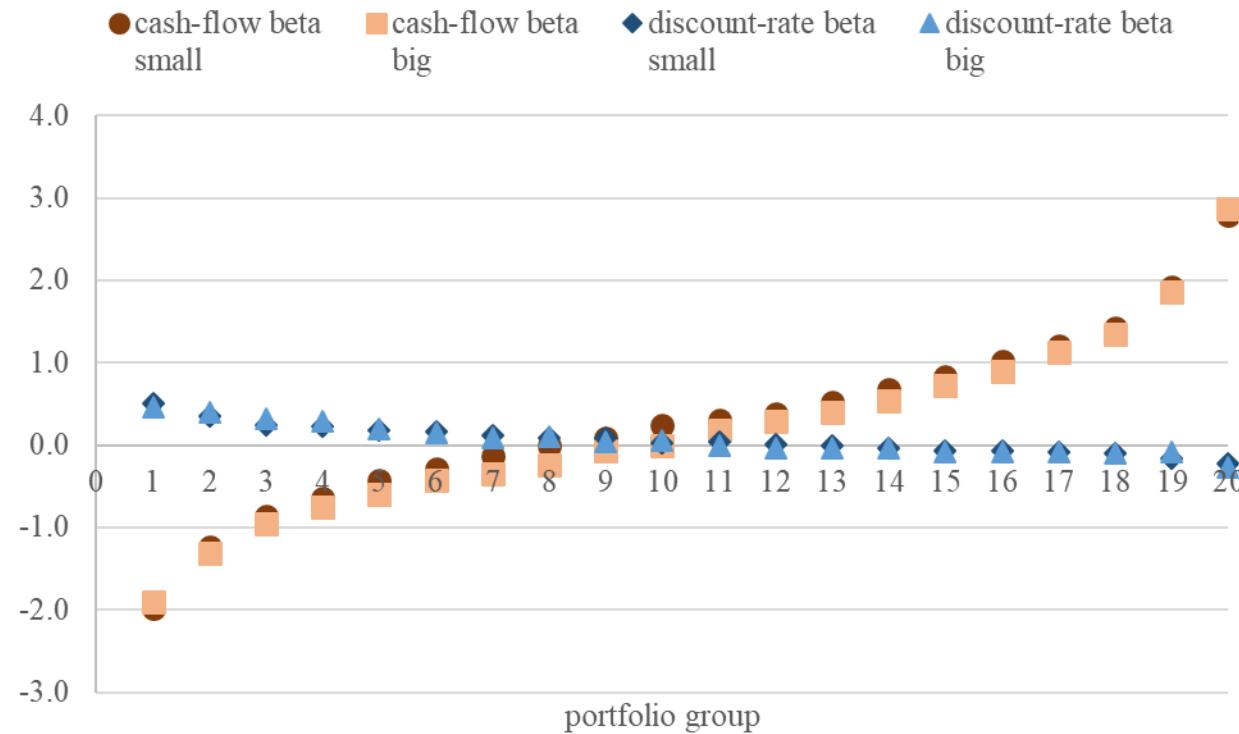
Country	N	Mean	SD	Min	P25	Median	P75	Max
France	428	-0.51	0.74	-3.29	-0.94	-0.48	-0.09	2.46
United Kingdom	1,178	-0.32	1.14	-3.21	-0.94	-0.38	0.15	4.20
Germany	507	-0.19	0.98	-3.29	-0.71	-0.24	0.22	4.07
Japan	2,586	-0.11	0.84	-2.95	-0.61	-0.13	0.34	4.07
United States	5,215	-0.03	1.12	-3.29	-0.63	-0.06	0.51	4.19
Taiwan	993	0.01	0.77	-2.91	-0.40	0.04	0.45	4.15
India	1,045	0.23	0.91	-3.25	-0.28	0.20	0.77	4.01
China	3,177	0.32	0.88	-3.25	-0.16	0.38	0.87	3.88
Hong Kong	1,217	0.39	1.00	-3.18	-0.17	0.35	0.97	4.06
Singapore	403	0.43	0.93	-3.22	0.00	0.47	0.88	3.79
South Korea	1,057	0.55	0.92	-3.25	0.04	0.51	1.05	4.20
Australia	747	0.91	1.18	-2.99	0.26	0.75	1.51	4.21
Canada	1,112	1.17	1.42	-3.29	0.23	0.98	2.15	4.22

Regional cross-sectional regressions

	USA	Europe	Asia	Global
BMG	-0.211 (-1.14)	-0.246 (-1.28)	-0.181 (-1.04)	-0.192 (-1.07)
er _M	-0.057 (-0.16)	0.043 (0.11)	0.028 (0.07)	-0.008 (-0.02)
SMB	-0.018 (-0.14)	0.004 (0.02)	0.029 (0.19)	-0.003 (-0.02)
HML	-0.136 (-0.78)	-0.270 (-1.49)	-0.165 (-0.92)	-0.178 (-1.01)
WML	0.216 (0.90)	0.350 (1.42)	0.402 (1.58)	0.388 (1.56)
Constant	0.482 (0.86)	1.429** (2.61)	2.190*** (3.49)	1.868*** (3.65)
Industry fixed effects	yes	yes	yes	yes
Controls	yes	yes	yes	yes
R ² (in %)	13.75	12.52	11.24	10.93
N	240,604	232,134	769,224	1,393,848

A.4 BMG beta decomposition

BMG beta decomposition of 40 BMG beta sorted portfolios



A.1 Further descriptive statistics (1)

Geographic and sectoral breakdown of data sample

a. Geographic			b. Sectoral			
Country	#	%	Sector	TRBC	#	%
United States	419	25.29	Industrials	52	374	22.57
Japan	231	13.94	Cyclical Consumer Goods & Services	53	281	16.96
United Kingdom	192	11.59	Basic Materials	51	242	14.60
Canada	98	5.91	Technology	57	193	11.65
Australia	74	4.47	Non-Cyclical Cons. Goods & Services	54	169	10.20
France	70	4.22	Energy	50	122	7.36
South Africa	59	3.56	Healthcare	56	108	6.52
Germany	54	3.26	Utilities	59	105	6.34
Taiwan	47	2.84	Telecommunications Services	58	63	3.80
South Korea	35	2.11				
Other Europe	249	15.03				
Other Asia	80	4.83				
Other Americas	37	2.23				
Other Australasia	12	0.72				
Total	1,657	100.00	Total		1,657	100.00

A.1 Transition probabilities of firms

Panel A. from year $t - 1$ to year t

Portfolio	SL_t	SN_t	SH_t	BL_t	BN_t	BH_t
SL_{t-1}	94.30%	1.93%	0.19%	3.44%	0.11%	0.02%
SN_{t-1}	1.96%	92.67%	1.91%	0.12%	3.13%	0.20%
SH_{t-1}	0.16%	1.70%	95.05%	0.01%	0.10%	2.98%
BL_{t-1}	1.64%	0.05%	0.01%	96.82%	1.31%	0.18%
BN_{t-1}	0.07%	1.98%	0.08%	1.93%	93.63%	2.31%
BH_{t-1}	0.01%	0.05%	2.02%	0.18%	2.29%	95.46%

Panel B. from year $t - 5$ to year t

Portfolio	SL_t	SN_t	SH_t	BL_t	BN_t	BH_t
SL_{t-5}	81.93%	7.08%	0.98%	9.03%	0.88%	0.10%
SN_{t-5}	7.42%	73.84%	7.96%	1.00%	8.48%	1.29%
SH_{t-5}	0.70%	6.89%	82.51%	0.07%	0.88%	8.95%
BL_{t-5}	3.33%	0.24%	0.04%	90.07%	5.52%	0.81%
BN_{t-5}	0.35%	3.97%	0.46%	8.61%	77.48%	9.13%
BH_{t-5}	0.07%	0.41%	4.33%	0.89%	9.20%	85.10%

A.1 Further descriptive statistics (2)

Descriptions of environmental variables of the four ESG databases

Variable	Description
<i>Value Chain</i>	
Emission Intensity (CDP)	Gross global Scope 1 & 2 emissions figures in metric tonnes CO ₂ e divided by net sales.
Emission Intensity (Thomson Reuters)	Total CO ₂ and CO ₂ equivalents emissions in metric tonnes CO ₂ e divided by net sales.
Emission Intensity (Sustainalytics)	Absolute Scope 1 & 2 GHG emissions (reported or otherwise estimated) in metric tonnes CO ₂ e divided by net sales.
Emission Intensity (Combined)	By taking the different data quality and estimation methods within each emissions database into account, we combine the three emission intensity measures using the following preference order: CDP > Thomson Reuters > Sustainalytics.
<i>Public Perception</i>	
Environmental Score (Thomson Reuters)	The environmental score consists of three subscores: Resource Use Score, Emissions Score, and Innovation Score. The Resource Use Score reflects a company's performance and capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management. The Emission Reduction Score measures a company's commitment and effectiveness towards reducing environmental emission in the production and operational processes. The Innovation Score reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes or eco-designed products.
Environmental Pillar Score (MSCI)	The Environmental Pillar Score represents the weighted average of all Key Issues that fall under the Environment Pillar. Among others, it contains the following key issues: carbon emissions, product carbon footprint, financing environmental impact, climate change vulnerability, opportunities in clean tech, green building, and renewable energy.
Performance Band (CDP)	The performance band represents a score which assesses progress towards environmental stewardship as reported by a company's CDP response. The score assesses the level of detail and comprehensiveness of the content, as well as the company's awareness of climate change issues, management methods, and progress towards action taken on climate change as reported in the response.
Environmental Score (Sustainalytics)	The research framework broadly addresses three themes: Environmental, Social, and Governance. Within these themes, the focus is placed on a set of key ESG issues that vary by industry. The key ESG issues are the most material areas of exposure and, therefore, define key management areas for the company. The key ESG issues were identified based on an analysis of the peer group and its broader value chain, a review of companies' business models, the identification of key activities associated with environmental and/or social impacts, and an analysis of the business impacts that may result from inadequate management of these factors.
<i>Adaptability</i>	
Environmental Innovation Score (Thomson Reuters)	The Environmental Innovation Score reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes or eco-designed products
Carbon Emissions Score (MSCI)	This key issue is relevant to those companies with significant carbon footprints. Companies that proactively invest in low-carbon technologies and increase the carbon efficiency of their facilities score higher on this key issue. Companies that allow legal compliance to determine product strategy, focus exclusively on activities to influence policy setting, or rely heavily on exploiting differences in regulatory frameworks score lower.
Preparedness (Sustainalytics)	Preparedness measures an issuer's level of commitment to manage environmental risks. It is assessed by analyzing the quality of an issuer's policies, programmes, and systems to manage environmental issues effectively.

A.2 Further asset pricing tests

Excluded factor regression coefficient estimates for different models

Coefficients								
LHS	Alpha in %	ϵ_{rM}	SMB	HML		Sum Alpha in %	Adj. R ² (%)	
SMB	0.0806 (0.57)	-0.00678 (-0.19)				0.0403	-0.010	
HML	-0.136 (-0.80)	0.0750* (1.69)				0.068	0.019	
BMG	-0.13 (-0.73)	0.0203 (0.44)				0.065	-0.009	

Coefficients								
LHS	Alpha in %	ϵ_{rM}	SMB	HML		Sum Alpha in %	Adj. R ² (%)	
WML	0.55 (2.37)	-0.0880 (-1.45)	-0.0190 (-0.11)	-0.516*** (-3.71)		0.1375	0.139	
BMG	-0.000967 (-0.56)	-0.00160 (-0.04)	0.0898 (0.71)	0.300*** (2.89)		0.0002418	0.059	

Coefficients								
LHS	Alpha in %	ϵ_{rM}	SMB	HML		Sum Alpha in %	Adj. R ² (%)	
RMW	0.377 (4.37)	-0.116*** (-5.16)	-0.305*** (-4.77)	-0.316*** (-6.08)		0.1885	0.514	
CMA	0.148 (1.71)	-0.0477** (-2.10)	-0.0458 (-0.71)	0.352*** (6.72)		0.074	0.514	
BMG	-0.104 (-0.60)	0.0000499 (0.00)	0.0903 (0.70)	0.293*** (2.80)		0.052	0.060	

Coefficients								
LHS	Alpha in %	ϵ_{rM}	SMB	HML	RMW	CMA	Sum Alpha in %	Adj. R ² (%)
WML	0.246 (1.02)	0.00808 (0.12)	0.221 (1.22)	-0.639*** (-3.44)	0.509* (1.92)	0.762*** (2.89)	0.0615	0.239
BMG	-0.186 (-0.96)	0.0254 (0.49)	0.157 (1.09)	0.366** (2.46)	0.221 (1.04)	-0.00681 (-0.03)	0.0465	0.050

A.3 Democratic orthogonalization (1)

Descriptive statistics – orthogonalized factors

Factor	Mean return (%)	SD (%)	T-stat.	Correlations				
				BMG	er_M	SMB	HML	WML
-0.09	1.70	-0.50	0.986					
0.97	3.78	2.50			0.996			
0.08	1.33	0.60				0.999		
-0.01	1.65	-0.09					0.959	
0.58	2.37	2.40						0.979

A.3 Democratic orthogonalization (2)

Quintiles with orthogonalized factors

Quintile	coefficients							Δ coefficients					Δ Adj. R ² (%)
	$Alpha^L$	er_M^L	SMB^L	HML^L	WML^L	BMG^L	Adj. R ² (%)	$\Delta Alpha$	Δer_M	ΔSMB	ΔHML	ΔWML	
Low	0.00 (-0.36)	1.04*** (40.66)	0.15** (2.11)	0.10 (1.65)	-0.24*** (-5.95)	-0.26*** (-4.53)	94.74%	0.000a	0.000a***	0.000a*	0.190a	-0.120a**	1.42***
2	0.00 (1.50)	0.98*** (34.91)	0.26*** (3.20)	0.02 (0.31)	-0.16*** (-3.60)	-0.08 (-1.25)	92.88%	0.000a	-0.010a***	0.000a***	0.140a	-0.100a	0.12
3	0.00 (-0.60)	1.09*** (39.66)	0.18** (2.35)	0.15** (2.45)	-0.21*** (-4.88)	0.04 (0.60)	94.41%	0.000a	0.000a***	-0.020a**	0.130a	-0.130a*	-0.06
4	0.00 (-1.39)	1.06*** (33.45)	0.21** (2.33)	0.24*** (3.32)	-0.33*** (-6.56)	0.51*** (7.18)	92.80%	0.000a	0.020a***	-0.040a**	0.080a	-0.130a***	3.03***
High	0.00 (-0.52)	1.06*** (33.07)	0.37*** (4.06)	0.09 (1.25)	-0.30*** (-5.84)	0.98*** (13.78)	93.34%	0.000a	0.010a***	-0.060a***	0.020a	-0.110a**	12.36***
High-Low	0.00 (-0.32)	0.02 (0.83)	0.22*** (3.14)	-0.01 (-0.08)	-0.06 (-1.44)	1.24*** (22.98)	84.94%						

A.3 Democratic orthogonalization (3)

Decomposition of R^2

Quintile	decomposed- R^2					systematic R^2 (%)	idiosyncratic variance ($1-R^2$) (%)
	er_M^\perp	SMB^\perp	HML^\perp	WML^\perp	BMG^\perp		
Low <i>BGS</i>	91.52%	0.25%	0.15%	1.96%	1.14%	95.02%	4.98%
2	91.39%	0.77%	0.01%	0.97%	0.12%	93.25%	6.75%
3	92.60%	0.33%	0.35%	1.40%	0.02%	94.70%	5.30%
4	84.77%	0.41%	0.84%	3.26%	3.91%	93.18%	6.82%
High <i>BGS</i>	76.71%	1.15%	0.11%	2.39%	13.31%	93.69%	6.31%

A.3 Democratic orthogonalization (4)

Decomposition of R^2 with orthogonalized factors on single stock level

Avg. decomposed- R^2 (%)					Avg. Systematic R^2 (%)	Avg. Idiosyncratic Variance ($1-R^2$) (%)
er_M^\perp	SMB $^\perp$	HML $^\perp$	WML $^\perp$	BMG $^\perp$		
12.89	2.38	1.68	1.90	2.28	21.14	78.86

A.3 Democratic orthogonalization (5)

Significance tests for factor betas for the Carhart + BMG model

T-test of significance of coefficients

Avg. coefficient	10% level		5% level		1% level		
	#	%	#	%	#	%	
er _M ¹	0.958	15,672	77.41	14,295	70.61	11,167	55.16
SMB ¹	0.846	4,864	24.02	3,151	15.56	1,189	5.87
HML ¹	0.121	2,880	14.23	1,696	8.38	529	2.61
WML ¹	-0.306	3,406	16.82	2,041	10.08	691	3.41
BMG ¹	0.251	4,245	20.97	2,930	14.47	1,374	6.79