# Valuing Green Funds

Shubhashis Gangopadhyay

*India Development Foundation,*

*UdyogVihar,*

*Gurgaon, 122001, India*

sg@idfresearch.org

and

Bappaditya Mukhopadhyay

*Management Development Institute,*

*Sukhrali, Mehrauli Gurgaon Road,*

*Gurgaon, 122001, India*

bappa@mdi.ac.in

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**Abstract:**

The paper investigates the effects of the operation of green funds on the efficiency of investment made by firms in developing the environment. We present a simple model where a fund manager has the ability to separate firms that undertake environment improving steps from those who don't. We show that such arrangements are efficient.

***JEL Classification***: Q50, Q51

**Key words**: *Green Fund, Green Technology, Certification*

## 1. Introduction

Green technology has been loosely defined as “any technology that has environmental benefits.” Worldwide, mutual funds which have environmentally friendly companies in their portfolio --- also known as green funds --- have generated a lot of interest among investors. The interest is growing although the performance of such funds has been mixed.

In 1985, approximately USD 65 billion was invested in stocks that were “socially screened.” Industry experts put that figure at about USD 639 billion in 1997. These are often called Socially Responsible Investments (SRIs). SRIs have become so popular that in 1990 an SRI Index was developed -- the Domini 400 Social Index. It screens for tobacco, alcohol, gaming, military weapons, nuclear power, employment diversity, product safety issues and environmental practices (Perryman, 1997). SRI rose to USD 3 trillion in 2000. It has been observed that socially responsible funds tend to regularly outperform established benchmarks like the Standard & Poor's 500 and the Morgan Stanley World Index (Less, 2001).

One of the reasons cited for SRIs outperforming these indices is that fund managers expect lower erosion of firm values owing to litigation and other regulatory costs associated with firms that invest in green technology. Based on the one-year returns for the one-year period ending June 30, 1998, 17 of the 50 socially responsible domestic growth funds were ranked in the top quartile of all the funds.[1]

One of the leading ecological funds, the Jupiter Ecology Fund launched in January 1988- has given a 240 per cent return till February 2005. (source: newsletter Jupiter Ecology Funds, March 2005). Another leading mutual fund specializing in selecting green stocks, Sierra Club Stock Fund, introduced in January 2003, produced a 32.02 percent return for investors last year. The fund’s benchmark, the Standard & Poor's 500 Index, rose 26.38 percent in 2003 (Baker 2004). The popularity of green funds is not limited to USA or Europe alone. In 2004, some of the Asian markets saw green technology transitioning from foreign imports to domestic products (Brown, 2004). The popularity of green funds can be seen from the fact that lately “green hedge funds” are on the rise (Fusaro, 2005).

However, it is not always that green funds outperform the market or importantly picks up firms in its portfolio which has invested in green technology. In a recent article published in Fortune a concern is raised regarding whether feel-good mutual funds deliver less than they promise? "(A)ssets of SRIs are growing slightly faster than the mutual fund industry as a whole --- up by 156 per cent over the past five years, to $31.9 billion, according to fund analyst Lipper. But critics, led by Paul Hawken, the author, environmentalist, and entrepreneur, say that the idea of "socially responsible investing" (SRI) has been stretched so far that it has become meaningless. In a blistering 35-page report that has roiled the SRI world, Hawken and his Natural Capital Institute say the industry has "no standards, no definitions, and no regulations other than financial regulations." Paul Hawken, another leading environmentalist and entrepreneur surveyed more than 600 SRI funds, most in Europe and Asia, and found that some held shares in Exxon Mobil, Wal-Mart, Halliburton, and Altria--companies often criticized by interest groups. Other major holdings of SRI funds include Microsoft, General Electric, and Citigroup. "The cumulative investment portfolio of the combined SRI mutual funds," Hawken says, "is virtually no different than the combined portfolio of conventional mutual funds".[2]

The above evidence suggests that green fund, if properly, certified can be value enhancing. The paper investigates the effects of the operation of green funds on the efficiency of investment made by firms in developing the environment. Growing environmental awareness has meant that more and more people are willing to pay a higher price for more environmentally friendly products. This should result in a market mechanism where consumers in favour of cleaner products discard polluting firm products, increasing the profitability of clean firms at the expense of dirty firms. This, in turn should be reflected in the relative valuation of these firms in the capital market.

However, there is a severe lack of information among the consumers regarding the exact nature of the clean technology being employed by a producer. They have to depend on sporadic and infrequent reports, news and investigations by governmental and non-governmental organisations before they know about the polluting nature of firms. The market response to this gap between the demand for value enhancing information and its supply has been the establishment of various funds that specialise in identifying the "greener" firms. The obvious question is whether in environmental matters, such a market response can improve environmental efficiency.

The first theoretical model showing the effects of consumers' willingness to pay on overall efficiency and on optimal environment policy was analysed by of Arora and Gangopadhyay (1995). Some more recent papers are by Cremer and Thisse (1999), Bansal and Gangopadhyay (2001, 2002). Empirical evidence of such behaviour among consumers have been studied by Arora

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[1] http://www.socialinvest.org/Areas/Research/Other/CDA-GoodGreen.htm

and Casson (1995), Konar and Cohen (1997), Segerson (1998) and Khanna and Damon (1999). Hamilton (1995), Lanoie and Laplante (1997), Lanoie, Laplante and Roy (1998) have studied the response of developed capital markets to green versus dirty firms. A more recent paper by Dasgupta and Laplante (2001) studies the importance of capital markets in separating the green from the dirty firms, in developing economies where environmental protection and the enforcement of laws is weak at best.

The major problem running through these papers is the imperfect nature of the information mechanism. Knowing the true impact on the environment of a production process requires specialised skill and specific resources that are too difficult for an individual investor in the capital market. This is where funds can step in and use technology experts and portfolio managers to pick out the green *and* valuable firms. Given asymmetric information, for the mechanism to work, the nature of fund activity and the identification technology they employ become very significant.

In this paper, we allow for a less than perfect technology with the fund managers and allow for different market structures within which the green funds operate. Our focus is on whether they have an impact on the efficient investment in environment activities by firms who know that making it to the portfolio of such a fund is a certificate to higher value in the capital market.

Our major conclusion is that without such fund activity in the capital market, firms will have less incentive to improve the environment even if consumers are willing to reward them with higher value. This is because environmentally friendly firms have no credible mechanism to signal their type. A fund manager provides this third party approval that allows investors to pass on a higher value to the firms. However, the market structures in which the funds operate have an important bearing on the degree of extra efficiency achieved by the funds. In general, competition among funds can lead to over-investment in the environment.

## 2. The Model

There is a continuum of firms in $[0,1]$, with each firm producing value $v$. There are also, a large number of small investors who together have enough resources to fund all firms. A firm can spend an additional amount of resource $k$ to improve the environment, by an amount $b$, where $0 \le b \le 1$. This environment productivity differs across different firms. Each firm knows the extent of its own

[2] http://www.asria.org/news/press/1109129292

productivity, the value of its $b$, and everyone knows the distribution of this productivity, $F(b)$, across the firms.

**A.1:** $F(b)$ *is uniform over* $[0,1]$.

The interpretation of $b$ is the additional money value the investors would have ascribed to a firm that improves the environment, had they known the value of $b$. In that case, the firm would be valued in a market with environmentally aware investors as $v-k+b$. All firms with $b \geq k$ will then prefer to make the investment in environment. However, the problem is that neither $k$, nor the firm's $b$, is observable by the small investor. While it is easy to justify why $b$ is not observed by the small investor, one also needs to explain why is $k$ not openly observed. This is because, even if the firm announces its investment in $k$, unless the environmental productivity is observed, the investor cannot be sure that the firm has actually made the investment. In other words, it is not possible to figure out from the (firm) accounting process, whether the firm manager made the investment for improving the environment or for the extraction of private benefit. Thus, even if the outside investor observes the $k$, it does not accept that the investment was made for the environment.

There is a fund manager, $G$, who has the technology to collect information on the firm's investment in $k$, as well as to infer, with possibly some error, the value of its $b$. Since investors are willing to pay more to firms that improve the environment, the fund manager can provide value to the firm, and investors, by picking up the shares of firms that have a positive impact on the environment. After identifying the firms that have invested $k$ in improving the environment, $G$ ascertains the impact of the firm on the environment. For those firms that do not invest $k$, $G$ knows that their contribution to the environment is zero.

Consider a firm who has invested $k$, and has environment productivity $\hat{b}$. Since the condition in A.1 is common knowledge, $G$ knows that $0 \leq \hat{b} \leq 1$. The technology that $G$ has allows it to narrow down the range of possible values of $\hat{b}$. The "informative ness" of this technology is measured by an error parameter $e$. Thus, in trying to observe the true value of $\hat{b}$, the technology throws up two numbers $l, u$ as the lower- and upper-most values of $\hat{b}$, respectively. In general, for any $b$, given $e$, we will denote $l = l(b,e)$ and $u = u(b,e)$. For the technology to be consistent with the given distribution of environment productivity, we must ensure that the revised range of $b$ satisfies $0 \le l(b,e) \le b \le u(b,e) \le 1$. Throughout the paper we will assume a specific functional form for $l$ and $u$ that guarantees this possibility.

**A.2:** $l(b,e) = eb$ *and* $u(b,e) = 1 - e(1-b)$.

As $e$ increases, the range $u(b,e) - l(b,e) = 1 - e$, within which $b$ is expected to lie, falls. If the technology is fully revealing, the range of possible values of $b$ will collapse to a single point, namely $b$ itself. Observe that this will be the case when $e = 1$. Alternatively, if $e = 0$, the technology is totally uninformative, since the updated range of $b$, even after the application of the fund manager's technology is $1$. Given A.1, the technology is, then, totally uninformative. We will assume that $e$ is a given parameter.

Recall that, investors know that a firm can improve the environment by an investment $k$. They, however, do not observe this investment, nor do they know the (environmental) productivity of each firm $b$. It is here that $G$ can play the role of a "certifying agency", by ensuring that it sells the papers of those firms whose contribution to productivity is above a certain value. Since consumers are environmentally aware and rational, they know that efficiency demands that all firms with $b \ge k$ should invest in the environment. Therefore, the information they need from $G$ is that the firm has productivity $b \ge k$ and that it has invested. If a firm with productivity lower than the cost of the investment invests, then the value of the firm falls below $v$ and it is better off not investing. Thus, even though $G$ will not know the exact value of $b$, it will have to ensure as accurately as possible that the firm has $b \ge k$. The problem is that $G$ can identify a firm's environmental productivity only approximately.

We define the probability, $p$, of a firm being accepted by $G$ as

(1) $$p(b,e) = \min\left\{ \max\left[ \frac{F(u(b,e)) - F(k)}{F(u(b,e)) - F(l(b,e))}, 0 \right], 1 \right\}$$

Observe that this is nothing but the probability that $G$ reads $b$ as being more than $k$, given the technology, which reduces the spread of $b$ to be the range $u(b,e) - l(b,e)$. This is the probability that $b \ge k$, conditional on the information obtained from the technology that $l(b,e) \le b \le u(b,e)$. If $k$ is high and $b$ is low, then it is possible that, $u(b,e) < k$. This, in turn, would imply that the maximum value of $b$ is less than $k$. Then $G$ will pick this firm with probability zero. On the other hand, if the firm's actual productivity is very high, so that $l(b,e) > k$, then the probability of this firm being in the fund's portfolio is 1, if it has made the environmental investment. Since the technology is common knowledge, so is equation (1).

The fund manager $G$ buys a firm at a price $v_F$ and sells it to investors at a price $v_I$. The spread between $v_F$ and $v_I$, if any, is the profit made by $G$, per firm. If a firm invests in the environment, with probability $p$ it will get $v_F$ and with probability $(1-p)$ it will get a value $v_0$, where $v_0$ is the price investors are willing to pay for a firm not sold by $G$. Investors do not observe whether the fund manager rejects the firm because its productivity is low, or whether its investment was for private benefits. Thus, whatever is the value of $v_0$, it has to be the same as the value a firm will get by not investing in the environment at all. This is driven mainly by the fact that the technology is such that $p < 1$. A firm will invest in the environment, if

(2) $$p(b,e)v_F + [1-p(b,e)]v_0 - k \geq v_0 \Rightarrow p(b,e) \geq \frac{k}{v_F - v_0} \equiv \frac{k}{\alpha}$$

where $\alpha$ can be interpreted as the premium enjoyed by a firm that has been picked as a green firm. Let $\tilde{b}$ be such that $p(\tilde{b},e) = k/\alpha$. Then, all firms with $b \geq \tilde{b}$ will invest the amount $k$, while those with $b < \tilde{b}$ will not. Recall that a firm not investing in the environment will never be picked by $G$. From equation (1) and A.1, if $l(b,e) < k < u(b,e)$, then $p(b,e) = [1-e(1-b)-k]/(1-e)$. Therefore, a firm will be picked up by $G$ with probability $p(b,e)$, where

(3) $$p(b,e) = \begin{cases} 1 & \text{if } 1 \geq b \geq k/e \\ \dfrac{1-e(1-b)-k}{1-e} & \text{if } k/e > b \geq \tilde{b} \\ 0 & \text{if } \tilde{b} > b \geq 0 \end{cases}$$

Equation (3) uses A.1, equation (1) and assumes that $1 \geq k/e$, that is, the precision of the technology, measured by $e$, is large enough ($e \geq k$). If, on the other hand, $e < k$, we have

(3a) $$p(b,e)=\begin{cases}\dfrac{1-e(1-b)-k}{1-e} & if\ \ 1\geq b\geq \tilde{b}\\ 0 & if\ \ \tilde{b}>b\geq 0\end{cases}$$

Clearly, (3) is more general than (3a), so we will use equation (3) throughout the paper.

For all $b\in[\tilde{b},k/e]$, we can rewrite (2) as

(4) $$\frac{1-e(1-b)-k}{1-e}\geq\frac{k}{\alpha}$$

Recall that $\tilde{b}$ is the value of $b$ where (4) holds with equality. The important thing to note here is that, $\tilde{b}$ could actually be less than $k$. This problem is in addition to the fact that some firms who are contributing their fair share to the environment may not be rewarded fully, since their probability of being picked by $G$ is less than $1$.

The total value of the portfolio held by $G$, can be written as:

(5) $$V=\int_{\tilde{b}}^{k/e}\frac{1-e(1-b)-k}{1-e}[v+b-k]dF(b)+\int_{k/e}^{1}[v+b-k]dF(b)$$

The first term on the right hand side of (5) is the expected value of the part of the portfolio that contains firms whose probability of being picked is less than one. The second term contains those firms who will definitely be picked by $G$. While the investors may know that $G$ has only firms whose $b\geq\tilde{b}$ and who have invested in the environment, they know nothing more about the firm being sold by the fund manager. They will, therefore, compute the average value of a firm being sold by $G$ as follows:

(6) $$v_I=\frac{\int_{\tilde{b}}^{k/e}\frac{1-e(1-b)-k}{1-e}[v+b-k]dF(b)+\int_{k/e}^{1}[v+b-k]dF(b)}{\int_{\tilde{b}}^{k/e}\frac{1-e(1-b)-k}{1-e}dF(b)+\int_{k/e}^{1}dF(b)}$$

where, the denominator in (6) is the measure of firms in the fund manager's portfolio. Observe that the measure of firms is not $(1-\tilde{b})$, but less than that since some of the firms from this group have been rejected by the errors made by the technology.

The investor does not know why a firm is not in the fund manager's portfolio. If its $b<\tilde{b}$, it has not invested anything in the environment and, hence, its value should be $v$. If, on the other hand, its $b$ was more than $\tilde{b}$, but less than $k/e$, its value to the investor is $v+b-k$. A firm with $b \geq k/e$ can never be outside the portfolio of $G$ --- if it has made the environmental investment it will be picked with probability 1 and its (sure) return is greater, by an amount $\alpha$, than what it gets if it does not invest in the environment. Hence, we have,

$$(7) \qquad v_0 = \frac{\int_0^{\tilde{b}} v dF(b) + \int_{\tilde{b}}^{k/e} [v+b-k]\left[1-\frac{1-e(1-b)-k}{1-e}\right]dF(b)}{\int_0^{\tilde{b}} dF(b) + \int_{\tilde{b}}^{k/e}\left[1-\frac{1-e(1-b)-k}{1-e}\right]dF(b)}$$

Equations (6) and (7) can be rewritten as

$$(8) \qquad v_I = v-k+\frac{\int_{\tilde{b}}^{k/e} p(b,e) b dF(b) + \int_{k/e}^{1} b dF(.)}{\int_{\tilde{b}}^{k/e} p(b,e) dF(b) + \int_{k/e}^{1} dF(.)} = v-k+\frac{\left(\frac{1-\tilde{b}^2}{2}\right)-\left(\frac{1}{1-e}\right)\int_{\tilde{b}}^{k/e} b(k-eb)dF(b)}{(1-\tilde{b})-\left(\frac{1}{1-e}\right)\int_{\tilde{b}}^{k/e}(k-eb)dF(b)}$$

and

$$(9) \qquad v_0 = v-k+\frac{k\int_0^{\tilde{b}} dF(b) + \int_{\tilde{b}}^{k/e}[1-p(b,e)] b dF(b)}{\int_0^{\tilde{b}} dF(b) + \int_{\tilde{b}}^{k/e}[1-p(b,e)]dF(b)} = v-k+\frac{k\tilde{b}+\left(\frac{1}{1-e}\right)\int_{\tilde{b}}^{k/e}(k-eb) b dF(b)}{\tilde{b}+\left(\frac{1}{1-e}\right)\int_{\tilde{b}}^{k/e}(k-eb)dF(b)}$$

We complete the model description by calculating the profit, $\pi$, of the (monopolist) fund manager. For each firm in its portfolio, it pays out a value $v_F = v_0 + \alpha$ and sells it at a price

$v_I$ to the investors. Its profit, therefore, is $(v_I - v_0 - \alpha)$ times the measure of the firms in its portfolio. Thus,

(10) $$\pi = (v_I - v_0 - \alpha)\left[(1-\tilde{b}) - \int_{\tilde{b}}^{k/e} \frac{k-eb}{1-e}\, dF(b)\right]$$

Before completing this Section, for completeness, let us mention what happens to equations (8) to (10), for the case when $k/e \geq 1$. Recall that then we will need to use equation (3a) rather than (3) for our calculations. The only difference is that the upper limit on the integrals in these equations changes from $k/e$ to $1$.

## 3. Properties of the Model

In this Section, we list some basic properties of the model. In particular, we distinguish between the cases when the fund manager's technology is perfect, or fully truth revealing, and when it is not. Our purpose is to demonstrate that many of the problems that arise in this paper are largely due to the imperfection in the technology, i.e., because $e < 1$. On the other hand, there are some issues that can be handled even when the technology is imperfect.

**Proposition 1:** *Let A.1 and A.2 hold and the audit technology be perfect, i.e.,* $e = 1$.

*(a) Let* $\alpha \geq k$. *Then, every firm in the fund manager's portfolio satisfies* $\tilde{b} \geq k$ *and, all firms with* $b \geq \tilde{b}$ *are included in the fund's portfolio. Moreover,* $\tilde{b} = k$ *and firms outside the portfolio will have a price* $v_0 = v$.

(b) *If* $\alpha < k$, *no firm invests in the environment.*

**<u>Proof:</u>** One can prove this Proposition directly, without having to evaluate the equations of the previous section as $e \to 1$.

(a) From the description of the technology in A.2, if $e = 1$, then $l(b,e) = u(b,e) = b$, and from equation (1), this implies that $p(b,e) = 1$ for all $b \geq k$, and $p(b,e) = 0$ for all $b < k$. With $\alpha \geq k$, this in turn implies that equation (2) is satisfied for all $b \geq k$. Thus all such firms will invest in the environment and be picked up in the fund with probability $1$. On the other hand, all firms with $b < k$ will be rejected with probability 1. Together, they imply that $\tilde{b} = k$. Observe that all firms with $b < k$ will have no incentive to invest in the environment. Investors will be aware of this and be unwilling to pay anything above $v$ for these firms.

(b) With $\alpha < k$, equation (1) is never satisfied for any firm and this is true for all values of $e$ in the range $0 \le e \le 1$. Thus, no firm will invest in the environment. □

The result is straightforward. It, however, emphasises the point that a perfect technology will ensure that one type of error is never committed, i.e., the fund manager's portfolio contains all firms that have a positive impact on the environment. This, in turn implies that the first best efficient level of investment in the environment can always be obtained by setting $\alpha \ge k$, whenever $e = 1$. Then we will have all, and only those, firms whose environment productivity is greater than the cost, investing in the environment. Firms whose productivity is too low ($b < k$) will not invest. The next Proposition states that efficiency can be attained even when $e < 1$.

**Proposition 2:** *Let A.1 and A.2 hold and the audit technology be less than perfect, i.e.,* $0 < e < 1$. *The first best can be achieved by setting* $\alpha = k/[1-k]$.

**Proof:** We first observe that, given $\alpha$, one can ensure that $\tilde{b} = k$, regardless of the value of $e$. Writing (4) with the equality sign, we can solve for $\tilde{b}$ as follows:

$$\tilde{b} = \frac{1}{e}\left[\left(\frac{k}{\alpha} - 1\right)(1-e) + k\right] \tag{11}$$

Setting $\tilde{b} = k$ in equation (11), we get $\alpha = \dfrac{k}{1-k}$. Then, we will have all $b \ge k$ investing in the environment and all those with $b < k$ not investing. This, we know is the efficient outcome. □

Proposition (2) gives us a useful insight. Equation (11) tells us that

$$\frac{\partial \tilde{b}}{\partial \alpha} = -\frac{1}{\alpha^2}(1-e) < 0$$

From Proposition 1(b), we know that for the fund manager to play any role, she must offer $\alpha \geq k$ to be able to operate in the market. From Propositions 1 and 2 and the description of $\tilde{b}$, we now know that whenever $k \leq \alpha < [k/(1-k)]$, $\tilde{b} > k$. Alternatively, $\tilde{b} \leq k$ for all $\alpha \geq [k/(1-k)]$. This implies that, if the fund manager offers too high a $\alpha$, it will have encourage even those firms which should not invest in the environment to do so. Thus a high premium to environmentally friendly firms not only reduces the margin of profit per firm (see equation (10)), it also destroys the credibility of the fund manager's claim that it only has firms in its portfolio that satisfy $b \geq k$. The optimal $\alpha$ the fund manager offers will be obtained by maximising $\pi$ and, indeed, it can be shown that there can be no guarantee that the efficient value of $\alpha$ will also maximise $\pi$, unless $e = 1$.

**Proposition 3:** *Let A.1 and A.2 hold, $k < e < 1$ and, $\alpha = k/[1-k]$. Then, $v_0$ is decreasing, and $v_I$ is increasing, in $e$.*

__**Proof:**__ Observe that, we can write equation (8) as

$$v_I = v - k + 1 - \frac{\frac{(1-\tilde{b})^2}{2}}{1 - \tilde{b} - \int_{\tilde{b}}^{k/e} \left(\frac{1}{1-e}\right)(k - eb)dF(b)} \tag{12}$$

From the proof of Proposition 2, we know that, given the conditions in this Proposition, $\tilde{b} = k$. The fact that $k < e < 1$, implies that the relevant equations for $v_I$ and $v_0$ are (8) and (9), respectively.[3] Evaluating the right-hand-side of (12) using A.1, we have

$$v_I = v - k + 1 - \frac{\frac{(1-k)^2}{2}}{(1-k) - \frac{1}{2}k^2 \frac{1-e}{e}}$$

As $e$ rises, $\frac{1-e}{e}$ falls and so, $v_I$ rises. Similarly, writing equation (9) as

(13) $$v_0 = v - k + 1 - \frac{\tilde{b}(1-k)}{\tilde{b} + \int_{\tilde{b}}^{k/e} \left(\frac{1}{1-e}\right)(k - eb)dF(b)},$$

plugging in $\tilde{b} = k$ and evaluating the integral, we have $v_0$ decreasing in $e$. □

Observe that, equations (12) and (13) depend only on the fact that $k < e < 1$ and not on how $\tilde{b}$ and $k$ are related. Indeed, if $k \geq e$, it is immediate that the expressions in (12) and (13) simply have 1 in place of $k/e$. Thus, (12) and (13) are the general equations for the value of the average firm in the portfolio of $G$ and that of those outside it, respectively. The average value of the firms in the entire industry, $\bar{v}$, can be defined as the expected value of all firms in this industry. Let $m_G$ be the measure of firms in the portfolio of $G$, and $(1-m_G)$ those outside it. Then,

(14) $$\begin{aligned}\bar{v} &= \left[v - k + 1 - \frac{\tilde{b}(1-k)}{1-m_G}\right](1-m_G) + \left[v - k + 1 - \frac{\left[1-\tilde{b}\right]^2/2}{m_G}\right]m_G \\ &= v - k + 1 - \frac{2\tilde{b}(1-k) + (1-\tilde{b})^2}{2}\end{aligned}$$

It is immediate that $\left[\partial\bar{v}/\partial\tilde{b}\right] = k - \tilde{b}$, implying that the value of the average firm in the industry is maximised at $\tilde{b} = k$, which is, indeed, the first best.

## 4. Competing Funds

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[3] The Proposition is also true when $e \geq k$.

So far we have restricted our focus on a monopolist fund manager. We now assume that there are two green funds, $G_1$ and $G_2$, with precision $e_1$ and $e_2$, respectively. Without any loss of generality, we will assume that $e_1 \geq e_2$.

In the previous section, with one fund, the fund manager drove a wedge between her buying and selling price for each firm. There is no reason why there should be only one fund manager, but analysing that case gave us some useful insights, which we will now use this section. Since there are two fund managers, we will have to describe the process of allocation of the firms between the two funds. We assume the following steps. First, a firm applies to a fund, depending on who offers the firm the better expected value (probability of acceptance times the premium offered). The fund manager first checks to make sure that the firm has invested the amount $k$ for environmental purposes. As before, we will assume that if the firm has not invested $k$, then the fund manager does not include it in its portfolio. Among all the firms that have invested $k$ and in addition has applied to the fund manager, the manager checks out its environmental productivity $b$ and, with some probability certifies that $b \geq k$. If rejected, the investor has no information about the firm. For a firm to be in the portfolio of $i, i = 1,2$, not only must the fund accept that the firm's $b$ is above $k$, the firm must also make the application to $i$ (rather than to $j$, $i \neq j$). Thus, in addition to $p(b, e_i)\alpha_i \geq k$, we also need that $p(b, e_i)\alpha_i \geq p(b, e_j)\alpha_j$.

**Proposition 4:** *Let A.1 and A.2 hold, with* $k < e < 1$*. If* $e_1 = e_2 = \bar{e}$ *then for both funds to operate, each must make zero profit.*

**<u>Proof:</u>** Since $e_1 = e_2$, we know that for all $b$, $p(b, e_1) = p(b, e_2)$. If $\alpha_i > \alpha_j$, then for all $b$ who make the investment, $p(b, e_i = \bar{e})\alpha_i > p(b, e_j = \bar{e})\alpha_j$, and $j$ will attract no firm. Thus, for both funds to operate, we must have $\alpha_1 = \alpha_2$. But then, firms will randomly allocate themselves to 1 and 2, and so, each will get half of all firms with $b \geq \tilde{b}$ coming to it. So, if we denote $m_i$ as the measure of all firms in the portfolio of $i, i = 1,2$, then

$$m_1 = m_2 = (1/2)\left[1 - \tilde{b} - \int_{\tilde{b}}^{k/\bar{e}} \left(\frac{1}{1-\bar{e}}\right)(k - \bar{e}b)dF(b)\right].$$

If $\pi_i$ is the profit of fund $i$ then, $\pi_i = [v_I - v - \alpha]m_i$. Let $\pi_i > 0$. Then any one fund, by offering $v_F = v_0 + \alpha + \varepsilon$, will ensure that all firms come to it and thus, will have a total measure of firms $2m_i$. For $\varepsilon$ small and positive, this new profit will be higher than $\pi_i$. Thus, in equilibrium, they cannot be making positive profit. □

This Proposition implies that, it is unlikely that $\tilde{b} = k$, when we have two fund managers with the same precision. Let us see why this is so. Suppose that $\pi$ in equation (10) is positive. We know from Section 3 that, $\tilde{b} = k$, only if $\alpha = k/(1-k)$. If both funds have the same $e$, and set $\alpha = k/(1-k)$, then each will get a profit $0.5\pi$. This will encourage them to increase $\alpha$, as argued in Proposition 4. This, in turn, will imply that $\tilde{b} > k$. Thus, the only time we will have $\tilde{b} = k$, is if the parameter values were such that $\pi = 0$.

**Proposition 5:** *Let A.1 and A.2 hold, with $k < e < 1$. If $e_1 > e_2$ then for both funds to operate, $\alpha_2$ must be at least as much as $\alpha_1$.*

**<u>Proof:</u>** Note that $p(b,e)$ is increasing in $e$ for all values of $k/e \geq b \geq k$, and $p(b,e) = 1$ for $1 \geq b \geq k/e$. Therefore, with $e_1 > e_2$, $p(b,e_1) > p(b,e_2)$. Suppose $\alpha_1 > \alpha_2$. Then, we have $p(b,e_1)\alpha_1 > p(b,e_2)\alpha_2$ for all firms with $b \geq k$. Therefore, all firms with $b \geq k$ will be in the portfolio of $G_1$. The consumers will correctly infer this and will not invest in any firms who belong to the portfolio of $G_2$. This, in turn, implies that no firm will apply to $G_2$. Thus $G_2$ cannot operate.

The above proposition implies that, if $k < e_2 < e_1 < 1$, for both the funds to operate, it must be the case that $\alpha_2 \geq \alpha_1$. For all $b \geq k$, define $\Pi_i = \alpha_i p(b,e_i)$. Thus $\Pi_i$ is the expected profit earned by the firm if it is in the portfolio of $G_i$. Therefore,

$$\Pi_1 = v_0 - k + \begin{cases} \dfrac{1-e_1(1-b)-k}{1-e_1}.\alpha_1 & if \;\; k/e_1 \geq b \geq k \\ \alpha_1 & if \;\; 1 > b \geq k/e_1 \end{cases}$$

$$\Pi_2 = v_0 - k + \begin{cases} \dfrac{1-e_2(1-b)-k}{1-e_2}.\alpha_2 & if \;\; k/e_2 \geq b \geq k \\ \alpha_2 & if \;\; 1 > b \geq k/e_2 \end{cases} 0.$$

Note that, $\Pi_1 > \Pi_2$ for $b = k$ and for $b \geq k/e_1$. Therefore, for both the funds to operate profitably in the market, it must be the case that $\exists b \in [k, k/e_1]$ such that $\Pi_1 \leq \Pi_2$. In other words, there should be a positive measure of firms with $b \geq k$ that finds it profitable to apply to $G_2$. Further, observe that, both $\Pi_1, \Pi_2$ are increasing in *b* for $b \leq k/e_1$ while $\Pi_1$ is constant and $\Pi_2$ is increasing in *b* for $k/e_1 \leq b \leq k/e_2$. This suggests that, there are two intersection points between $\Pi_1$ and $\Pi_2$. Let $b_l, b_u$ denote the firms who are indifferent between applying to either $G_1$ or $G_2$ (see figure 1).

Therefore,

$$b_l = 1 - \frac{(1-k)[\alpha_1(1-e_2) - \alpha_2(1-e_1)]}{\alpha_1 e_1(1-e_2) - \alpha_2 e_2(1-e_1)}$$

$$b_u = 1 - \frac{(1-k)\alpha_2 - \alpha_1(1-e_2)}{\alpha_2 e_2}$$

The measure of firms that apply to $G_1$ is $b_u - b_l$, while the remaining firms, who has invested *k* will apply to $G_2$. The measure of all such firms that apply to $G_2$ are $1 - b_u + b_l - \tilde{b}$, where

$$\tilde{b} = \frac{1}{e_2}\left[\left(\frac{k}{\alpha_2} - 1\right)(1-e_2) + k\right].$$

Denote $\pi_i$ as the expected profits earned by $G_i$. Therefore,

$$\pi_1 = (v_I - v_0 - \alpha_2)[b_u - b_l] \quad \text{and} \quad \pi_2 = (v_I - v_0 - \alpha_1)[1 - b_u + b_l - \tilde{b}]$$

The portfolio managers, $G_1$ and $G_2$ choose $\alpha_1$ and $\alpha_2$ respectively to maximize their expected profits. Denote $\alpha_i^*$ as the optimal choice of $\alpha_i$ by $G_i$. The relevant conditions are,

(15.1) $$\alpha_1^* = \arg\max_{\alpha_1} (v_I - v_0 - \alpha_1)[b_u(\alpha_1, \alpha_2^*) - b_l(\alpha_1, \alpha_2^*)]$$

(15.2) $$\alpha_2^* = arg\,max_{\alpha_2}(v_I - v_0 - \alpha_2)[1-(b_u(\alpha_1^*,\alpha_2) - b_l(\alpha_1^*,\alpha_2)) + \tilde{b}(\alpha_2)]$$

(15.3)

$$\int_{\tilde{b}}^{b_l} \frac{1-e_2(1-b)-k}{1-e_2}[b-k]dF(b) + \int_{b_u}^{k/e_2} \frac{1-e_2(1-b)-k}{1-e_2}[b-k]dF(b) + \int_{k/e_2}^{1}[b-k]dF(b) \geq 0$$

The constraint (15.4) guarantees that the investors will invest in a firm that is in the portfolio of $G_2$. Observe that, as $e_2$ is observable, the investors can correctly compute the average value of the firm, $v_I$ sold by $G_2$. Note that,

$$v_I - v = \frac{\int_{\tilde{b}}^{b_l} \frac{1-e_2(1-b)-k}{1-e_2}[b-k]dF(b) + \int_{b_u}^{k/e_2} \frac{1-e_2(1-b)-k}{1-e_2}[b-k]dF(b) + \int_{k/e_2}^{1}[b-k]dF(b)}{\int_{\tilde{b}}^{b_l} \frac{1-e_2(1-b)-k}{1-e_2}dF(b) + \int_{b_u}^{k/e_2} \frac{1-e_2(1-b)-k}{1-e_2}dF(b) + \int_{k/e_2}^{1}dF(b)}$$

The investor will invest in any firm that is sold by $G_2$ if $v_I \geq v$. Condition (15.4) guarantees this. Any $\alpha_1^*, \alpha_2^*$ that satisfy (15.1)-(15.4) will be candidates for equilibrium.

The above equilibrium has interesting properties. One, the market can simultaneously support two different fund managers although one fund manager has a perfect technology. Two, the market is divided among the two fund managers in the following way. The fund manager that has a more efficient technology, gets applications from only those firms that are profitable. However, none of the extremely profitable firms (i.e., the ones with it yield $b \geq b_u \geq k$ ) apply to it. The extremely profitable firms as well as some of the non profitable firms (i.e., the ones with $k \geq b \geq \tilde{b}$ ) apply only to the fund manager that has a less precise technology.

## 5. Conclusion

In this paper we consider the role played by funds that keep only environmentally friendly firms in its portfolio. There are two major issues that we investigate. First, we allow an imperfect detection technology. That is, the technology employed by fund managers to identify "green" firms is inaccurate. Both types of errors are possible. Firms which should not invest in the environment because their costs are greater than the (money value of the) benefits they produce may do so and end up in the fund manager's portfolio. Alternatively, firms that have a positive impact on the environment may not be picked up by the fund.

Second, we check the effect of green funds on the efficiency of investment in the environment. In particular, we investigate which one of the two errors is more sensitive to market structure faced by green funds.

It is easier for a monopoly green fund to ensure that no unnecessary investment in the environment is made. With competitive funds, vying with each other, it may become impossible to prevent socially inefficient firms sneaking into the portfolio of fund managers. This is not the result of moral hazard on the part of the fund managers, but more a result of the imperfect technology of detection and the competition among funds.

We then analyze the effect of competing fund managers. We show that, if the fund managers have identical precision levels, then both of them would make zero profits. However, both the fund mangers can operate profitably in the market even if one of them has a perfect technology of identifying true firm values while the other has imperfect technology. We show that, the fund managers share the market with the one having the perfect technology, getting moderately profitable firms. The fund manger who has an imprecise technology, has in his clientele, firms that are highly profitable as well as some who are unprofitable.

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Figure 1