A primer in sustainable finance theory

Stefano Lovo

HEC Paris

Two broad questions for sustainable finance research

- Is sustainability relevant for finance? (Mostly empirical question: climate risk, regulation risk, greenium, etc.)

- Is finance relevant for sustainability? Can finance help transitioning toward a more sustainable economy?

Road map

This talk focus on some recent theories on how and whether finance can help the green transitions?

Simplified version of:

- Green and Roth (2020) (many firms with give technology)
- Oehmke and Opp (2020) (carrot to induce transition)
- Heinkel, Kraus, and Zechner JFQA (2001) (stick to induce transition)
- Landier and Lovo (2020) (stick vs carrot to induce transition)

Most Common assumptions

1. Firms can be green or brown. Green firms have worst financial performance (F-performance) than brown firms. Brown firms have worst sustainable or social performance (S-performance) than green firms.

2. All investors care about the financial performance of their investment and some also care about the S-performance.

3. All firms' managers care about their firms' F-performance, and some may also care about their firms' S-performance.

Many firms with given technology (Inspired from Green and Roth (2019)

Firms

- continuum of firms.
- Each firm requires one unit of capital to be run.
- If financed, firm i generates cash-flow F_i and social performance S_i
- Firm i's contribution to social welfare:

$$w_i = F_i - 1 + S_i$$

- Three types of firms
  - Mass 1 of Financial performing green firms $F_i = F_H > 1$ $S_i = S$
  - Mass 1 of Financial performing brown firms $F_i = F_H > 1$ $S_i = -S$
  - Mass 1 of Financial under performing green firms $F_i = F_L < 1$, $S_i = S$
  - Mass 1 of Financial under performing brown firms $F_i = F_L < 1$, $S_i = -S$

Contribution to social welfare

Assumption:

$$F_L - 1 < 0 < F_H - 1$$

$$F_H - 1 - S < 0 < F_L - 1 + S$$

- Only Financial performing firms produce positive return
- Only green firms contribute to social welfare.

Capital

An exogenous mass $K \in [1, 2]$.

- Social optimal allocation of capital: Finance in priority all financial performing green firms, and put remaining capital into the other green firms.

$$w^\star : F_H - 1 + S + (K - 1)(F_L - 1 + S)$$

- Return maximizing allocation of capital: Finance only financial performing firms

$$w^{RM} : F_H - 1 + S + (K - 1)(F_H - 1 - S) < w^\star$$

Investors and their preferences

- A **standard investor** only cares about the F-performance of his/her investment: financial return and risk. How much money do I get?

- A **value-aligned investor** cares about both the F-performance and the S-performance of *his/her* investment, no matter whether this has in impact or not on social welfare.

- An **impact investor** cares about the F-performance of his investment but also on how the investment improves social welfare relative to a situation in which he does not invest.
  $\Rightarrow$ **Impact need to be defined relative to a counterfactual.**

Mutual funds catering to investors preferences

- **RM fund:** Standard return maximizing fund
- **VA fund:** Value-aligned fund (ESG fund)
- **I fund:** Impact fund

RM fund's capital allocation rule

k: funds' AUM

$$\max_{x} \quad \overbrace{\sum_{j\in\Omega} x_j(F_j-1)}^{\text{Fund financial return}}$$

$$s.t. \quad \sum_{j} x_j = 1,$$

$$x_j \geq 0, \forall j$$

$$\Omega := \{F_H + S, F_H - S, F_L + S, F_L - S\}$$

Value Alignment fund's capital allocation rule

k: funds' AUM

$$\max_{x} \quad \overbrace{k \sum_{j \in \Omega} x_j (F_j - 1 + S_j)}^{\text{Social welfare associated to the fund owned firms}}$$

$$s.t. \quad \sum_{j} x_j = 1,$$

$$x_j \geq 0, \forall j$$

Impact fund's capital allocation rule

k: funds' AUM

$$\max_{x} \quad \overbrace{\sum_{j\in\Omega}(x_j k + y_j(K-k))(F_j - 1 + S_j)}^{\text{Aggregate social welfare}} \tag{1}$$

$$s.t. \quad \sum_{j} x_j = 1, \tag{2}$$

$$x_j \geq 0, \forall j \tag{3}$$

where $K - k$ is the AUM not managed by the fund, and y_j is the fraction of such capital invested in sector j.

Capital allocation with homogeneous investors

Theorem

- *If all investors have the standard preference, then capital is allocated as to maximize return and social welfare is* w^{RM}.
- *If all investors have the VA or impact preference, then capital is allocated as to maximize social welfare leading to* $w^{\star}$.

Theorem

Suppose that VA investors owns a fraction λ of capital and the rest of capital is owned by standard investors.
Then

- *If $\lambda K \leq 1$ then*
  - *The value-aligned and the standard fund offer the same financial rerun of $r_H := F_H - 1$.*
  - *The social return per unit of capital is higher for the the VA fund than for the RM fund*
  - *the presence of the value-alignment fund has no impact on social welfare that remains w^{RM}.*

Theorem

Suppose that VA investors owns a fraction λ of capital and the rest of capital is owned by standard investors.
Then

- *If $\lambda K > 1$ then*
  - *The VA fund offers lower financial than the RM fund*

$$r^{VA} - r^{RM} = -(F_H - F_L)\left(\frac{\lambda K - 1}{\lambda K}\right) < 0$$

  - *Social welfare is*

$$\underbrace{(F_H - 1 + S) + (\lambda K - 1)(F_L - 1 + S)}_{\text{Social welfare from VA financed firms}} + \underbrace{(1 - \lambda)K(F_H - 1 - S)}_{\text{Social welfare from RM financed firms}}$$

Theorem

Suppose that I investors owns a fraction λ of capital and the rest of capital is owned by standard investors.
Then

- *if* $(1-\lambda)K \geq 1$,
  - *The I fund offers lower financial than the RM fund*

$$r^I - r^{RM} = -(F_H - F_L) < 0$$

  - *The social return per unit of capital is higher for the the I fund than for the RM fund*
  - *Social welfare is*

$$\overbrace{\lambda K(F_L - 1 + S)}^{\text{Social welfare from I fund financed firms}} + \underbrace{(F_H - 1 + S) + ((1-\lambda)K - 1)(F_H - 1 - S)}_{\text{Social welfare from RM financed firms}} \geq w^{RM}$$

Theorem

Suppose that I investors owns a fraction λ of capital and the rest of capital is owned by standard investors.
Then

- *if* $(1-\lambda)K < 1$,
  - *The I fund offers lower financial than the RM fund*

$$r^I - r^{RM} = -(F_H - F_L)\frac{K-1}{\lambda K} < 0$$

  - *The social return per unit of capital is higher for the the I fund than for the RM fund*
  - *Social welfare is*

$$\overbrace{(\lambda K - 1)(r_L + S) + (1 - (1-\lambda)K)(r_H + S)}^{\text{Social welfare from I fund financed firms}} + \underbrace{(1-\lambda)K(r_H + S)}_{\text{Social welfare from RM financed firms}}$$

Exercise

Find the equilibrium when I investors, VA investors and standard investors own fractions of total capital λ_I, λ_{VA} and $1 - \lambda_1 - \lambda_{VA}$, respectively.

Some empirical implications

Empirical implications:

- A fund that caters to value aligned investor
  - If large enough, has better S-performance than a standard fund
  - Can have F-performance comparable to standard fund, but F-performance deteriorate as the VA fund size increases.
  - The presence of VA fund has no effect on social welfare unless it is large enough $\rightarrow$ Impact has a cost.
- A fund that caters to impact investor
  - has better S-performance than a standard fund
  - has worse F-performance than a standard fund, with the return spread that decreases with the I fund size.
  - The presence of I fund improves social welfare proportionally to its size.

Conclusion from this first part

- SR investing can improve social welfare but the extent depends on SR investor's preferences
- No matter SR investor preference impact has a financial cost
- SR investor do not reduce social welfare....

Conclusion from this first part

- SR investing can improve social welfare but the extent depends on SR investor's preferences
- No matter SR investor preference impact has a financial cost
- SR investor do not reduce social welfare.... **Really?**

Extra capital from social responsible investors

Theorem

Suppose RM AU is $K_{RM} = 1$ and there is some extra capital $K_S < 1$ arriving from socially responsible investors. Then:

- *If SR investors have VA preference then their presence deteriorates social welfare by SK_S as the dislocate RM capital from green financial performing firms to brown financial performing firms.*
- *If SR investors have Impact preference then their presence improves social welfare by SK_S.*

Carrot to induce transition (Inspired from Ohemke and Opp (2019)

How can responsible investors induce entrepreneurs to go green?

- Penny-less entrepreneur needs 1 unit of capital to run her firm
- Entrepreneur can choose between running a green project or a brown project.
- Brown project's F-performance $= F_B > F_G =$ Green project's F-performance.
- Brown project's S-performance $= S_B < 0 < S_G =$ Green project's S-performance.
- Unit cost of S-performance:

$$c := -\frac{F_G - F_B}{S_G - S_B}$$

- Green project maximizes social welfare

$$F_G - 1 + S_G > F_B - 1 + S_B$$

Entrepreneur preference

An entrepreneur's utility from receiving C in cash and running a firm with social performance S

$$U_{ent} = C + \eta S$$

where $\eta \geq 0$ is the entrepreneur's sensitivity to her firm's S-performance.

Investors

$U(C, S)$:= investor's Utility from receiving cash C while financing project with S-performance S:

- There is a mass of competitive standard investors who only care about the F-performance of their investment.

$$U(C, S) = C$$

- There is a mass of competitive social responsible investors
  - VA investors

$$U(C, S) = C + \mu S$$

  - Impact investor

$$U(C, S) = C + \mu(S - S_{co})$$

where :
$\mu \geq 0$= investor's sensitivity to the firm's S-performance,
S_{co}= the firm's S-performance in the absence of impact investor.

Competitive investors

Suppose the firm promises investors to receive a return R and to generate S-performance S.
Then an investors invests in the firm as long as

- $R \geq 1$, for standard investors
- $R \geq 1 - \mu S$, for VA investors
- $R \geq 1 - \mu(S - S_{co})$, for Impact investors

Entrepreneur choice of project when facing standard investors

1. The entrepreneur offers investors a payment that makes the standard investor indifferent between investing or not:

$$R = 1$$

2. The entrepreneur opts for the green project only if

$$F_G - R + \eta S_G \geq F_B - R + \eta S_B$$

that is iff

$$\eta \geq c$$

recall that $c := \frac{F_B - F_G}{S_G - S_B}$

Entrepreneur choice of project when facing standard investors and VA investors

1. The entrepreneur offers investors a payment that makes the standard investor indifferent between investing or not:
   - A green project can be financed by VA investor offering
   $$R_G = 1 - \mu S_G < 1$$
   - A brown project can be financed by VA investor offering
   $$R_B = 1 - \mu S_B > 1$$
   - Any project can be financed standard by investors, by offering
   $$R = 1$$
2. The entrepreneur opts for the green project only if
   $$F_G - R_G + \eta S_G \geq F_B - R + \eta S_B$$
   that is iff
   $$\eta + \mu \frac{S_G}{S_G - S_B} \geq c$$

Entrepreneur choice of project when facing Im. investors

1. Counterfactual

$$S_{co} : \begin{cases} S_B \text{ if } \eta < c \\ S_G \text{ if } \eta > c \end{cases}$$

   - A green project can be financed by I investor offering

$$R_G = 1 - \mu(S_G - S_{co}) \leq 1$$

   - A brown project can be financed by I investor offering

$$R_B = 1 - \mu(S_B - S_{co}) \geq 1$$

   - Any project can be financed standard investors, by offering

$$R = 1 < R_B$$

2. The entrepreneur opts for the green project only if

$$F_G - R_G + \eta S_G \geq F_B - R + \eta S_B$$

   that is iff

$$\eta + \mu \geq c$$

Impact investors have more impact than VA investors

$$\eta < \eta + \mu \frac{S_G}{S_G - S_B} < \eta + \mu$$

Some empirical implications 1

- Absent SR investors
  - only responsible enough entrepreneurs implement green projects
  - the cost of capital of green and brown projects is the same.

Some empirical implications 2

- In the presence of VA investors
  - responsible enough investors can induce some entrepreneur to switch to green projects.
  - The cost of capital for brown project is larger than the cost of capital of green project.

Some empirical implications 3

- In the presence of Impact investors
  - Responsible enough investors can induce (even more entrepreneurs) to switch to green projects.
  - The cost of capital for green project implemented by responsible entrepreneurs is the same as the cost of capital for brown projects.
  - The cost of capital for green project implemented by non-responsible entrepreneurs is the smaller than the cost of capital for brown projects.

Exercise

Find the equilibrium when I investors, VA investors and standard competitive investors are present.

Threat of divestiture to induce transition (inspired from Heinkel at al. (2001)

- One firm with a mass 1 of outstanding shares
- Firm pays a random cash-flow $\tilde{v}$ per share with $\tilde{v} : N(\overline{v}, \sigma)$
- Firm manager:
  - Can turn green the firm. This reduces the firm's cash-flow by c per share.
  - Aims at maximizing the market value of the firm.

Investors

- Mass one of competitive investors with CARA utility function:

$$U(C) = -\exp[-\frac{\gamma}{2}(C)]$$

- A fraction λ of the investors are 'radical' VA investors: they do not invest into a firm that is not green.

Timing

1. Manager chooses whether to go green or not

2. Investors observe manager's choice and choose whether to invest or not

3. Stock price market clears

Equilibrium price of brown and green firms

- If the firm does not transition to the green technology, then in equilibrium

$$(1-\lambda)\frac{\overline{v}-p}{\gamma\sigma^2} = 1 \Rightarrow p = p_B := \overline{v} - \frac{\gamma\sigma^2}{1-\lambda}$$

$$E[r_B] = \frac{\gamma\sigma^2}{\overline{v}(1-\lambda) - \gamma\sigma^2}$$

- If the firm transition to the green technology, then in equilibrium

$$\frac{\overline{v}-c-p}{\gamma\sigma^2} = 1 \Rightarrow p = p_G := \overline{v} - c - \gamma\sigma^2$$

$$E[r_G] = \frac{c+\gamma\sigma^2}{\overline{v}-c-\gamma\sigma^2}$$

- The firm turns green iff $p_G > p_B$, that is,

$$c < \frac{\lambda}{1-\lambda}\gamma\sigma^2$$

$$\Downarrow$$

$$E[r_G] < E[r_B]$$

Implications

- Firm transition only if there are enough responsible investors, and if investors are enough risk averse.
- Threat of exclusion is effective for firms with cash-flows that are more risky.
- Expected return is lower for green firms than for brown firms.

Variant: being green allows to hedge climate risk

- One firm with a mass 1 of outstanding shares
- Firm pays a random cash-flow $\tilde{v}$ per share with $\tilde{v} : N(\overline{v}, \sigma^2(1 - \alpha s))$
- s represents the firm's S-performance.
- $\alpha > 0$ gather the idea that better S-performance reduce the firm's cash-flow volatility
- Firm manager:
  - To achieve S-performance s has a cost of cs^2
  - Choose s as to maximizing the market value of the firm.

Investors

- Mass $1-\lambda$ one of competitive investors with CARA utility function:

$$\max_x E(-\exp[-\frac{\gamma}{2}((\tilde{v}-p)q]$$

- Mass λ one of competitive VA investors with CARA utility function:

$$\max_x E(-\exp[-\frac{\gamma}{2}((\tilde{v}+s-p)q]$$

Timing

1. Manager chooses the level s of S-performance.

2. Investors observe manager's choice and choose whether to invest or not

3. Stock price market clears

Investors demand and equilibrium price

Given s,

- Each standard investor demands

$$\frac{\overline{v} - p - cs^2}{\gamma\sigma^2(1 - \alpha s)}$$

- Each VA investor demands

$$\frac{\overline{v} + s - p - cs^2}{\gamma\sigma^2(1 - \alpha s)}$$

- Equilibrium condition

$$(1 - \lambda)\frac{\overline{v} - p - cs^2}{\gamma\sigma^2(1 - \alpha s))} + \lambda\frac{\overline{v} + s - p - cs^2}{\gamma\sigma^2(1 - \alpha s)} = 1$$

$$\Downarrow$$

$$p(s) = \overline{v} - \gamma\sigma^2(1 - \alpha s) - cs^2 + \lambda s$$

Manager's choice of s

$$\max_s \overline{v} - \gamma\sigma^2(1-\alpha s) - cs^2 + \lambda s$$

$$\Downarrow$$

$$s^\star = \frac{\lambda + \alpha\gamma\sigma^2}{2c}$$

- Firm goes greener the more SR investors there are
- When sustainability becomes a risk factor, firms do not need sustainable investors to go green.
- Example of 'doing good by doing well'.

Exercise

Find the equilibrium when entrepreneur also give some value to her firm S-performance, and a fraction λ of investors are Impact investors.