Green Price Pressure

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Motivation

- **Sustainable investing**: influence **corporate behavior** through **capital allocation**
  - Stock prices respond to investor preferences for sustainability
  - This **price pressure** can incentivize environmental improvements by (i) reducing **financing costs** and (ii) influencing **managerial decisions**
- **Limited evidence linking price pressure to tangible environmental performances**
  - Existing literature rely on theoretical frameworks rather than empirical evidence
  - Empirical studies often study price effects and real effects in isolation

$\Rightarrow$ **This paper**: develop a **measure of firm-level incentive** (via prices) to be "greener"

What we do

- **Construct firm-level "green price pressure" (GPP) using an asset demand system**
  - Define GPP as sensitivity of a firm's stock price to improvements in its greenness
  - Estimate investor-level demand coefficients
  - Compute GPP in closed form using the market clearing condition
- **Examine the validity of GPP**
  - Look at price responses to ESG incidents
  - Document trends in GPP over time
- **Examine the "catering theory" mechanism of GPP**
  - Regress improvements in greenness on GPP
  - Subsample analyses on management compensation and sub-components of E-scores

What we find

- **Findings:**
  - Firms with **higher GPP** $\Longrightarrow$ **larger stock price reactions** to environmental incidents
  - Average GPP $\nearrow$ since 2016 + **larger for green firms** than for brown firms
  - Firms with **higher GPP** $\Longrightarrow$ **larger future environmental improvements**... BUT:
    - only in firms whose executive compensations are sensitive to stock prices
    - only in dimensions of environment scores that are easy to improve
- **Implications**:
  - Firm-side: importance of managerial incentives in driving corporate action
  - Investor-side: inelastic investors amplify preferences for sustainability

Framework (1/2)

- **Investor i's demand:**

$$q_i = -\zeta_i p + \gamma_i g + \epsilon_i$$

- **Market clearing ($\sum_i q_i = 1$, normalized):**

$$p(g) = \frac{\gamma_S \cdot g + \epsilon_S - 1}{\zeta_S} \quad \text{where} \quad \gamma_S = \sum_i A_i \gamma_i$$

- **Green price pressure (GPP):**

$$\frac{\partial p}{\partial g} = \frac{\gamma_S}{\zeta_S}$$

- **Other measures related to GPP:**
  - Institutional ownership (Dyck et al., 2019)
  - Fraction of PRI signatory ownership (Kim & Yoon, 2023)
  - Green tilts (Pástor et al., 2023)

Framework (2/2)

- **Green price pressure (GPP):**

$$\frac{\partial p}{\partial g} = \frac{\gamma_S}{\zeta_S}$$

  - GPP increases with stronger green demand (γ) and lower price elasticity (ζ)
  - Firm heterogeneity: GPP varies by investor composition
- **Empirical challenges:**
  - Need estimates of γ_i: control for other correlated firm characteristics
  - Need estimates of ζ_i for all investors: endogeneity between price and demand
  - Need cross-elasticities for a complete characterization
- **Solution:** use an asset demand system (Koijen & Yogo, 2019)

Estimating GPP

Data

- **Institutional equity holdings**: FactSet (based on 13F filings)
  - Investors formed into groups following (Koijen et al., 2023)
- **Stock characteristics:** CRSP and Compustat
  - Sort US firms in each quarter by their market equity, and then choose N largest stocks whose combined market equity covers at least 95% of total US stock market capitalization
  - These firms are classified as "inside assets," while the remaining firms are aggregated into an "outside asset"
- **Environmental performance**: MSCI and TruCost
  - Follow Pastor, Stambaugh and Taylor (2022) to construct industry-unadjusted firm "greenness"
  - Annual scope 1 greenhouse gas emissions data from S&P TruCost

An empirical model of investor demand

- **Characteristics-based demand** (Koijen and Yogo, 2019):
  - Investors with **heterogeneous beliefs** (“agree to disagree”)
  - Returns follow a **factor structure**
  - Factor loadings depend on **characteristics**

An empirical model of investor demand

- **Model setup:**
  - I investors indexed by $i = 1, \ldots, I$
  - N stocks indexed by $n = 1, \ldots, N$ with characteristics $\boldsymbol{x}_t(n)$
  - $S_t(n)$ shares outstanding and $P_t(n)$ price at date t
  - Lowercase for logged variables and boldface for vectors:

$$\boldsymbol{me}_t = \log(\boldsymbol{ME}_t) = \log(\boldsymbol{P}_t \boldsymbol{S}_t) = \boldsymbol{p}_t + \boldsymbol{s}_t$$

An empirical model of investor demand

- **Investor's problem:**
  - Investor i has wealth $A_{i,t}$ at time t
  - Chooses portfolio weights $w_{i,t}(n)$ to maximize utility over terminal wealth at T:

$$\max_{w_{i,t}} \mathbf{E}\left[\log(A_{i,T})\right]$$

  - Intertemporal budget constraint:

$$A_{i,t+1} = A_{i,t}(R_{t+1}(0) + \boldsymbol{w}'_{i,t}(\boldsymbol{R}_{i,t+1} - R_{t+1}(0)\mathbf{1}))$$

  - Taylor approximation leads to a mean-variance portfolio solution

An empirical model of investor demand

- **Factor and information structure:**
  - Expected returns and covariance depend on characteristics (information)
  - Need some additional structure on coefficients (omitted)
- **Exponential-linear demand:**

$$\frac{w_{i,t}(n)}{w_{i,t}(0)} = \delta_{i,t}(n) = \exp\left(b_{0,i,t} + \beta_{0,i,t} mb_t(n) + \boldsymbol{\beta}'_{1,i,t} \boldsymbol{x}_t(n)\right) \epsilon_{i,t}(n)$$

- **Portfolio weights:**

$$w_{i,t}(n) = \frac{\delta_{i,t}(n)}{1 + \sum_{m \in \mathcal{N}_{i,t}} \delta_{i,t}(m)} \quad \text{and} \quad w_{i,t}(0) = \frac{1}{1 + \sum_{m \in \mathcal{N}_{i,t}} \delta_{i,t}(m)}$$

Greenness as a characteristic

- **Justification for expanding the set of characteristics is necessary**
  - Original set: book equity, profitability, investment, dividend, and market beta
- **Theoretical justification:** greenness enters the investors' problem in one of the following
  - Greenness is informative about expected returns
  - Investors derive utility from holding greener stocks
  - Investor faces a "minimum greenness constraint"
- **Empirical justification**: lasso regressions of log portfolio weights on 153 characteristics
  - Count occurrences where each characteristic is in top 10 characteristics selected
  - MSCI environment score is the 6th most frequently selected characteristic

Identification and estimation

- **Estimating equation:**

$$\frac{w_{i,t}(n)}{w_{i,t}(0)} = \exp\left(b_{0,i,t} + \beta_{0,i,t} mb_t(n) + \boldsymbol{\beta}'_{1,i,t} \boldsymbol{x}_t(n) + \beta_{g,i,t} g_t(n)\right) \epsilon_{i,t}(n),$$

- **Identification concerns and solutions**:
  - Endogeneity concern 1: $g_t(n)$ is correlated with $\epsilon_{i,t}(n)$
    $\Rightarrow$ Control for S and G components of ESG to address confounders
    $\Rightarrow$ Robustness using lagged environment scores
  - Endogeneity concern 2: $mb_t(n)$ is correlated with $\epsilon_{i,t}(n)$ (Koijen and Yogo, 2019)
    $\Rightarrow$ Instrument for $mb_t(n)$ using counterfactual $mb_t(n)$ based on investor mandates
- **Estimation**: two-step IV ridge estimation (Koijen et al., 2023)
  - Step 1: pooled IV ridge to estimate group-level demand
  - Step 2: investor-level ridge, shrunk toward group estimates

Green price pressure

- **Market clearing:**

$$\log(\boldsymbol{ME}) = \boldsymbol{p} + \boldsymbol{s} = \log\left(\sum_i A_i w_i(\boldsymbol{p}, \boldsymbol{x}, \boldsymbol{\epsilon})\right)$$

- **Implicit differentiation w.r.t. greenness:**

$$\text{GPP}(n) = \boldsymbol{P}_{n,n}$$

$$\boldsymbol{P} := \frac{\partial \boldsymbol{p}}{\partial \boldsymbol{g}} = \left(\boldsymbol{I} - \sum_i \beta_{0,i} A_i \boldsymbol{H}^{-1} \boldsymbol{G}_i\right)^{-1} \left(\sum_i \beta_{g,i} A_i \boldsymbol{H}^{-1} \boldsymbol{G}_i\right)$$

$$\boldsymbol{H} := \text{diag}\left(\sum_i A_i \boldsymbol{w}_i\right) = \sum_i A_i \text{diag}\left(\boldsymbol{w}_i\right) \qquad \boldsymbol{G}_i = \text{diag}\left(\boldsymbol{w}_i\right) - \boldsymbol{w}_i \boldsymbol{w}_i'$$

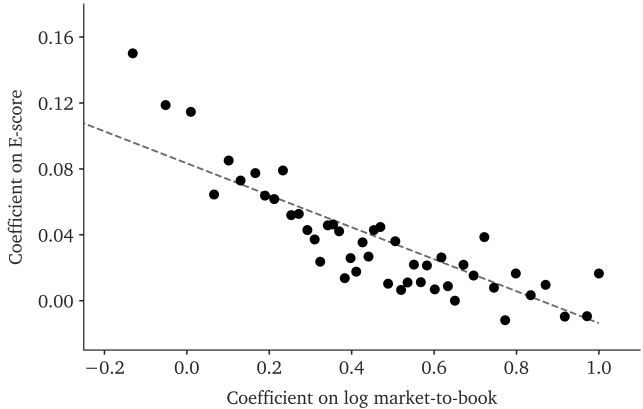
- **A useful approximation**:

$$\text{GPP}(n) \approx \frac{\sum_i s_i(n) \beta_{g,i}}{1 - \sum_i s_i(n) \beta_{0,i}}$$

Dynamics of GPP

Investor demand for sustainability

- **Price-elastic** investors have a **stronger** preference for sustainability



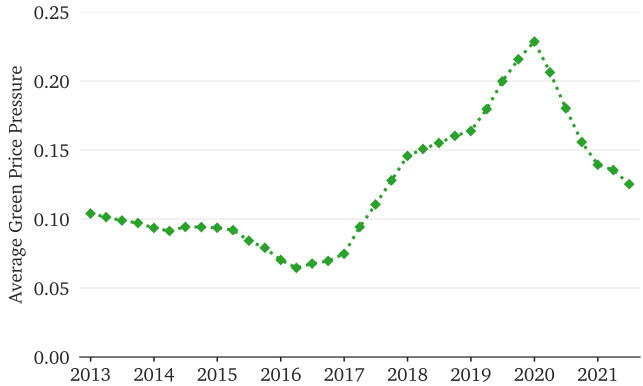
GPP and price response to ESG incidents

- ESG incident = monthly increase of at least 10 points in the firm's RepRisk Index
- Estimate CAPM abnormal returns for groups of firms sorted by GPP
- **High pressure** stocks experience **larger** price responses

	Window $[-5, 5]$			Window $[-10, 10]$		
	CAR	t-stat	N(Events)	CAR	t-stat	N(Events)
All	-0.209^{***}	-5.098	2,086	-0.293^{***}	-7.060	2,085
Low Pressure	-0.143^{*}	-1.895	742	-0.086	-1.137	742
Medium Pressure	-0.170^{**}	-2.466	695	-0.325^{***}	-4.679	695
High Pressure	-0.328^{***}	-4.859	649	-0.498^{***}	-7.151	648

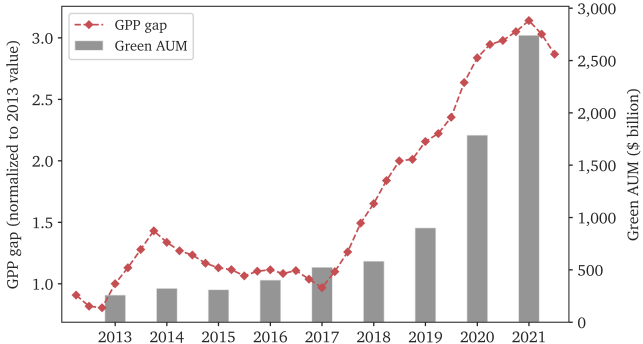
Trend over time

- GPP **rises** starting in 2016 and peaks around COVID



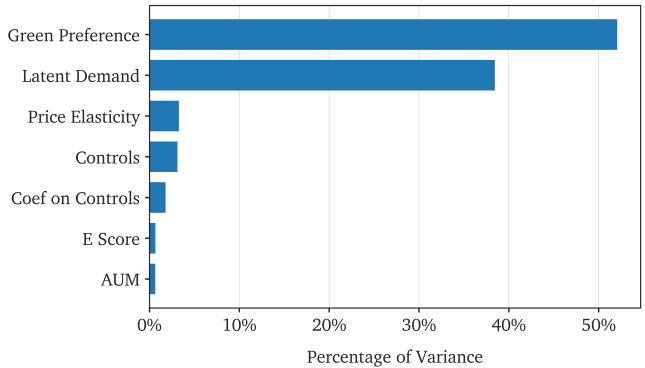
The green-brown GPP gap

- **Green firms face higher GPP** than brown firms, especially after 2016



What drives GPP?

- **Variance decomposition:** update x, g, ... sequentially, add up changes to GPP
- **Changes in green preferences** explain more than half of the variation in GPP



Firm response to GPP

Improvements in environmental performance

- GPP predicts **future environmental improvements** in the cross-section of firms

$$\text{Escore}_{n,t+h} = \delta \text{GPP}_{nt} + \gamma \text{Escore}_{nt} + \Gamma' \mathbf{X}_{nt} + \alpha_t + \alpha_{\text{ind}(n)} + \epsilon_{nt}$$

	E-score$_{t+3}$		Emission$_{t+3}$
	(1)	(2)	(3)
GPP	0.101**		−9.080*
	(0.028)		(3.884)
GPP approx		0.100**	
		(0.028)	
E-score	0.784***	0.784***	
	(0.039)	(0.039)	
Emission			0.797***
			(0.025)
Controls	✓	✓	✓
Industry FE	✓	✓	✓
Year FE	✓	✓	✓
Within R^2	0.629	0.628	0.881
Observations	4,326	4,326	2,558

Heterogeneity across manager incentives

- Split firms based on CEO delta (Coles et al., 2006; Core & Guay, 2002)
- GPP predicts improvements only for firms with the right **managerial incentives**

	E-score$_{t+3}$		
	Low delta	Medium	High delta
	(1)	(2)	(3)
GPP	−0.002	0.115*	0.132**
	(0.048)	(0.057)	(0.043)
E-score	0.733***	0.798***	0.802***
	(0.043)	(0.043)	(0.037)
Controls	✓	✓	✓
Industry FE	✓	✓	✓
Year FE	✓	✓	✓
Within R^2	0.592	0.622	0.659
Observations	1,154	1,354	1,441

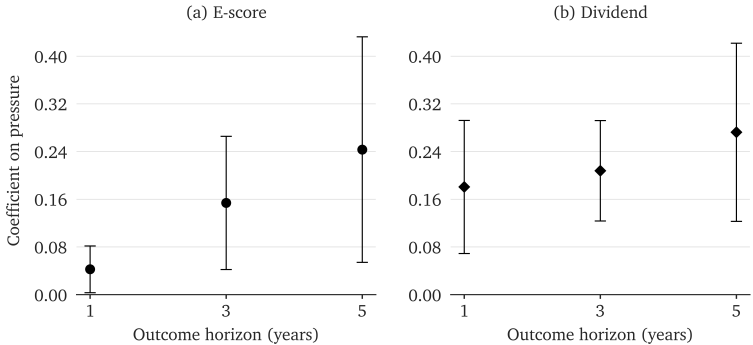
Heterogeneity across environmental themes

- Split MSCI environment score into four sub-components

		Theme score			
	E-score$_{t+3}$	Waste MGMT$_{t+3}$	Natural res$_{t+3}$	Climate change$_{t+3}$	E opp$_{t+3}$
	(1)	(2)	(3)	(4)	(5)
GPP	0.101**	0.225***	0.145**	0.081*	0.010
	(0.028)	(0.053)	(0.051)	(0.036)	(0.040)
E-score	0.784***				
	(0.039)				
Waste MGMT		0.629***			
		(0.041)			
Natural res			0.705***		
			(0.055)		
Climate change				0.750***	
				(0.033)	
E opp					0.626***
					(0.061)
Controls	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Within R^2	0.629	0.472	0.598	0.642	0.513
Observations	4,326	2,367	3,230	4,238	1,712

Benchmarking GPP: a catering theory analogy

- Adapt our methodology to dividends and forecast future dividends
- Framework generalized to other firm decisions



Conclusion

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- **Investor demand for sustainability ⇒ stock prices ⇒ firm behavior**
  - Use an asset demand system to construct green price pressure (GPP)
  - GPP aligns well with market reaction and time trends in sustainable investing
  - GPP predicts future firm improvement... but:
    - only in firms where executive compensation is sensitive to stock prices
    - only in dimensions of environment scores that are easy to improve
- **Implications:**
  - Sustainable investing can influence corporate behavior, but only when market forces align well with managerial incentives
  - Need for better incentive structure and improved disclosure standards

Thank You!

Questions and comments most welcome

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