Climate change concerns and the performance of green versus brown stocks

David Ardia
> *HEC Montréal*

Keven Bluteau
> *UGent, HEC Montréal*

Kris Boudt
> *UGent, VUB, VUA*

Koen Inghelbrecht
> *UGent*

NBB Conference 2020

Our Motivation

Lawmakers' concerns

Republicans: Not concerned

Democrats: Concerned

Our Motivation

Lawmakers' concerns

Republicans: Not concerned

Democrats: Concerned

Consumers' concerns

Our Motivation

Lawmakers' concerns

Republicans: Not concerned

Democrats: Concerned

Consumers' concerns

Investors' Concerns

Dec 06, 2018   businesswire   **Business Wire**

TORONTO — The vast majority of Canadian investors are concerned about climate change, says a new survey from the Responsible Investment Association (RIA).

The 2018 RIA Investor Opinion Survey, which is based on an Ipsos poll of 800 individual investors in Canada, found that 80% of respondents are concerned about climate change and the environment. It also found most investors view climate change as a financial issue: 70% of respondents believe climate change will have negative financial impacts on companies in some industries within the next five years, and 79% believe this to be true within twenty years.

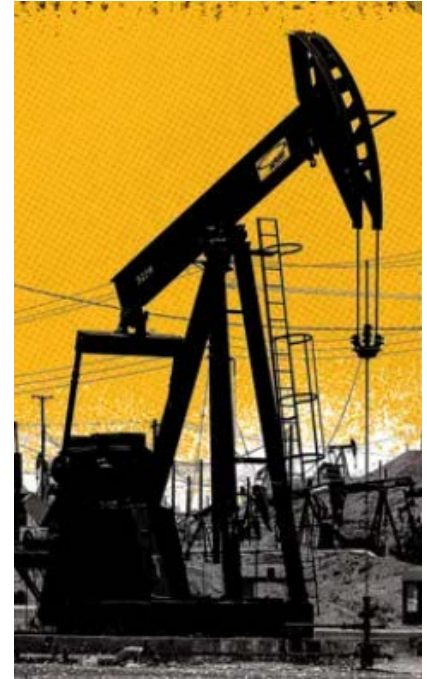Do increases in concerns about climate change affect the performance of green vs. brown stocks?

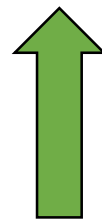Do increases in concerns about climate change affect the performance of green vs. brown stocks?

Event increasing concerns about climate change

Impact (the expectation):

1. Climate regulations
2. Sustainable consumption choices
3. Sustainable investments taste

Climate Change Concerns and Stock Returns

- The sustainable investing model of Pastor, Stambaugh, and Taylor (2020) predicts that:

Climate Change Concerns and Stock Returns

- The sustainable investing model of Pastor, Stambaugh, and Taylor (2020) predicts that:

  1. Brown firms' stocks **outperform** green firms' stocks in the **long run**.

Climate Change Concerns and Stock Returns

- The sustainable investing model of Pastor, Stambaugh, and Taylor (2020) predicts that:

    1. Brown firms' stocks **outperform** green firms' stocks **in the long run**.

    2. Green firms' stocks **outperform** brown ones when **climate change concerns strengthen unexpectedly** due to**:**

Climate Change Concerns and Stock Returns

- The sustainable investing model of Pastor, Stambaugh, and Taylor (2020) predicts that:

    1. Brown firms' stocks **outperform** green firms' stocks in the **long run**.

    2. Green firms' stocks **outperform** brown ones when **climate change concerns strengthen unexpectedly** due to**:**

        1. Change in green (brown) firms' **expected cash-flows**.

Climate Change Concerns and Stock Returns

- The sustainable investing model of Pastor, Stambaugh, and Taylor (2020) predicts that:

  1. Brown firms' stocks **outperform** green firms' stocks in the **long run**.

  2. Green firms' stocks **outperform** brown ones when **climate change concerns strengthen unexpectedly** due to**:**

     1. Change in green (brown) firms' **expected cash-flows**.

     2. Change in investors' tastes regarding **sustainable investments**.

Our Contributions

- We empirically **test the predictions** by Pastor, Stambaugh, and Taylor (2020) and show that:

Our Contributions

- We empirically **test the predictions** by Pastor, Stambaugh, and Taylor (2020) and show that:

    1. The stock returns of green firms outperform brown ones when climate change concerns increases unexpectedly.

Our Contributions

- We empirically **test the predictions** by Pastor, Stambaugh, and Taylor (2020) and show that:

    1. The stock returns of green firms outperform brown ones when climate change concerns increases unexpectedly.

    2. The stock returns of brown firms outperform green ones in the absence of unexpected increase in climate change concerns (long-run).

Our Contributions

- We empirically **test the predictions** by Pastor, Stambaugh, and Taylor (2020) and show that:

    1. The stock returns of green firms outperform brown ones when climate change concerns increases unexpectedly.

    2. The stock returns of brown firms outperform green ones in the absence of unexpected increase in climate change concerns (long-run).

    3. The relationship between climate change concerns and the stock market can be linked to the cash-flow channel and the taste channel.

Our Contributions

- We empirically **test the predictions** by Pastor, Stambaugh, and Taylor (2020) and show that:

  1. The stock returns of green firms outperform brown ones when climate change concerns increases unexpectedly.

  2. The stock returns of brown firms outperform green ones in the absence of unexpected increase in climate change concerns (long-run).

  3. The relationship between climate change concerns and the stock market can be linked to the cash-flow channel and the taste channel.

- We propose **Media-derived Climate Change Concerns** indices to proxy for the latent unexpected increases in climate change concerns.

Outline

1. How do we proxy unexpected increases in climate change concerns?

2. What is the relationship between green vs. brown firms' stock returns and unexpected increases in climate change concerns?

3. Do concerns about different topics of climate change have different effect on green vs. brown firms' stock return?

Outline

1. **How do we proxy unexpected increases in climate change concerns?**

2. What is the relationship between green vs. brown firms' stock returns and unexpected increases in climate change concerns?

3. Do concerns about different topics of climate change have different effect on green vs. brown firms' stock return?

Using News as a Proxy

- We propose to derive the **unexpected increase in climate change concerns from news media data**:

  1. News sources publish unexpected information: News!

  2. The media covers a broad range of climate change topics which can affect concerns.

  3. There is a relationship between the level of news coverage and news content on a subject and the **population's perception** about that subject.

  4. We can detect concerns-generating news articles about climate change using textual analysis.

News Sources

Source name	N. climate articles	N. total articles	% of articles
The Wall Street Journal	3,776	1,673,007	0.23
The New York Times	3,711	1,477,936	0.25
The Washington Post	2,323	1,029,917	0.23
The Los Angeles Times	1,594	747,557	0.21
The Chicago Tribune	509	1,058,643	0.05
USA Today	249	149,450	0.17
The New York Daily News	129	220,002	0.06
The New York Post	109	190,880	0.06

- News articles from very high circulation US newspapers (above 500k daily).

- Climate change articles identified using the news aggregators (Factiva, ProQuest and LexisNexis) topics classification scheme.

- News data from January 2003 to June 2018.

News Article-level Concerns Score

- Definition of concerns:

*"The perception of **risk** and the related **negative consequences** associated with that risk."*

- For news article n published at day t by source $s,$ the article concerns score is :

Risk level   Level of negativity

$$concerns_{n,t,s} = 100 * \frac{RW_{n,t,s}}{N_{n,t,s}} * \left(\frac{NW_{n,t,s} - PW_{n,t,s}}{NW_{n,t,s} + PW_{n,t,s}} + 1\right)/2$$

- $RW_{n,t,s}$: Number of risk-related words
- $PW_{n,t,s}$: Number of positive words
- $NW_{n,t,s}$: Number of negative words
- $N_{n,t,s}$: Number of words

Example of Concern Scoring

Republicans and Democrats in congress acted responsibly in passing a billion-aid bill for victims of hurricane Sandy. Having utilities charge a few more pennies a month on electric bills for improvements to power plants that would curb manmade global warming is more prudent than having congress write big checks after each disaster pollution controls. Concern about climate change isn't treehugging. The military sees it as a threat to national security. Insurance firms track it to adjust policy rates. The dollars that congress is allocating for disaster argue for a more proactive approach. Lawmakers of both parties need to get serious finally about this environmental threat.

$$RW = 6$$
$$NW = 4$$
$$PW = 3$$
$$N = 105$$

$$Concern = 100 * \frac{6}{105} * \frac{\left(\frac{4-3}{7}+1\right)}{2} = 3.2$$

Media Climate Change Concerns Index

Date	Concern	Title	Source
2018-01-05	3.44	Storms, Fires and Floods Lead to Record Payouts	The New York Times
2014-04-06	2.57	The perils of climate change	The Washington Post
2011-12-08	2.89	2011 saw record number of high-cost weather disast	The Los Angeles Times
2008-10-07	2.73	One in 4 Mammals Threatened With Extinction, Group	The New York Times

Media Climate Change Concerns Index

Date	Concern	Title	Source
2018-01-05	3.44	Storms, Fires and Floods Lead to Record Payouts	The New York Times
2014-04-06	2.57	The perils of climate change	The Washington Post
2011-12-08	2.89	2011 saw record number of high-cost weather disast	The Los Angeles Times
2008-10-07	2.73	One in 4 Mammals Threatened With Extinction, Group	The New York Times
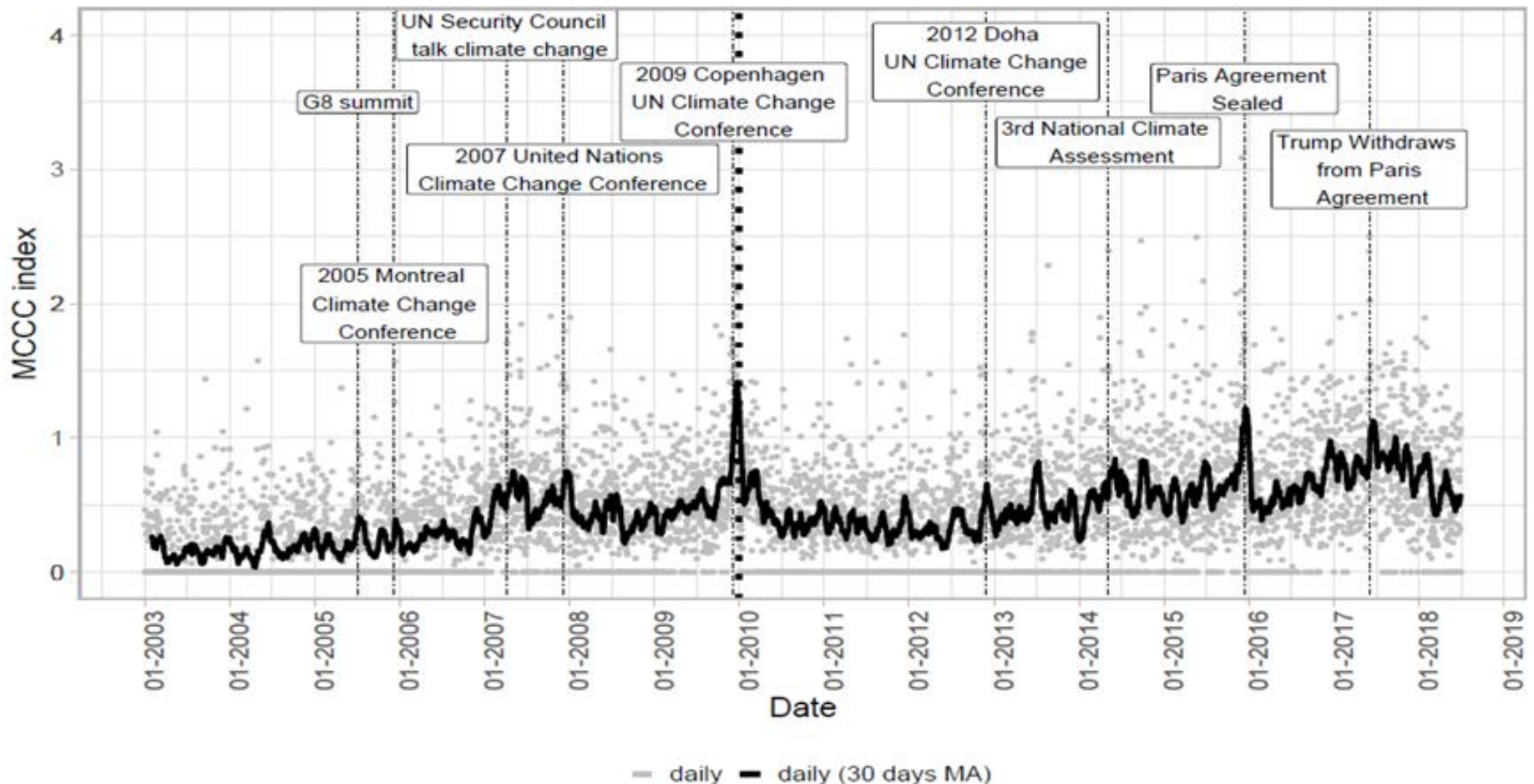
Outline

1. How do we proxy unexpected increases in climate change concerns?

2. **What is the relationship between green vs. brown firms' stock returns and unexpected increases in climate change concerns?**

3. Do concerns about different topics of climate change have different effect on green vs. brown firms' stock return?

S&P 500 Stock Universe and Greenhouse Gas Emission

- We define green (brown) firms as:

  *"Firms that **create economic value** while (not) **minimizing damages to the environment** and particularly damages that contribute to climate change."*

- As such we use **GHG intensity** to measure the greenness of a firm (yearly **GHG CO2 equivalent emission divided by yearly revenue**).

- We focus on **S&P 500 firms**.

- About 50%-60% of firms' GHG coverage from 2009 to 2017. Non-sufficient coverage prior to that.

Portfolio: Based on GHG Emission Level

- Three portfolios: Green, Brown, Green minus Brown.

- We define:

  - Green firms: below 25th percentile of the GHG intensity.
  - Brown firms: above 75th percentile of the GHG intensity.

- Build portfolios every day; equally weighted.

- Frequency of analysis: daily returns.

- Time-window : January 2010 to June 2018

Multivariate Factor Analysis

$$r_{p,t} = c_p + \boxed{\beta_p^{MCCC} MCCC_t} + \boldsymbol{\beta}_p \mathbf{f}_t + \varepsilon_{p,t}$$

When p = Green - Brown,
- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Green,
- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Brown,
- $\boldsymbol{\beta}_p^{MCCC} < 0$

Multivariate Factor Analysis

$$r_{p,t} = c_p + \beta_p^{MCCC} MCCC_t + \boldsymbol{\beta}_p \mathbf{f}_t + \varepsilon_{p,t}$$

When p = Green - Brown,
- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Green,
- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Brown,
- $\boldsymbol{\beta}_p^{MCCC} < 0$

	GMB	Green	Brown
Intercept	-0.035^*	-0.011^*	0.025^*
	(0.018)	(0.008)	(0.013)
MCCC	0.075^{***}	0.028^{***}	-0.056^{***}
	(0.024)	(0.011)	(0.018)
MKT	0.159^{***}	1.106^{***}	0.965^{***}
	(0.017)	(0.007)	(0.012)
HML	0.169^{***}	0.175^{***}	0.031^{***}
	(0.046)	(0.023)	(0.030)
SMB	0.119^{***}	0.018^{***}	-0.109^{***}
	(0.034)	(0.013)	(0.028)
CMA	-0.558^{***}	-0.091^{***}	0.439^{***}
	(0.063)	(0.034)	(0.045)
RMW	-0.207^{***}	-0.138^{***}	0.121^{***}
	(0.049)	(0.019)	(0.039)
MOM	0.130^{***}	-0.063^{***}	-0.182^{***}
	(0.028)	(0.013)	(0.020)

Multivariate Factor Analysis

$$r_{p,t} = c_p + \beta_p^{MCCC} MCCC_t + \boldsymbol{\beta}_p \mathbf{f}_t + \varepsilon_{p,t}$$

When p = Green - Brown,
- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Green,
- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Brown,
- $\boldsymbol{\beta}_p^{MCCC} < 0$

	GMB	Green	Brown
Intercept	-0.035^{*}	-0.011^{*}	0.025^{*}
	(0.018)	(0.008)	(0.013)
MCCC	0.075^{***}	0.028^{***}	-0.056^{***}
	(0.024)	(0.011)	(0.018)
MKT	0.159^{***}	1.106^{***}	0.965^{***}
	(0.017)	(0.007)	(0.012)
HML	0.169^{***}	0.175^{***}	0.031^{***}
	(0.046)	(0.023)	(0.030)
SMB	0.119^{***}	0.018^{***}	-0.109^{***}
	(0.034)	(0.013)	(0.028)
CMA	-0.558^{***}	-0.091^{***}	0.439^{***}
	(0.063)	(0.034)	(0.045)
RMW	-0.207^{***}	-0.138^{***}	0.121^{***}
	(0.049)	(0.019)	(0.039)
MOM	0.130^{***}	-0.063^{***}	-0.182^{***}
	(0.028)	(0.013)	(0.020)

Multivariate Factor Analysis

$$r_{p,t} = c_p + \beta_p^{MCCC} MCCC_t + \boldsymbol{\beta}_p \mathbf{f}_t + \varepsilon_{p,t}$$

When p = Green - Brown,
- $\beta_p^{MCCC} > 0$

When p = Green,
- $\beta_p^{MCCC} > 0$

When p = Brown,
- $\beta_p^{MCCC} < 0$

	GMB	Green	Brown
Intercept	-0.035^*	-0.011^*	0.025^*
	(0.018)	(0.008)	(0.013)
MCCC	0.075^{***}	0.028^{***}	-0.056^{***}
	(0.024)	(0.011)	(0.018)
MKT	0.159^{***}	1.106^{***}	0.965^{***}
	(0.017)	(0.007)	(0.012)
HML	0.169^{***}	0.175^{***}	0.031^{***}
	(0.046)	(0.023)	(0.030)
SMB	0.119^{***}	0.018^{***}	-0.109^{***}
	(0.034)	(0.013)	(0.028)
CMA	-0.558^{***}	-0.091^{***}	0.439^{***}
	(0.063)	(0.034)	(0.045)
RMW	-0.207^{***}	-0.138^{***}	0.121^{***}
	(0.049)	(0.019)	(0.039)
MOM	0.130^{***}	-0.063^{***}	-0.182^{***}
	(0.028)	(0.013)	(0.020)

Multivariate Factor Analysis

$$r_{p,t} = c_p + \beta_p^{MCCC} MCCC_t + \boldsymbol{\beta}_p \mathbf{f}_t + \varepsilon_{p,t}$$

When p = Green - Brown,

- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Green,

- $\boldsymbol{\beta}_p^{MCCC} > 0$

When p = Brown,

- $\boldsymbol{\beta}_p^{MCCC} < 0$

- **GMB portfolio (hedged against the other factors) expected returns are positive above a MCCC level of 0.55.**

	GMB	Green	Brown
Intercept	-0.035^*	-0.011^*	0.025^*
	(0.018)	(0.008)	(0.013)
MCCC	0.075^{***}	0.028^{***}	-0.056^{***}
	(0.024)	(0.011)	(0.018)
MKT	0.159^{***}	1.106^{***}	0.965^{***}
	(0.017)	(0.007)	(0.012)
HML	0.169^{***}	0.175^{***}	0.031^{***}
	(0.046)	(0.023)	(0.030)
SMB	0.119^{***}	0.018^{***}	-0.109^{***}
	(0.034)	(0.013)	(0.028)
CMA	-0.558^{***}	-0.091^{***}	0.439^{***}
	(0.063)	(0.034)	(0.045)
RMW	-0.207^{***}	-0.138^{***}	0.121^{***}
	(0.049)	(0.019)	(0.039)
MOM	0.130^{***}	-0.063^{***}	-0.182^{***}
	(0.028)	(0.013)	(0.020)

$$r_{i,t} = c + \boxed{\gamma^{GHG} \log(GHG_{i,t})} + \gamma^{MCCC} MCCC_t \log(GHG_{i,t}) + \boldsymbol{\beta}_i \mathbf{f}_t + \epsilon_{i,t}$$

- Lower intensity firms outperform higher intensity firms in the long run:

$$\gamma^{GHG} > 0$$

$$r_{i,t} = c + \gamma^{GHG} \log(GHG_{i,t}) + \boxed{\gamma^{MCCC} MCCC_t \log(GHG_{i,t})} + \boldsymbol{\beta}_i \mathbf{f}_t + \epsilon_{i,t}$$

- Lower intensity firms outperform higher intensity firms in the long run:

$$\gamma^{GHG} > 0$$

- The higher the increase in climate change concerns, the the lower the return of high intensity firms is compared to to low intensity firms.

$$\gamma^{MCCC} < 0$$

$$r_{i,t} = c + \gamma^{GHG} \log(GHG_{i,t}) + \gamma^{MCCC} MCCC_t \log(GHG_{i,t}) + \beta_i \mathbf{f}_t + \epsilon_{i,t}$$

- Lower intensity firms outperform higher intensity firms in the long run:

$$\gamma^{GHG} > 0$$

- The higher the increase in climate change concerns, the the lower the return of high intensity firms is compared to to low intensity firms.

$$\gamma^{MCCC} < 0$$

- Above some level of MCCC, for two equivalent firms except in GHG intensity, the stock returns of the lower intensity one performs better then the higher intensity one:

$$-\frac{\gamma^{GHG}}{\gamma^{MCCC}}$$

$$r_{i,t} = c + \boxed{\gamma^{GHG} \log(GHG_{i,t})} + \gamma^{MCCC} MCCC_t \log(GHG_{i,t}) + \boldsymbol{\beta}_i \mathbf{f}_t + \epsilon_{i,t}$$

$$\boxed{\gamma^{GHG} > 0}$$

$$\gamma^{MCCC} < 0$$

	One-factor	Three-factor	Six-factor
Intercept	0.003*	0.004**	0.003**
	(0.002)	(0.002)	(0.002)
log(GHG)	0.017***	0.016***	0.013***
	(0.003)	(0.003)	(0.003)
log(GHG) × MCCC	−0.033***	−0.031***	−0.027***
	(0.004)	(0.004)	(0.004)

$$r_{i,t} = c + \gamma^{GHG} \log(GHG_{i,t}) + \boxed{\gamma^{MCCC} MCCC_t \log(GHG_{i,t})} + \boldsymbol{\beta}_i \mathbf{f}_t + \epsilon_{i,t}$$

$$\gamma^{GHG} > 0$$

$$\boxed{\gamma^{MCCC} < 0}$$

	One-factor	Three-factor	Six-factor
Intercept	0.003*	0.004**	0.003**
	(0.002)	(0.002)	(0.002)
log(GHG)	0.017***	0.016***	0.013***
	(0.003)	(0.003)	(0.003)
log(GHG) × MCCC	−0.033***	−0.031***	−0.027***
	(0.004)	(0.004)	(0.004)

Climate Change Concerns in the Cross-Section of Stock Returns

$$r_{i,t} = c + \gamma^{GHG} \log(GHG_{i,t}) + \gamma^{MCCC} MCCC_t \log(GHG_{i,t}) + \boldsymbol{\beta}_i \mathbf{f}_t + \epsilon_{i,t}$$

$\gamma^{GHG} > 0$

$\gamma^{MCCC} < 0$

$-\dfrac{\gamma^{GHG}}{\gamma^{MCCC}}$

	One-factor	Three-factor	Six-factor
Intercept	0.003*	0.004**	0.003**
	(0.002)	(0.002)	(0.002)
$\log(GHG)$	0.017***	0.016***	0.013***
	(0.003)	(0.003)	(0.003)
$\log(GHG) \times MCCC$	−0.033***	−0.031***	−0.027***
	(0.004)	(0.004)	(0.004)
	0.51	0.51	0.48

Moments in time above the threshold
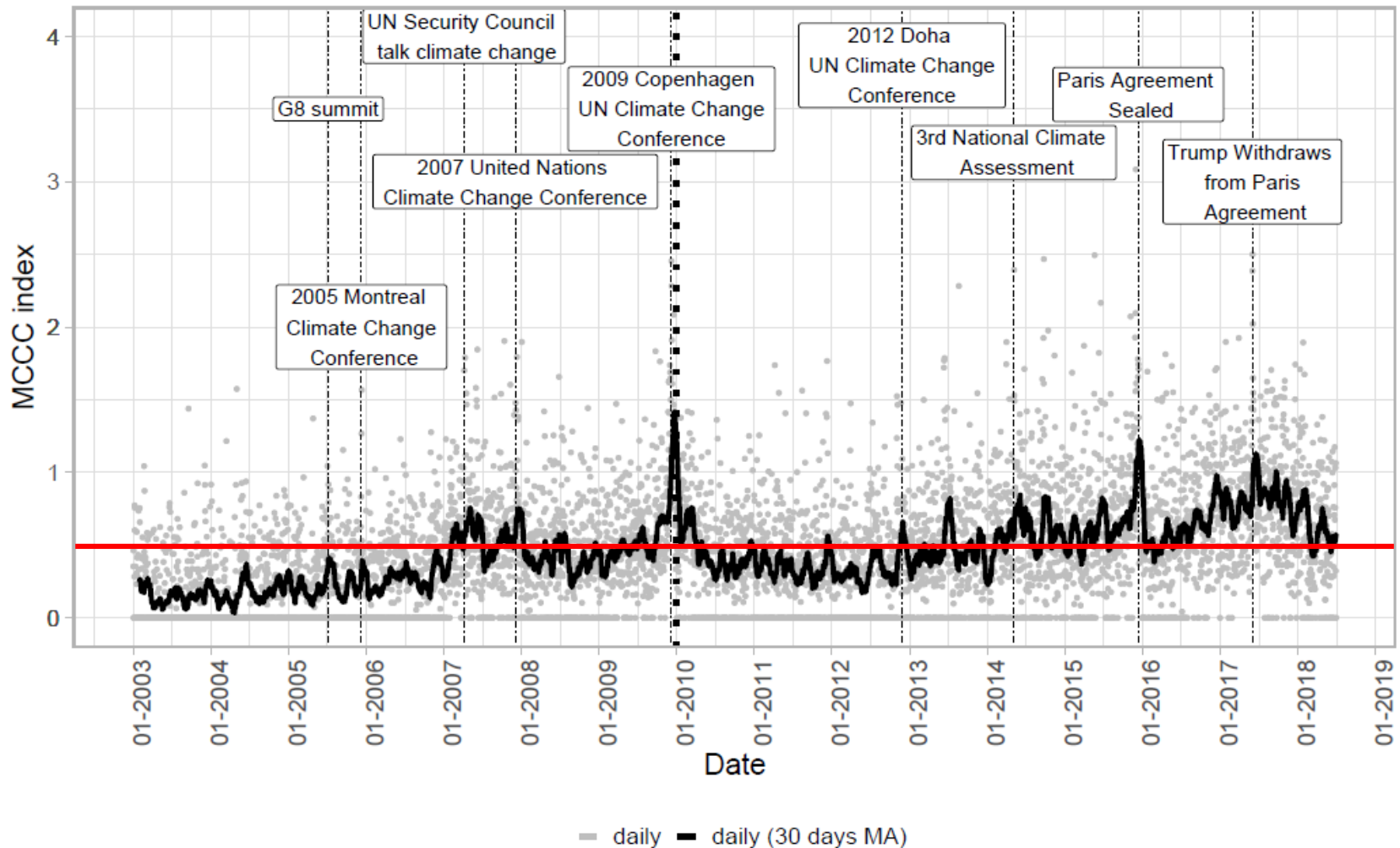
Outline

1. How do we proxy unexpected increases in climate change concerns?

2. What is the relationship between green vs. brown firms' stock returns and unexpected increases in climate change concerns?

3. **Do concerns about different topics of climate change have different effect on green vs. brown firms' stock return?**

Multiple Topic of Discussion Around Climate Change

Disasters

Agreements and Regulations

Technologies

Research
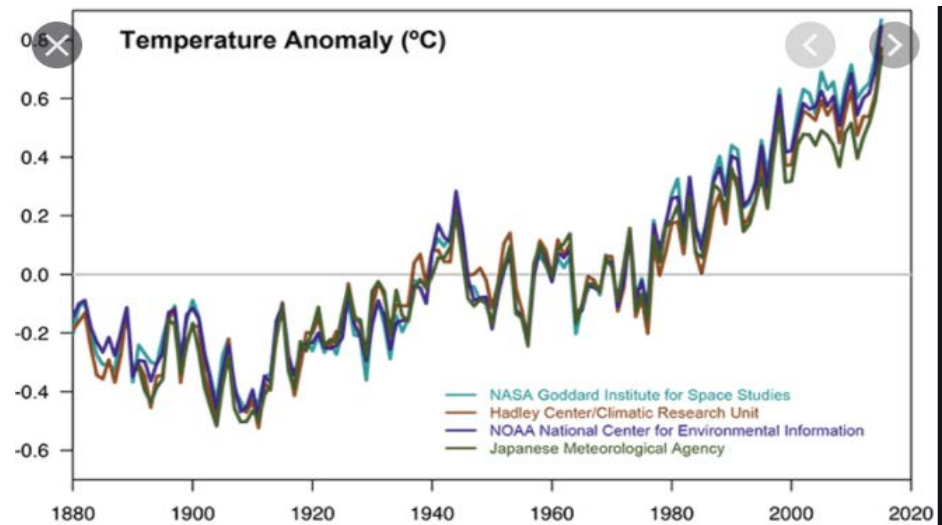
Dimension of Climate Change

- The model of Pastor, Stambaugh, and Taylor (2020) implies that the effect of climate change concerns on stock return arises from two channels:

  - **Change in expected cash-flow** (e.g., expectation about new regulation)

  - **Investors' taste**

- To answer this, we build **topical Media Climate Change Concerns indices.**

- Latent topics are estimated using the **Correlated Topic Model** of Blei et al. (2006).

Climate Change Themes

- We identify K = 40 topics organized in 7 themes (+ unclassified):

1. Financial and Regulation

Topic 40	project	technology	plant	cost	coal
Topic 32	car	vehicle	standard	truck	automaker
Topic 31	oil	tax	fuel	price	carbon_tax
Topic 25	home	business	product	consumer	building
Topic 21	market	industry	emission	permit	credit
Topic 17	investor	investment	business	executive	risk
Topic 16	bill	legislation	vote	measure	lawmaker

2. Agreement and Submit
3. Societal Impact
4. Research
5. Disaster
6. Environmental Impact
7. Agricultural Impact

Climate Change Topics and GMB Portfolio Returns

$$r_{p,t} = \alpha_p + \boxed{\beta_{k,p}^{MCCC} MCCC_{k,t}} + \boldsymbol{\beta}_p \mathbf{f}_t + \epsilon_{p,t}$$

- 22 of the 40 topics have a significant coefficient.

- Themes that have several significant coefficients:

  - Financial and Regulation : Cash-flow channel
  - Agreement and Submit : Cash-flow and taste channel
  - Societal Impact : Cash-flow and taste channel
  - Research : Taste channel
  - Disaster : Taste channel

Conclusion

*Do unexpected increases about climate change affect brown vs. green stock return performance: **Yes**.*

- We proxy the unexpected increase in climate change concerns using news media articles (*using the* risk, sentiment, and attention dimensions).

- Concerns about some topics of climate change influence green vs. brown stock return performance, while others do not.

- Topics driving the relationship can be related to the cash-flow and taste channels, validating Pastor, Stambaugh, and Taylor (2020).

In the works: Live MCCC Belgium Index
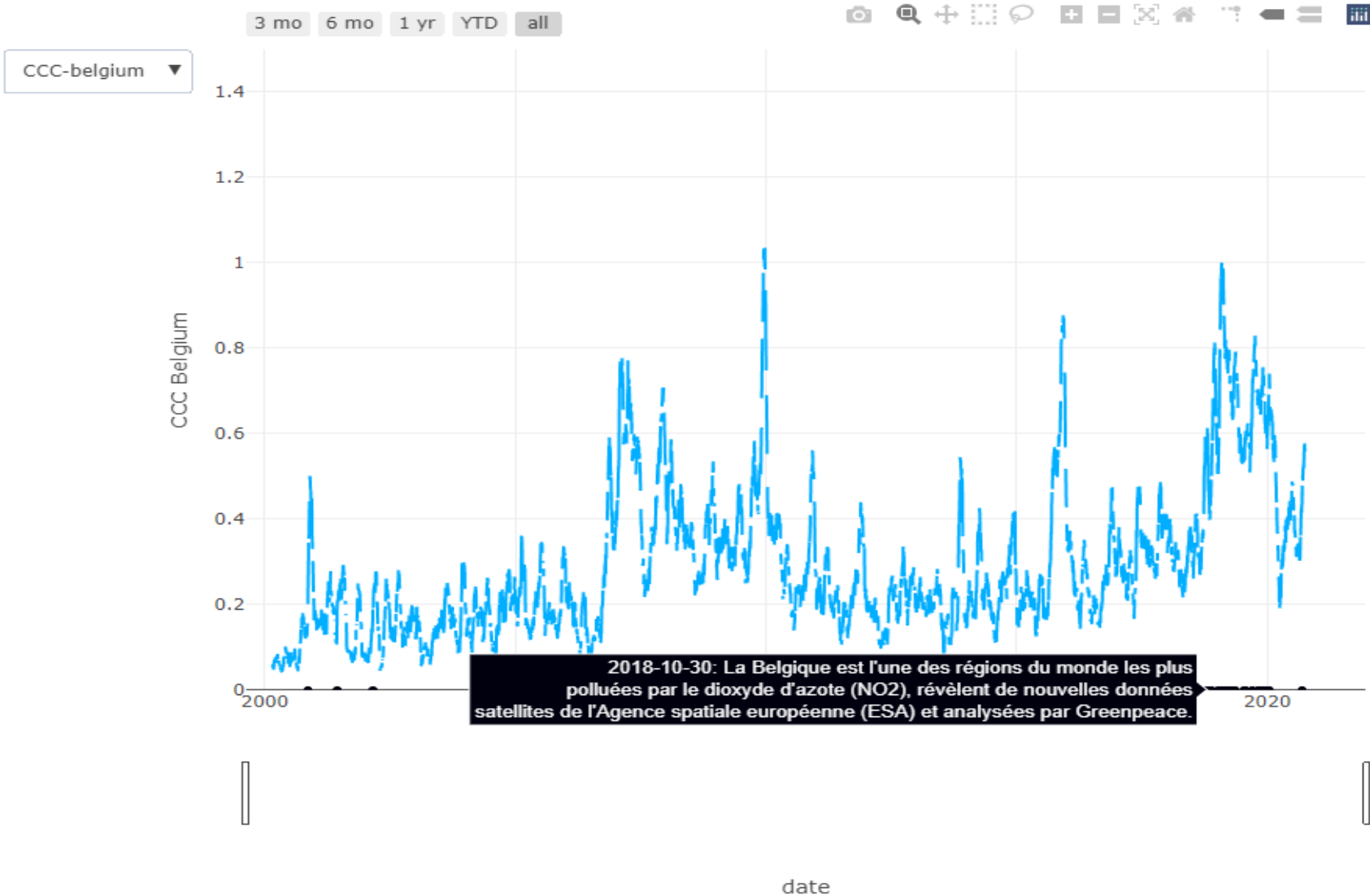
References

- Ball-Rokeach, S. J., and M. L. DeFleur. 1976. A dependency model of mass-media effects. *Communication Research* 3:3-21.

- Bertolotti, A., D. Basu, K. Akallal, and B. Deese. 2019. Climate risk in the US electric utility sector: A case study. Working Paper.

- Choi, D., Z. Gao, and W. Jiang. 2020. Attention to global warming. *Review of Financial Studies* 33:1112-45.

- Chong, D., and J. N. Druckman. 2007. Framing theory. *Annual Review of Political Science* 10.

- Engle, R. F., S. Giglio, B. Kelly, H. Lee, and J. Stroebel. 2020. Hedging climate change news. *Review of Financial Studies* 33:1184-216.

- Gentzkow, M., and J. M. Shapiro. 2006. Media bias and reputation. *Journal of Political Economy* 114:280-316.

- Hong, H., F. W. Li, and J. Xu. 2019. Climate risks and market efficiency. *Journal of Econometrics* 208:265-81.

- McCombs, M. E., and D. L. Shaw. 1972. The agenda-setting function of mass media. *Public Opinion Quarterly* 36:176-87

- Pastor, L., R. F. Stambaugh, and L. A. Taylor. 2020. Sustainable investing in equilibrium. *Forthcoming in Journal of Financial Economics*.

Supplementary Material

Media Focus on Topics Over Time
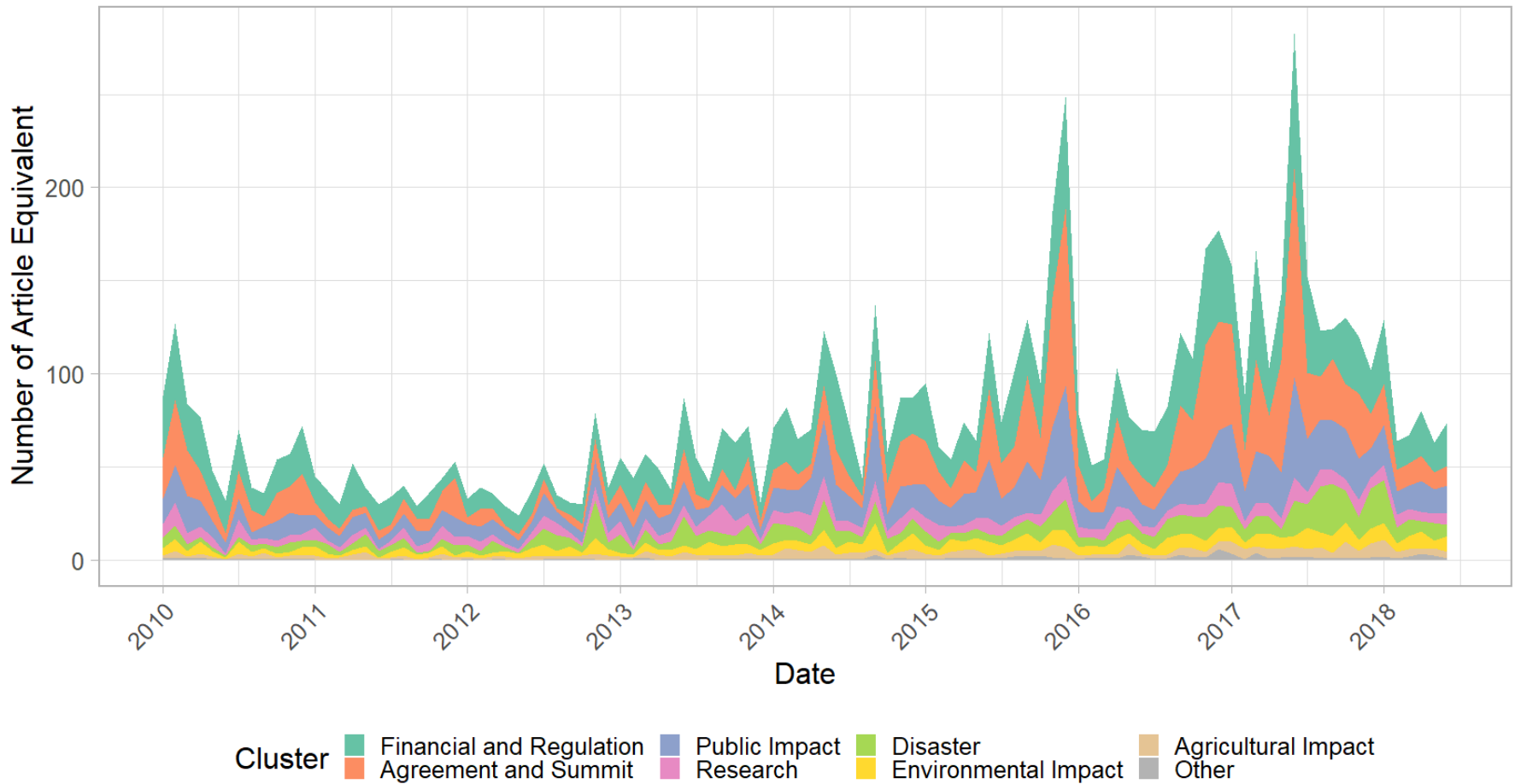
Aggregation

- For each day t and source s, we compute the sum of the concerns scores across the $N_{t,s}$ climate change-related articles:

$$concerns_{t,s} = \sum_{n=1}^{N_{t,s}} concerns_{n,t,s}.$$

- We then standardize each source specific time series by their standard deviation computed over time τ_1 to τ_2:

$$stdconcerns_{t,s} = \frac{concerns_{t,s}}{\sigma_s}.$$

- Finally, we take a strictly increasing concave function of the average of the standardized time series across all sources S to obtain the Media Climate Change Concerns index $MCCC_t$:

$$MCCC_t = \sqrt{\frac{\sum_{s=1}^{S} stdconcerns_{t,s}}{S}}.$$

Topical Media Climate Change Concerns Indices

- To compute the topical media climate change concerns indices, **we define a generalization the article-level concerns** scores to take into account topic attribution:

$$concern_{k,t,s} = \sum_{n=1}^{N_{t,s}} \theta_{k,n,t,s}\, concern_{n,t,s}\,.$$

- We then follow the standardization by sources and the aggregation process.

Conditional Mean Analysis

- Average return of the GMB portfolio conditional on being above or below a percentile of the Media Climate Change Concerns index.
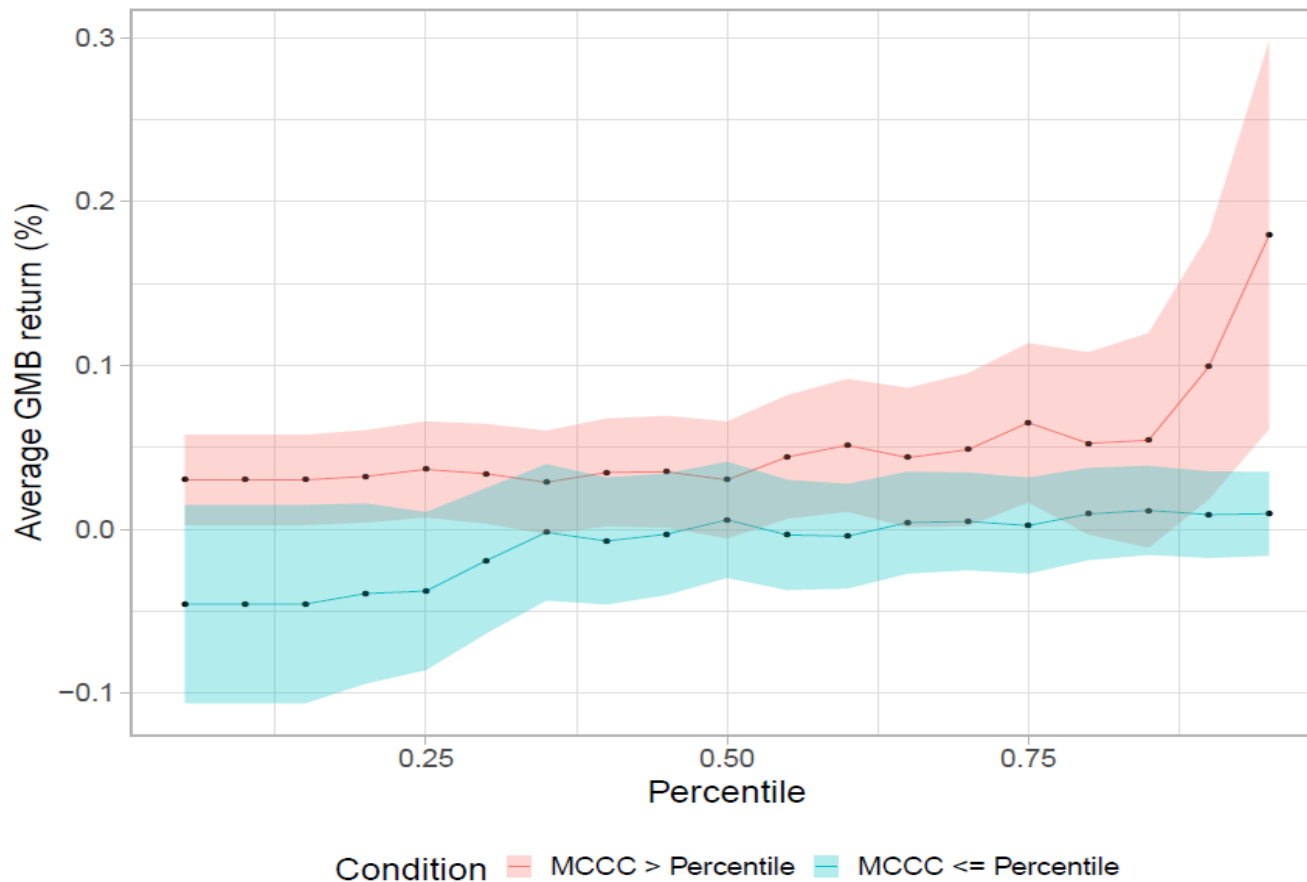
Conditional Mean Analysis

- Average return of the GMB portfolio conditional on being above or below a percentile of the Media Climate Change Concerns index.

- **Green outperforms brown when the media climate change concerns index is high.**

Most Important Word for Each Topic and Theme

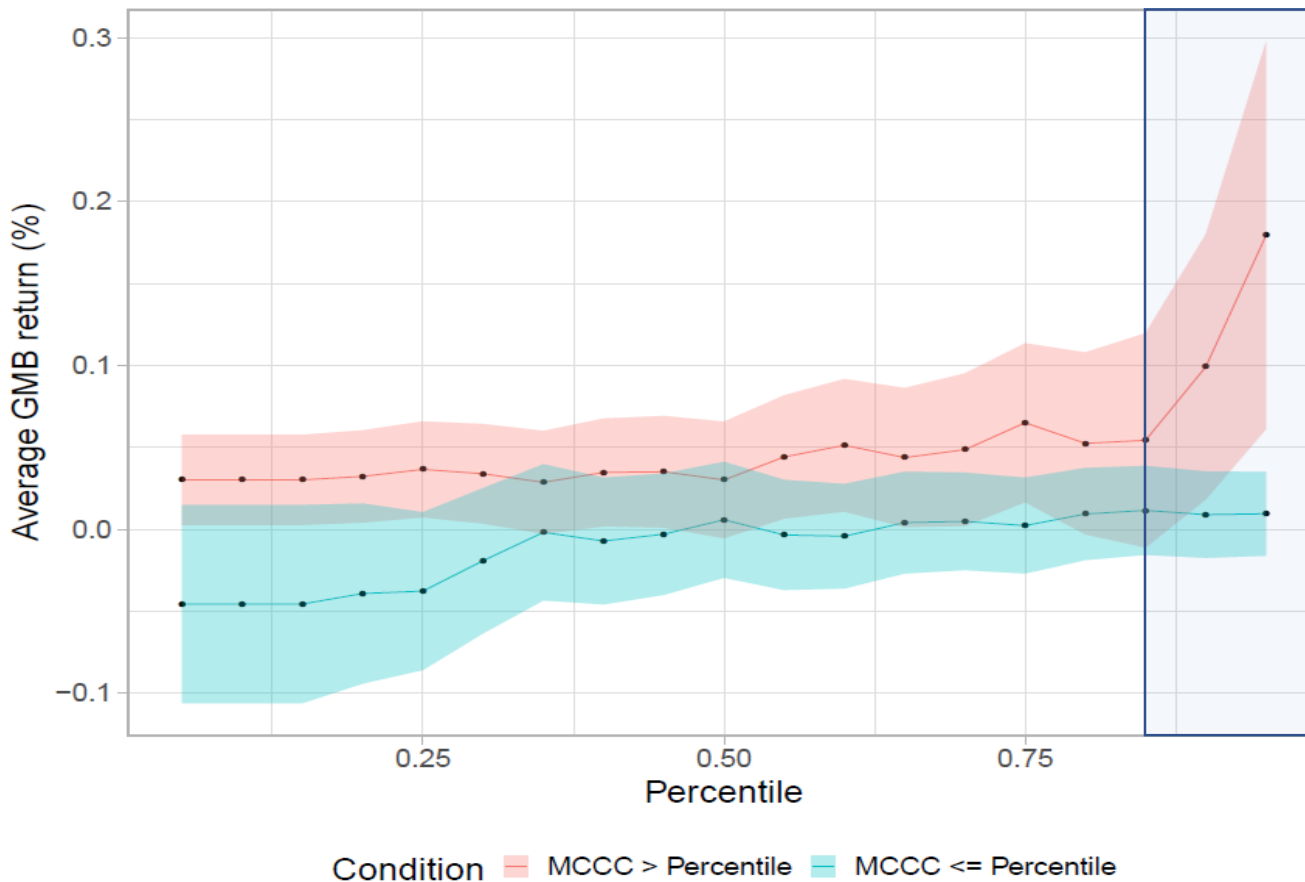| Topic	1	2	3	4	5	6	7	8	9	10	Theme
Topic 40	project	technology	plant	cost	coal	carbon_dioxide	power_plant	facility	scale	carbon	Financial and Regulation
Topic 32	car	vehicle	standard	truck	automaker	diesel	emission	auto	engine	fuel	
Topic 31	oil	tax	fuel	price	carbon_tax	production	taxis	cost	ethanol	revenue	
Topic 25	home	business	product	consumer	building	panel	energy_efficiency	customer	bulb	light	
Topic 21	market	industry	emission	permit	credit	system	allowance	cap	price	cost	
Topic 17	investor	investment	business	executive	risk	firm	fund	bank	shareholder	asset	
Topic 16	bill	legislation	vote	measure	lawmaker	senator	governor	proposal	sen	gov	
Topic 15	power	electricity	coal	plant	wind	utility	capacity	power_plant	reactor	renewable	
Topic 13	gas	methane	chemical	leak	waste	ozone	production	industry	carbon_dioxide	atmosphere	
Topic 7	airline	flight	air	aviation	airport	pollution	plane	aircraft	travel	emission	
Topic 6	rule	administration	agency	regulation	law	court	decision	authority	administrator	action	
Topic 37	leader	article	pope	trade	security	official	meeting	summit	trump	visit	Agreement and Summit
Topic 35	obama	campaign	trump	election	candidate	voter	party	policy	position	job	
Topic 19	pipeline	mr_obama	mr_trump	coal	job	project	decision	land	oil	mine	
Topic 18	agreement	deal	talk	meeting	commitment	conference	target	accord	treaty	official	
Topic 14	email	science	document	headline	information	investigation	research	letter	statement	committee	
Topic 38	policy	action	cost	solution	economy	planet	reason	future	growth	politician	Public Impact
Topic 34	poll	survey	majority	public	pew	penguin	concern	opinion	result	support	
Topic 30	money	program	budget	development	fund	funding	effort	initiative	aid	poverty	
Topic 11	child	school	student	family	woman	life	street	art	event	police	
Topic 9	health	death	disease	security	population	threat	child	life	war	risk	
Topic 8	science	book	story	truth	film	news	movie	medium	reader	life	
Topic 22	earth	atmosphere	planet	space	cloud	science	satellite	system	research	sun	Research
Topic 5	study	researcher	temperature	research	paper	finding	effect	change	author	activity	
Topic 3	datum	temperature	model	trend	record	estimate	period	figure	increase	rate	
Topic 36	weather	storm	hurricane	record	temperature	event	heat	heat_wave	drought	wind	Disaster
Topic 33	fire	wildfire	insurance	risk	home	property	disaster	loss	flood	zone	
Topic 24	city	mayor	building	resident	community	plan	county	housing	neighborhood	official	
Topic 12	island	sea	sea_level	storm	flood	flooding	land	beach	home	village	
Topic 39	ice	glacier	snow	ice_sheet	ocean	temperature	sea_level	satellite	mountain	researcher	Environmental Impact
Topic 29	team	researcher	lake	rock	period	study	layer	sample	evidence	eruption	
Topic 28	forest	tree	land	deforestation	carbon	plant	wood	soil	rain_forest	pine	
Topic 10	specie	bird	park	habitat	animal	wildlife	conservation	population	extinction	plant	
Topic 1	ship	drilling	oil	sea	fishing	shipping	coast	boat	shell	exploration	
Topic 23	farmer	crop	farm	agriculture	plant	soil	corn	rice	land	wheat	Agricultural Impact
Topic 20	food	animal	meat	cow	cattle	farm	ski	resort	beef	diet	
Topic 4	drought	region	river	rain	desert	lake	dam	rainfall	water_supply	mountain	
Topic 2	wine	grape	coffee	region	fruit	vineyard	temperature	sugar	bottle	harvest	
Topic 27	bear	permafrost	ice	sea_ice	population	seal	species	hunting	animal	wildlife	Other
Topic 26	reef	ocean	coral	algae	fish	barrier_reef	sea	ecosystem	acidification	tourism	

Rank

Probability
0.10
0.05