Green Investing, Information Asymmetry, and Capital Structure

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EEA-ESEM Barcelona 2023
August 2023

Climate change awareness is increasing

- Sustainable investing has attracted attention over the last decades
- More and more investors are becoming "green"

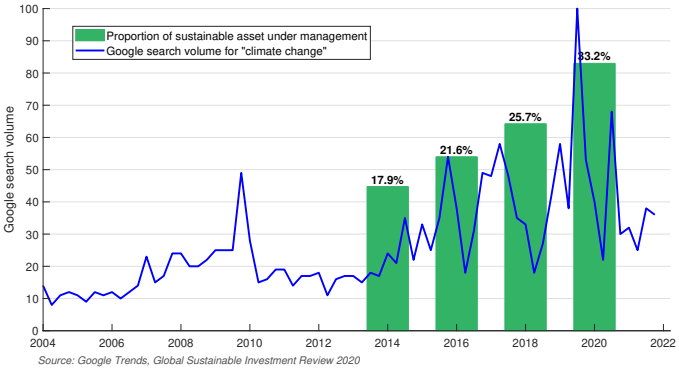

Figure: Google search volume and sustainable investment in the U.S.

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- The Pecking Order Theory implies that information asymmetry determines capital structure decisions (Bharath et al., 2009; Myers and Majluf, 1984)

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Question 2: How does a growing interest in green investing affect firms' capital structure decisions

- The Pecking Order Theory implies that information asymmetry determines capital structure decisions (Bharath et al., 2009; Myers and Majluf, 1984)
- Green investing can influence firms' capital structure through changing their information environment

Roadmap

- A static three-period model based on Kacperczyk et al. (2016)

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- Empirical findings support our model predictions using firm-level information asymmetry
  - higher share of green investment also leads to lower leverage (debt-to-asset ratio) for green firms

Literature

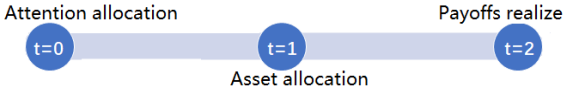
- The impact of investors' ESG preferences on the cross-sectional financial market
  - Bolton and Kacperczyk (2021), Pastor et al. (2021), Pedersen et al. (2021), etc.
- Endogenous information acquisition and ESG preferences
  - Kacperczyk et al . (2016), Van Nieuwerburgh and Veldkamp (2010), Peng and Xiong (2006), Sims (2003), etc.
  - Avramov et al. (2022), Zhou and Kang (2023), Goldstein et al. (2021), etc.
- The relationship between information asymmetry and capital structure
  - Bharath et al. (2009), Easley and O'hara (2004), Amihud (2002), etc.

This paper: a first attempt to study impact of green investing on firm's information asymmetry and capital structure decision

The model

Setup

- Three periods, $t = 0, 1, 2$



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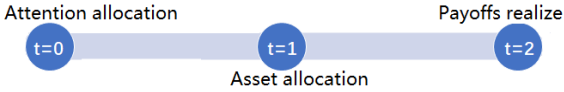

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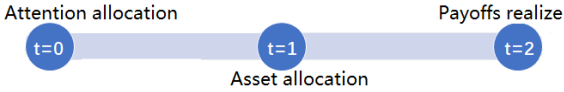

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- **Investors**: a continuum of investors with
  - fraction λ being green investor: non-pecuniary utility from holding green assets
  - fraction $1 - \lambda$ being traditional investor: mean-variance utility on final payoff

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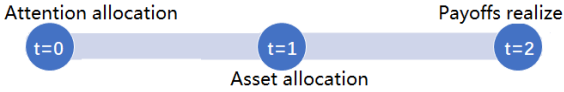

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- Payoffs are uncertain, but investors can attentively learn to reduce uncertainty at $t = 0$, subject to limited attention

Payoff structure and greenness

- Riskless asset is normalized with both price and payoff equal to 1
- For the risky assets:

Risky assets	**Financial payoffs**	**Greenness**
Green	$f_1 = \mu_1 + b_1\tilde{z}_3 + \tilde{z}_1$	$g_1 = s$
Brown	$f_2 = \mu_2 + b_2\tilde{z}_3 + \tilde{z}_2$	$g_2 = -s$
Market	$f_3 = \mu_3 + \tilde{z}_3$	$g_3 = 0$

- $\tilde{\boldsymbol{z}} = [\tilde{z}_1, \tilde{z}_2, \tilde{z}_3]' \sim \mathcal{N}(0, \Sigma)$ are the fundamental shock with a **diagonal prior variance** Σ

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- $\tilde{\boldsymbol{z}} = [\tilde{z}_1, \tilde{z}_2, \tilde{z}_3]' \sim \mathcal{N}(0, \Sigma)$ are the fundamental shock with a **diagonal prior variance** Σ
- Following Kacperczyk et al. (2016), we can write the asset payoff into $\boldsymbol{f} = \boldsymbol{\mu} + \Gamma\tilde{\boldsymbol{z}}$ and work on the **risk factors**:

$$\tilde{\boldsymbol{f}} = \Gamma^{-1}\boldsymbol{\mu} + \tilde{\boldsymbol{z}}$$

Information acquisition and attention allocation

- At $t = 0$, an investor j allocate attention across risk factors to receive **signals** on the fundamental shocks

$$\eta_{ij} = \tilde{z}_i + \epsilon_{ij}, \quad \text{for } i = 1, 2, 3$$

$$\epsilon_{ij} \sim \mathcal{N}(0, \sigma_{\eta,ij})$$

- We follow the literature (Van Nieuwerburgh and Veldkamp, 2010; Kacperczyk et al., 2016) and make the following **assumptions:**
  - posterior variance of the signal $\sigma_{\eta,ij} = K_{ij}^{-1}$, where K_{ij} is the attention allocated to shock i by investor j
  - total amount of attention is limited: $\sum_{i=1}^{3} K_{ij} \leq \bar{K}$
  - investor cannot "unlearn" what they already know: $K_{ij} \geq 0$

Investors' optimization problem

- $t = 1$: **asset allocation**

$$\max_{\tilde{\boldsymbol{q}}_j} \quad U_{1j} = E_j[W_j] - \frac{\gamma}{2} Var_j[W_j] + d_j \cdot \tilde{\boldsymbol{q}}_j{}' \boldsymbol{g}$$

$$s.t. \qquad W_j = W_0 + \tilde{\boldsymbol{q}}_j{}'(\tilde{\boldsymbol{f}} - \tilde{\boldsymbol{p}})$$

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  - $\tilde{\boldsymbol{q}}_j$ is investor j's demand on the risk factors
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    - $d_j = d > 0$ for green investors
    - $d_j = 0$ for traditional investors

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  - $E_j(\cdot)$ and $Var_j(\cdot)$ is taken based on (1) **investor j's signals** and (2) **the price signal** through Bayesian updating

Investors' optimization problem

- $t = 0$: **attention allocation**

$$\max_{\boldsymbol{K_j}} \quad U_{0j} = E_0\left[E_j[W_j] - \frac{\gamma}{2} V_j[W_j] + d_j \cdot \tilde{\boldsymbol{q}}_{\boldsymbol{j}}^{*'} \boldsymbol{g}\right]$$
$$s.t. \qquad \sum_{i=1}^{3} K_{ij} \leq \bar{K} \quad K_{ij} \geq 0 \text{ for } i = 1, 2, 3$$

  - $E_0(\cdot)$ is the *unconditional* expectation

Model solution on the equilibrium price

- We follow literature to guess and verify a **linear equilibrium price**

Lemma 1

The prices of risk factors are given by

$$\tilde{\boldsymbol{p}} = A + B\tilde{\boldsymbol{z}} + C\boldsymbol{x}$$

where

$$A = \Gamma^{-1}\boldsymbol{\mu} - \gamma\bar{\Sigma}\bar{\boldsymbol{x}} + \bar{\boldsymbol{d}}\boldsymbol{g}$$

$$B = I - \bar{\Sigma}\Sigma^{-1}$$

$$C = -\gamma\bar{\Sigma}\left(I + \frac{1}{\gamma^2\sigma_x}\bar{\Sigma}_\eta^{-1'}\right)$$

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- Here $\bar{\boldsymbol{d}} = \left(\int_j \hat{\Sigma}_j^{-1} dj\right)^{-1}\left(\int_j \hat{\Sigma}_j^{-1} d_j dj\right)$ reflects the **aggregate green preference** in the market

Model solution on the attention allocation

- The attention allocation problem at $t = 0$ can be simplify as follows

$$\max_{\boldsymbol{K_j}} \quad U_{0j} = \sum_{i=1}^{3} \kappa_{ij} K_{ij} + \text{constant}$$
$$s.t. \quad \sum_{i=1}^{3} K_{ij} \leq \bar{K}, \quad K_{ij} \geq 0 \text{ for } i = 1, 2, 3$$

where $\kappa_{ij} = \bar{\sigma}_i^2 + (\gamma\sigma_x + \bar{K}_i)\bar{\sigma}_i + (\gamma\bar{x}_i\bar{\sigma}_i + (d_j - \bar{d}_i)g_i)^2$

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- Clearly, an investor j will allocate full attention to the risk factor(s) with the highest κ_{ij}
  - A green investor $(d_j = d > \bar{d}_i)$ has higher incentive to learn the green risk factor
  - A traditional investor $(d_j = 0 < \bar{d}_i)$ has higher incentive to learn the brown risk factor

Model solution on the attention allocation

Comparative statics w.r.t. green investment shares λ

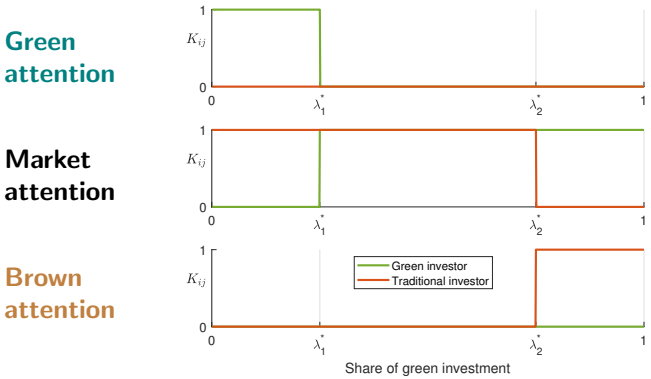

Figure: Optimal attention allocation as a function of λ

Attention and information asymmetry

- Define firm-level information asymmetry as prior precision - aggregate posterior precision

$$InfoAsy \equiv \Sigma_i^{-1} - \bar{\Sigma}_i^{-1} = \bar{\Sigma}_{s,i}^{-1} + \Sigma_{i,p}^{-1}$$

  - If no learning at all: $InfoAsy = 0$
  - More learning $\Rightarrow$ higher posterior precision $\Rightarrow$ lower information asymmetry

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Proposition 1

When share of green investment $\lambda < \lambda_1^*$, an increase in λ decreases the information asymmetry of green firms.

- *The threshold λ_1^* is increasing in the green preference d and greenness score s*
- *The threshold λ_1^* is decreasing in the market volatility*

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- Firm level greenness indicator: Refinitiv Environmental Pillar Score (ENSCORE)
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- Green investment share: Google Search Volume on the keyword *Climate Change*
- Information Asymmetry: **first principal component** of seven information asymmetry and liquidity measures (Bharath et al., 2009)
  - (1,2) the adverse selection component of the quoted and effective bid-ask spread, AD and RAD (George et al., 1991; Roll, 1984); (3) stock's volume return dynamics, C2 (Llorenteet al., 2002); (4) probability of informed trading, PIN (Easley et al., 1996); (5,6) price impact, ILL and LR (Amihud, 2002; Amihud et al., 1997); and (7) interaction between stock return and orderflow, GAM (Pastor and Stambaugh, 2003)

Empirical Analysis

Test the impact of green taste on information asymmetry

- OLS Specification

$$InfoAsy_{i,q} = \alpha_i + \gamma_q + (\beta_0 + \beta_1 \cdot ENSCORE_{i,q-4})\,\Delta GSV_q + \gamma X_{i,q} + \epsilon_{i,q}$$

  - $InfoAsy_{i,q}$: information asymmetry measure of firm i at quarter q
  - $ENSCORE_{i,q-4}$: ENSCORE of firm i in the previous year, normalized between 0 and 1
  - $\Delta GSV_{i,q}$: growth rate of GSV of keywrod *Climate Change* in U.S.
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- IV Specification
  - temperature anormaly (Choi et al., 2021) as instrumental variable for green taste (strong first stage result)

Empirical Analysis

Greater green GSV reduces information asymmetry of green firms

	OLS		IV	
	(1) ASY	(2) ASY	(3) ASY	(4) ASY
ENSCORE × growthcc	-0.174***	-0.164***	-0.677***	-0.697***
	(-6.27)	(-6.03)	(-8.15)	(-8.12)
ENSCORE	-0.467***	0.00355	-0.474***	0.00422
	(-5.39)	(0.04)	(-5.49)	(0.04)
growthcc	0.101***	0.133***	0.180***	0.391***
	(8.48)	(11.14)	(4.61)	(9.64)
Control	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Adjusted R^2	0.321	0.408	0.231	0.149
Observations	48478	48478	48478	48478

Empirical Analysis

Lower information asymmetry, lower leverage

Higher green taste $\Rightarrow$ lower information asymmetry of green firms
$\Rightarrow$ lower leverage of green firms (finance through stock $\uparrow$)

	(1) mktlev	(3) mktlev
ASY	0.0194***	0.0198***
	(0.00222)	(0.00230)
tangibility	0.191**	0.189**
	(0.0767)	(0.0765)
qratio	-0.0168***	-0.0166***
	(0.00304)	(0.00304)
firmsize	1.365**	1.448**
	(0.551)	(0.560)
profit	-0.364***	-0.377***
	(0.0848)	(0.0906)
cat_firm		-0.0202*
		(0.0105)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	11525	11503
R^2	0.821	0.819

Empirical Analysis

Higher Green Preference, lower leverage for green firms

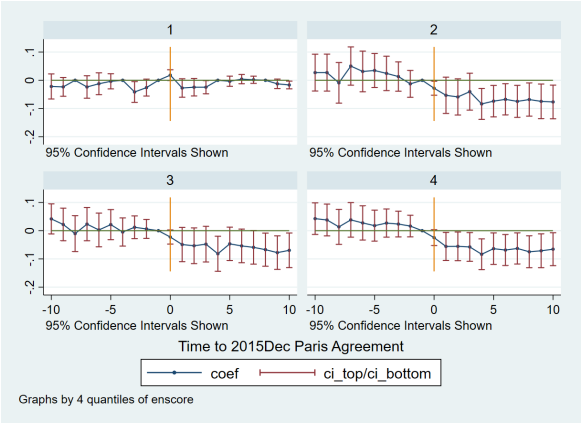

Figure: 2015 December Paris Agreement and Capital Structure

Conclusion

- We study how an increasing green investment affects firms' information asymmetry and capital structure
- We provide a three-period model with endogenous learning and heterogeneous preference for green investing
- Our model shows that a higher green investment share
  - reduces the information asymmetry of green firms
  - implies green firms finance more through equity and a lower leverage ratio
- We provide empirical evidence that supports our findings

Thanks!

Any comments are welcome:

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