Green financing and firm dynamics

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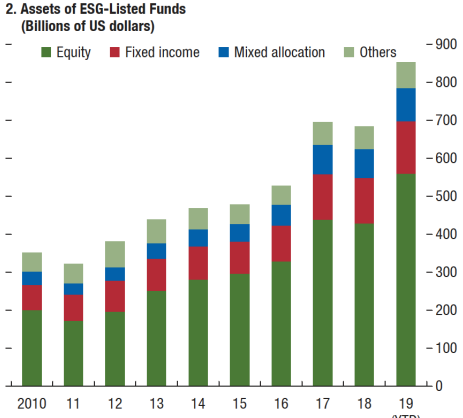
Introduction

- Concerns surrounding climate change have heightened considerably in recent years.
- Investing according to ESG criteria is gaining momentum

Figure: Growth of ESG-Dedicated funds



Source: Bloomberg Finance L.P.; JPMorgan Chase & Co.; and IMF staff calculations.; YTD=year to date.

Introduction

- Increasing in the threat of greenwashing.
- Motivation for consideration of realised measures (firm's carbon intensity) rather than project base classification (Ehlers et al. (2020)).
- Ex-ante firm heterogeneity in terms of asset and ability for green innovation become relevant for firm financing.
- **This paper:**
- **What are the effects of green financing on firm growth and survival ?**
- **Are the effects quantitatively significant?**
- **What are the role of R&D policy in mitigating the effects?**

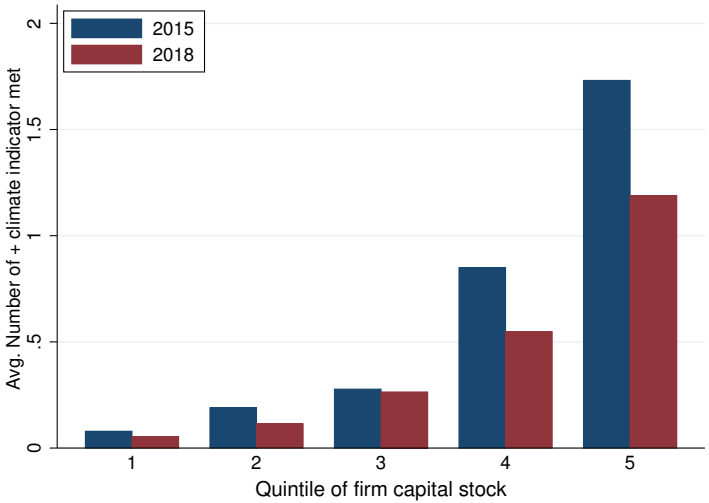
Motivating facts

Data

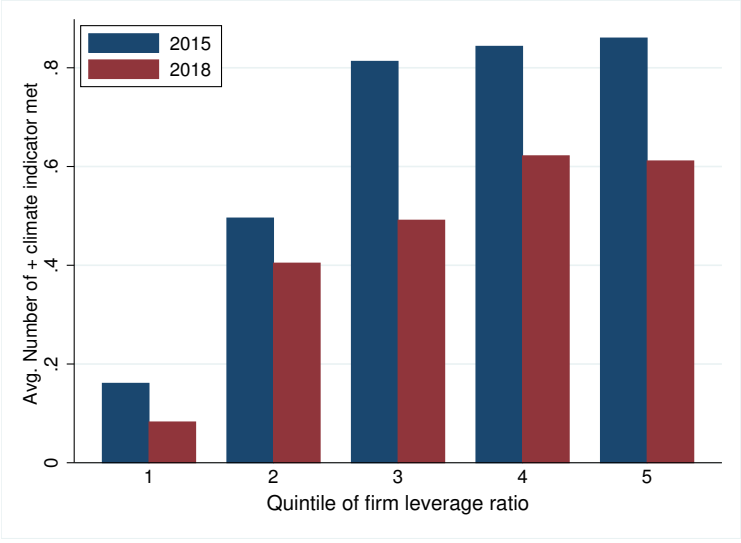
- MSCI ESG KLD STATS data
  - Positive performance indicators designed to capture the company's management best practices concerning environmental risks and opportunities.
  - 18 performance indicators See table each scored by a simple binary scoring model:
    - If a company meets the assessment criteria established for an indicator, it has scored 1 otherwise 0.
  - Construct aggregate indicator by summing up all the scores for each company
    - Number of positive climate performance met by a company
- Compustat-CRSP merged data
  - Informations on companies balance sheet.
- Balanced annual panel dataset of 1479 companies over 2015-2018 for the U.S. after combining the two data source.
- Exclusion of financial companies (SIC 6000-6999) and companies in utilities sector (SIC=4900) leading to 1151 publicly traded companies in the sample.

Fact 1: Larger firms are more likely reduce their carbon footprint

Manufacturing sector | Transport and Utilities



Fact 2: The better is the firm climate performance the higher is its financial leverage



Model

Built on Clementi and Palazzo (2016) and Moll (2014)

Model- Setup

- Time is discrete ($t \geq 0$)
- Continuum of heterogeneous firms i operated by price takers entrepreneurs
- Heterogeneity in entrepreneurs' net worth a_t and productivity z_t.
- z_t is persistent random with conditional probability distribution $H(z_{t+1}|z_t)$.
- A each t, the state of the economy is the joint distribution : $\Gamma(z_t, a_t)$
- Firms produce homogeneous good using capital k_t and labor ℓ_t.
  - Pollution is emitted during production process at t:

$$y_{it} = z_{it}(1 - \Gamma(M_t)) \left(k_{it}^{\alpha} \ell_{it}^{1-\alpha}\right)^{\theta} , \qquad \alpha, \theta \in (0,1) \tag{1}$$

  where M_t is an emission stock and $\Gamma(M_t)$ a damage function attached to pollution.
- Denote E_{it} Pollutant emitted by firm i at time t:

$$E_{it} = \frac{1}{\varphi_{it}} y_{it} \tag{2}$$

Model : Setup - II

- φ_{it} is the abatement technology evolving as:

$$\varphi_{it+1} = (1 - \delta_{\varphi})\varphi_{it} + f(x_{it}) \tag{3}$$

- φ_{i0} is given and equal φ_0 for all firm.
- x_{it} is the (in final good terms) R&D spending on improving abatement technology.
- Firm i borrows capital $b_{it} = k_{it} - a_{it}$, s.t borrowing constraint $k_{it} \leq \gamma(e_{it})\, a_{it}$
- $e_{it} = \dfrac{E_{it}}{y_{it}}$ is the emission per unit of output of firm i at time t.
- Leverage ratio is endogenously linked to the emission per unit of output of firm.
- In addition firm faces a carbon tax p_c per unit of emission.

Incumbent problem

- Firm static profit:

$$\pi(\Gamma, z, a) = \left\{ \max_{k,\ell} \; y - Rk - w\ell - p_c \frac{y}{\varphi} \quad \text{s.t.} \quad k \leq \gamma(\varphi^{-1})\, a \right\} \tag{4}$$

- A firm's flow budget constraint (in final good terms) is:

$$a' = \pi(\Gamma, z, a) + R\, a + (1 - \delta) a - x \tag{5}$$

- Homogeneous good is the numeraire.
  - R: real rental rate of capital
  - p_c: real carbon tax per unit of emission
  - δ: capital depreciation rate
  - w: real wage

- Assuming functional form for leverage ratio:

$$\gamma(s) = 1 + \exp\left(\frac{1}{s}\right) \tag{6}$$

Dynamic problem.

- Dynamic problem of firm (choice of R&D spending : x)
  - The start-of-period value of an incumbent firm $V(\Gamma, z, a)$ solves:

$$V(\Gamma, z, a) = \pi(z, a, \varphi) + R\,a + (1-\delta)a + \max\left\{0\,;\ \tilde{V}(\Gamma, z, a) - \chi\right\} \tag{7}$$

  - where:

$$\begin{aligned} \tilde{V}(\Gamma, z, a) \quad = \quad & \max_{x} -x - g(x, \varphi) + \beta \int V(\Gamma', z', a')\, dH(z'|z)\, J(\Gamma'|\Gamma) && (8) \\ & \text{s.t.} \quad \varphi' = (1-\delta_\varphi)\varphi + f(x) \\ & \qquad\ \ a' = \pi(z, a, \varphi) + R\,a + (1-\delta)a - x && (9) \end{aligned}$$

  - δ_φ: depreciation rate of abatement tech.
  - f: transform final good to abatement tech. ($f' > 0$, $f'' < 0$)
  - g: abatement techn. adjustment cost
  - β: discount factor.
  - χ: fixed cost of operation.

Exit/Entry

- Firms that exit producing cannot reenter the market at a later stage
- Prospective entrant enter replacing exiting firm
  - Inherits the same firm (same asset a and technology abatement φ)
  - But receives a signal q about her productivity with $q \sim Q(q)$.
  - Conditional on entry, the distribution of the idiosyncratic shock in the first period of operation is $H(z'|q)$, strictly decreasing in q
  - pays entry cost $c_e \geq 0$ when decide to enter.
- Given aggregate state Γ, the value of a prospective entrant that obtains a signal q is:

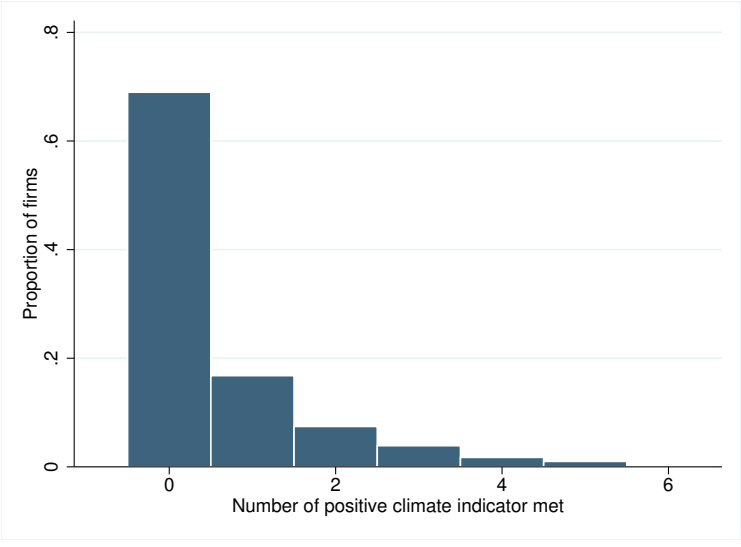
$$\begin{aligned} V_e(\Gamma, q, a) \quad = \quad & \max_x -x - g(x, \varphi) + \beta \int V(\Gamma', z', a') dH(z'|q) J(\Gamma'|\Gamma) \\ & \text{s.t.} \quad \varphi' = (1 - \delta_\varphi)\varphi + f(x) \\ & \qquad a' = \pi(z, a, \varphi) + R\, a + (1 - \delta) a - x \end{aligned} \tag{10}$$

- She starts operating if $V_e(\Gamma, q, a) \geq c_e$

Next Steps

- Robustness check of facts 1 and 2 with other measures of firm environment performance
- Defining Stationary equilibrium
- Calibrate and simulate the model.
  - Look at the NSF' survey on R&D at firm level (publicly available)
- Analyze the aggregate dynamics from the model
- Add government and analyze R&D policy

Distribution of firms over environmental performance



Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P50	P75
Env. perf.	4604	.56	1.04	0	6	0	0	1
Firm size	4553	7.61	1.55	3.89	13.3	6.44	7.43	8.55
Leverage ratio	4595	.57	.28	-1.64	4.35	.42	.57	.71
Inv. ratio	4473	.06	.14	0	0.91	.01	.04	.12
R&D ratio	4498	.14	.15	0	.95	.01	.1	.21
CF ratio	4536	.03	.05	0	1.26	0	.01	.03
Tobin Q	4598	1.87	1.93	.02	25.03	.72	1.27	2.3

MSCI ESG KLD STATS INDICATOR

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Positive Environment Performance Indicators	Data Set Column Headers
Environmental Opportunities - Clean Tech	ENV-str-A
Waste Management - Toxic Emissions and Waste	ENV-str-B
Waste Management - Packaging Materials & Waste	ENV-str-C
Climate Change - Carbon Emissions	ENV-str-D
Environmental Management Systems	ENV-str-G
Natural Resource Use - Water Stress	ENV-str-H
Natural Resource Use - Biodiversity & Land Use	ENV-str-I
Natural Resource Use - Raw Material Sourcing	ENV-str-J
Natural Resource Use - Financing Environmental	ENV-str-K

Impact	
Environmental Opportunities - Green Buildings	ENV-str-L
Environmental Opportunities in Renewable Energy	ENV-str-M
Waste Management - Electronic Waste	ENV-str-N
Climate Change - Energy Efficiency	ENV-str-O
Climate Change - Product Carbon Footprint	ENV-str-P
Climate Change - Insuring Climate Change Risk	ENV-str-Q
Environment - Other Strengths	ENV-str-X

Large firms perform better in managing environmental risk and opportunities (Manufacturing)

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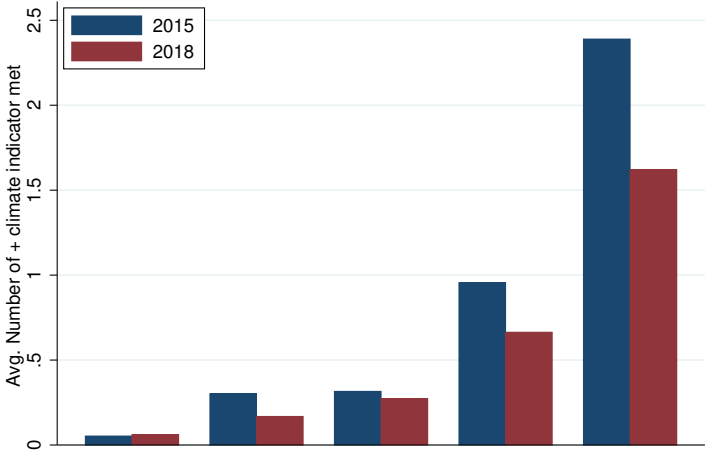

High leverage firms perform better in managing environmental risk and opportunities (Transport and Utilities sector)

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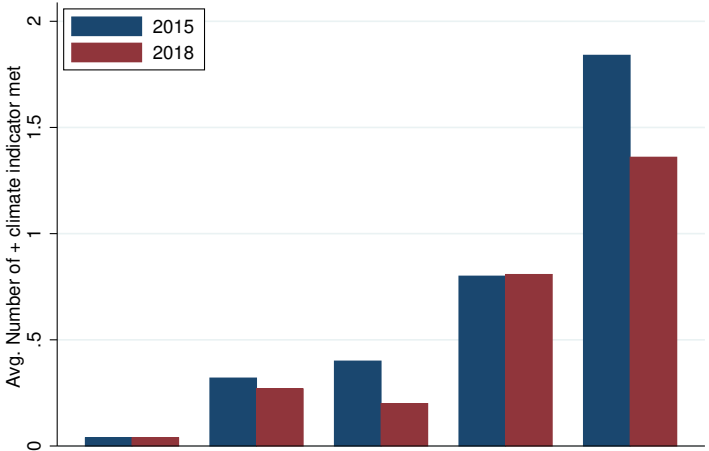

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