The Effect of Green Investment on Corporate Behavior

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Abstract

This paper explores the effect of exclusionary "ethical investing" on corporate behavior in a risk averse, equilibrium setting. While arguments exist that ethical investing can influence a firm's cost of capital, and so affect investment, no equilibrium model has been presented to do so. We show that exclusionary ethical investing leads to "polluting" firms being held by fewer investors since "green" investors eschew polluting firms' stock. This lack of risk-sharing among "non-green" investors leads to lower stock prices for polluting firms, thus raising their cost of capital. If the higher cost of capital more than overcomes a cost of reforming (i.e., a polluting firm cleaning up its activities), then polluting firms will become socially responsible because of exclusionary ethical investing. A key determinant of the incentive of polluting firms to reform is the fraction of funds controlled by green investors. In our model, empirically reasonable parameter estimates indicate that more than 20% green investors are required to induce any polluting firms to reform. Existing empirical evidence indicates that at most 10% of funds are invested by green investors.

1 Introduction

The concept of *ethical investing* has received considerable attention and has led to the formation of different forms of *ethical* mutual funds. Organizations, such as the Social Investment Forum in the United States, and the Social Investment Organization in Canada, promote *socially responsible investing* (SRI). The Social Investment Forum, for example, has stated that approximately 10% of American investments is managed under SRI guidelines.[1] Much of this money is in the form of private investments of wealthy individuals, charities and private pension plans.

The definitions of SRI can vary greatly. Many are exclusionary, in that the strategies aim to screen out socially irresponsible investments. This might mean avoiding firms producing nuclear weapons, or it could include not holding US Government T-bills or bonds that might be financing clandestine operations. In 1989 the Social Investment Forum introduced CERES, the Coalition for Environmentally Responsible Economies. The ideals of CERES are reflected in the Valdez Principles, which cover such things as sustainable use of natural resources, recyclcing, wise energy use, the marketing of safe products and protection of the biosphere. CERES receives voluntary reports from firms that adhere to the Valdez Principles, and CERES makes these reports available to interested investors.

We abstract here from the difficulties in defining SRI, and focus on the objectives of ethical investors. Is the reward from excluding particular stocks from one's portfolio simply the satisfaction obtained from not participating in the economic returns to "irresponsible social behavior"? Or, is the restricted investment a type of *boycott*, designed to induce firms to act appropriately?

While we cannot measure the utility obtained from the former goal, we will attempt to assess, in a very simple model, the impact on corporate behavior of ethical investors' boycotting specific investments. Assume a simple world with two types of risk averse investors: *neutral* investors who will ignore ethical considerations in forming their optimal portfolios and *green* investors who refuse to invest in firms that do not meet their (identical) ethical criteria. We also assume a finite number of firms, each with one of two production technologies. Firms with a *clean* technology satisfy the

[1] See Hamilton, Jo and Statman (1993).

investing criteria of the green investors, while firms with a *polluting* technology will not be held in green investors' portfolios unless they act to "reform" their operations.

That is, green investors boycott, in an investment sense, unreformed firms with polluting technologies and this changes the risk sharing opportunities in the market. There are now fewer investors available to hold the stock of firms with polluting technologies, causing those share prices to fall to reflect that lost diversification.

We then allow firms with polluting technologies to make their technologies *acceptable* to green investors (i.e., *reform*), at a cost. Our most basic question is, will the presence of green investors cause firms to alter their corporate behavior, cleaning up their polluting technology? If so, then green investors' "ethical" behavior can be said to have economic impact.

If investors do have an impact on firms with polluting technologies, causing some of those firms to *reform*, then there will be three types of firms in the market: *acceptable* firms with clean technologies, *unacceptable* firms with unreformed polluting technologies and acceptable firms with *reformed* polluting technologies. Acceptable firms may be held by both neutral and green investors, while only neutral investors will hold unacceptable firms.

We assume that firms act to maximize share price. Holding the total number of investors constant, an increase in the number of green investors, who refuse to hold the stock of firms with unreformed polluting technologies, means that the smaller number of neutral investors demand a higher expected return to compensate them for having to hold more of the polluting firms than they would otherwise hold. The higher expected return results from the polluting firm's share price falling below an acceptable firm's share price. If the price differential exceeds the cost of converting a polluting technology from unacceptable to acceptable, then some firms with polluting technolgies will reform, broadening once again the risk sharing opportunities, and shrinking the stock price differential. Thus, for any given proportion of green investors in the economy, we can calculate the equilibrium proportions of acceptable and unacceptable firms in the economy, determined by individual firms acting to maximize share price.

We illustrate these phenomena in numerical examples for a wide range of parameter values.

Comparative statics are performed, both analytically and numerically. For example, we initially assume a fixed cost of reforming a polluting technology of 5% of the expected cash flow to the firm. If this cost is reduced to 1% of the expected cash flow, then even a small proportion of green investors will cause some firms to reform their polluting technology. On the other hand, we start our base case by assuming that there are equal numbers of clean and polluting technologies before green investors appear. This is optimal from a risk sharing perspective with no green investors. However, an interpretation of this assumption is that if a green investor appears, she would initially boycott 50% of the population of firms. Suppose we alter the starting distribution of technologies so that 75% are clean technologies before green investors appear. The risk sharing dislocation of this starting distribution of technologies is, however, much less disadvantageous to investors, so that converting technologies produces less diversification gain. With 75% starting clean technologies, we find there must be over 60% green investors before any firm reforms its polluting technology.

Existing research regarding SRI examines both the reasons for such strategies and the evidence about performance of these strategies. Investors may choose to restrict their investment to green companies or mutual funds in "a desire for an integration of money into one's self" (Hamilton (1993)). Alternatively, Wall (1995) argues, without an equilibrium model, that SRI can affect corporate investment by affecting the firm's cost of capital. However, he argues that such a result requires an inefficient capital market. We show such an effect while maintaining the assumption of an efficient capital market. Our model does not prescribe a motive for green investors, but rather estimates the impact that they may have acting for whatever reason they choose. Contrary to the existing literature, having an equilibrium model allows us to experiment with different parameter values to assess the potential impact of SRI.

Section 2 describes the model and its notation. The equilibrium and comparative statics are given in Section 3 and Section 4 provides a numerical example. We review others' investigations into the extent of green investing in Section 5, as well as review the evidence related to performance of green companies and mutual funds. Electing to "reform" in our model results from value-maximizing firms reacting to changes in investors' required rates of return (i.e., the firms' costs of capital). Section 6 provides a conclusion.

2 The Model

2.1 Firms

We assume a one-period world in which there exist three categories of firms: *acceptable* (A) firms satisfy the investing criteria of the green investors; *unacceptable* (U) firms do not satisfy green investors' criteria; *reformed* (R) firms previously did not satisfy green investors' creiteria, but have achieved acceptablility at a certain cost. All A firms have the same production technology and U and R firms share a common technology. That is, a firm that incurs a cost to switch from category U to category R retains its original production technology but takes some costly action that makes it acceptable to green investors. The total number of firms, N, consists of N_A acceptable firms, N_U unacceptable firms and N_R reformed firms.[2]

Each category A firm uses the clean technology and generates a normally distributed cash flow with mean μ_C and variance σ_C^2. The cash flows of A firms are perfectly correlated with each other. A firm of either category U or category R uses the polluting technology and generates a normally distributed cash flow with mean μ_P and variance σ_P^2. The cash flows of these firms are perfectly correlated with each other. The covariance between the cash flows of a category A firm and those of a category U or category R firm is σ_{CP}.

In addition to the risky production technologies, there also exists a riskless asset in perfectly elastic supply with a rate of return normalized to zero. Borrowing is allowed but short selling of shares is prohibited. The latter restriction is required because of the simplifying assumption that the cash flows of the U and R firms are perfectly correlated with each other.

2.2 Preferences

Investors differ in their tolerance of environmental damage. We assume that there are two investor types, $i \in \{g, n\}$. *Green* (g) investors refuse to hold shares in unacceptable firms. *Neutral* (n) investors, on the other hand, have no preference for one category of firm over the others. There are

[2]Throughout the paper we use the terms "socially responsible investing" (SRI) and "green investing" interchangably. In reality, there are many forms of SRI: green investing may focus exclusively on environmental concepts, while broader SRI can include health, labor and many other ethical issues.

I investors in total, consisting of I_n *neutral* investors and I_g *green* investors. Each investor exhibits constant absolute risk aversion (CARA) with risk tolerance parameter τ.

2.3 Firms' Choice of Acceptability

Firms are initially endowed with a technology such that, of the N firms, N_P firms have the polluting technology and N_C firms have the clean technology. Each of the firms with the polluting technology then has the opportunity to reduce the environmental damage caused by its technology, at a cost K (i.e., to become a *reformed* firm), making the firm eligible for inclusion in green investors' portfolios.[3] We assume that reformed firms retain their original risk-return characteristics.[4] We denote the number of originally polluting firms that spend K to become reformed by N_R. There are then three classes of firms: (i) $N_C = N_A$ original clean (therefore, acceptable) firms with risk and return σ_C and μ_C, (ii) N_U unacceptable polluting firms, with risk and return σ_P and μ_P and (iii) N_R reformed firms also with risk and return σ_P and μ_P. As mentioned, σ_{CP} denotes the covariance between the cash flows of the two technologies.

To summarize, the total N firms can be divided by technologies (clean, polluting) as:

$$N = N_C + N_P.$$

Alternatively, classifying firms by acceptability to green investors (acceptable, unacceptable, reformed) gives:

$$N = N_A + N_U + N_R.$$

Since clean firms are acceptable and reformed firms retain the polluting technology,

$$N_C = N_A$$

$$N_P = N_U + N_R.$$

[3] Our assumption that all firms face the same cost, K, and that reforming is an all-or-none choice will be discussed in Section 5.

[4] We have also solved for the equilibrium in which firms that reform take on the risk-return characteristics of the clean technology. This case is discussed in the conclusion.

3 Equilibrium

3.1 For Given Acceptabilities

The combination of normally distributed cash flows and CARA preferences yields the utility functions:

$$U_n = x_{nA}\mu_C + (x_{nU} + x_{nR})\mu_P - \frac{x_{nA}^2\sigma_C^2 + (x_{nU} + x_{nR})^2\sigma_P^2 + 2x_{nA}(x_{nU} + x_{nR})\sigma_{CP}}{2\tau}$$
$$-(x_{nA} - \omega_{nA})P_A - (x_{nU} - \omega_{nU})P_U - (x_{nR} - \omega_{nR})P_R \quad (1)$$

$$U_g = x_{gA}\mu_C + x_{gR}\mu_P - \frac{x_{gA}^2\sigma_C^2 + x_{gR}^2\sigma_P^2 + 2x_{gA}x_{gR}\sigma_{CP}}{2\tau}$$
$$-(x_{gA} - \omega_{gA})P_A - (x_{gR} - \omega_{gR})P_R \quad (2)$$

where:

- x_{ik} is the number of shares of firms of category k ($k = A, U, R$) held by a type i investor
- P_k is the price per share of a firm of category k
- ω_{ik} is the endowment of shares in firms of category k of a type i investor.

We now derive investors' optimal portfolio choices. Neutral investors allocate their wealth between unacceptable and clean firms. They do not find it optimal to hold reformed (i.e., type R) firms for the following reason. Firms endowed with a polluting technology will only invest K to become reformed if their share price subsequent to the investment exceeds that of unacceptable firms by the amount K. Since reformed firms have the same risk-return characteristics as unacceptable firms but a higher share price, neutral investors do not hold shares of type R firms. Thus, neutral investors optimize U_n with respect to x_{nA} and x_{nU} and optimally set $x_{nR} = 0$.[5]

[5]Because, in equilibrium, $P_R > P_U$, but both reformed and unacceptable firms have identical technologies (i.e., risk and return characteristics), the short selling constraint is binding for neutral investors. If short selling were

By contrast, green investors hold only acceptable and reformed firms, and so optimize over x_{gA} and x_{gR}.

Therefore, the first order conditions for a neutral investor's optimal portfolio holdings follow from taking the derivative of U_n with respect to x_{nA} and x_{nU}, and can be written as:

$$x_{nA}\sigma_C^2 + x_{nU}\sigma_{CP} - \tau(\mu_C - P_A) = 0 \tag{3}$$

$$x_{nA}\sigma_{CP} + x_{nU}\sigma_P^2 - \tau(\mu_P - P_U) = 0. \tag{4}$$

Solving simultaneously yields a neutral investor's optimal portfolio holdings:

$$x_{nA}^* = \frac{\tau}{\phi}[(\mu_C - P_A)\sigma_P^2 - (\mu_P - P_U)\sigma_{CP}] \tag{5}$$

and

$$x_{nU}^* = \frac{\tau}{\phi}[(\mu_P - P_U)\sigma_C^2 - (\mu_C - P_A)\sigma_{CP}] \tag{6}$$

where $\phi = \sigma_C^2\sigma_P^2 - \sigma_{CP}^2$.

The first order conditions for a green investor can be written as:

$$x_{gA}\sigma_C^2 + x_{gR}\sigma_{CP} - \tau(\mu_C - P_A) = 0 \tag{7}$$

$$x_{gA}\sigma_{CP} + x_{gR}\sigma_P^2 - \tau(\mu_P - P_R) = 0. \tag{8}$$

Solving simultaneously yields a green investor's optimal portfolio holdings:

$$x_{gA}^* = \frac{\tau}{\phi}[(\mu_C - P_A)\sigma_P^2 - (\mu_P - P_R)\sigma_{CP}] \tag{9}$$

and

$$x_{gR}^* = \frac{\tau}{\phi}[(\mu_P - P_R)\sigma_C^2 - (\mu_C - P_A)\sigma_{CP}] \tag{10}$$

Equilibrium share prices are derived by substituting the above optimal portfolio holdings in the following market clearing conditions:

$$I_n x_{nA}^* + I_g x_{gA}^* = N_A = N_C \tag{11}$$

allowed, neutral investors could make unlimited arbitrage profits by shorting reformed firms and buying unacceptable firms. This restriction on short selling is required solely because we assume that reformed firms retain the polluting technology. In a model with reformed firms assuming the clean technology, no short selling restriction is required. This alternative model, and why we chose not to use it to explain our result, is discussed in the conclusion.

$$I_n x^*_{nU} = N_U \tag{12}$$

$$I_g x^*_{gR} = N_R. \tag{13}$$

The resulting equilibrium prices are:

$$P_A = \mu_C - \frac{1}{I\tau}[N_C\sigma_C^2 + N_P\sigma_{CP}] \tag{14}$$

$$P_U = \mu_P - \frac{1}{I\tau}[N_C\sigma_{CP} + N_U\sigma_P^2 + N_U\frac{I_g}{I_n}\frac{\phi}{\sigma_C^2} + N_R\frac{\sigma_{CP}^2}{\sigma_C^2}] \tag{15}$$

$$P_R = \mu_P - \frac{1}{I\tau}[N_C\sigma_{CP} + N_U\frac{\sigma_{CP}^2}{\sigma_C^2} + N_R\sigma_P^2 + N_R\frac{I_n}{I_g}\frac{\phi}{\sigma_C^2}] \tag{16}$$

We note for later results that equation (14) shows that the price of a share of an acceptable firm, P_A, is independent of the number of green investors, I_g. To see what causes this, we can take the total derivative of equations (11) through (13) with respect to I_g. Because, in equation (12), $N_U = N_P - N_R$, the change in demand by investor n for U firms must equal, but with opposite sign, the change in demand by investor g for R firms (equation (13)). In equilibrium (where the change in P_R must equal the change in P_U), the change in the demand function for U firms by investor n is equal to the change in demand by investor g for R firms. In addition, the demand functions for firm A by both investors n and g change with price in the same way. The only way these changes in demands can balance is for the price of A firms, which are the only firms held by both types of investors, to remain unchanged.

3.2 Optimal Corporate Acceptability Choice

The number of unacceptable firms that pay to become reformed either will be zero or will adjust until the price of reformed firms is equal to the price of unacceptable firms plus the cost of becoming reformed, K. That is,

$$P_R = P_U + K.$$

Solving this equality for N_R reveals:

$$N_R = \max\{0, \frac{I_g}{I}(N - N_C - KI_n\tau\frac{\sigma_C^2}{\phi})\}. \tag{17}$$

A variable of particular interest is I_g^*, the minimum proportion of investors applying ethical investment screens required to induce the first unacceptable polluting firm to become reformed. We find that I_g^* depends on the number of firms acceptable to green investors, the risk tolerance of investors, the covariance between the cash flows produced by the two technologies and the cost of becoming reformed. Thus, we define I_g^* as the value of I_g at which N_R becomes positive in equation (17). That is,

$$I_g^* : \; N_R > 0 \text{ for } I_g > I_g^*. \tag{18}$$

3.3 Comparative Statics

We examine how changing the model's parameters affects the number of reformed firms.

First, we show that N_R is montonic in I_g. Note from equation (17) that, as I_g goes to zero, so does N_R. Also, since $dI_g + dI_n = 0$, it is easy to see that N_R goes to $N - N_C$ as I_g goes to I. Then, taking the total derivative of N_R with $dI_g + dI_n = 0$ yields $dN_R/dI_g \geq 0$. Whenever $N_R > 0$, increasing the number of green investors leads to a larger number of reformed firms. Holding the total number of investors constant, more green investors means that there are fewer neutral investors who are willing to hold unacceptable firms' shares. Lower demand for unacceptable firms' shares due to an increasing number of green investors results in downward "price pressure" that reduces those shares' value, inducing more of them to pay K to become type R firms.

Next, it is clear from equation (17) that increasing the cost of reforming, K, leads to fewer unacceptable firms reforming.

Also, increasing the risk tolerance, τ, leads to a decrease in the number of reformed firms. Reformed firms increase the diversification possibilities for the green investors, and this matters less if the green investors are more risk tolerant.

The number of reformed firms is a concave function of the covariance (and the correlation) between the cash flows of technologies P and C. This function has its unique maximum where the covariance is zero. To see this, we examine the special case in which technologies P and C have identical risk-return features and there are an equal number of firms with each technology.

Then, consider the case of a correlation of minus one. Neutral investors can own all firms without bearing any risk. Thus, there are no incentives for unacceptable firms to reform.

When the two technologies are perfectly positively correlated, all possible portfolios have identical risk-return features. Again, there are no incentives for unacceptable firms to reform.

When the correlation is between these extremes, there are diversification gains to unacceptable firms reforming, and these gains increase as the absolute value of the correlation approaches zero.

Finally, the number of reformed firms will vary with N_C, the number of originally clean (acceptable) firms. From equation (17), it is clear that the number of reformed firms decreases with more acceptable firms. When there are many originally clean firms, there are few unacceptable firms, implying a small diversification loss for green investors. This means that the share price of unacceptable firms is relatively high, providing little incentive to reform.

Unacceptable firms reform in order to increase their share price (i.e., reduce their cost of capital). Given expected future cash flow, μ_j, $j \in \{C, P\}$, a firm's cost of capital, $\mu_j/P_k - 1$, $k \in \{A, U, R\}$, is inversely related to its price, P_k. Substituting the definition of N_R in equation (17) into the expression for P_R, equation (16), yields

$$P_R = \mu_P - \frac{1}{I\tau}[N_C\sigma_{CP} + (N - N_C)\sigma_P^2 - KI_n\tau]. \tag{19}$$

We can examine the comparative statics of P_R with respect to the model parameters to determine how a reformed firm's cost of capital changes with model parameter changes.

First, a reformed firm's cost of capital decreases as the cost of reforming, K, increases. This is because a larger drop in the cost of capital is required to justify incurring a larger reforming cost.

Next, more green investors implies a higher cost of capital for reformed firms. For a fixed number of investors, more green investors means fewer neutral investors, which in turn means a lower price for unacceptable firms. However, in equilibrium, the price of reformed firms is equal to the price of unacceptable firms plus K. Thus, a lower unacceptable firm price implies a lower reformed firm price, which implies a higher cost of capital for reformed firms.

Also, more risk tolerant investors quite obviously will provide a lower cost of capital for all firms.

Finally, the cost of capital for reformed firms is monotonically increasing in the covariance between the technologies' cash flows. Decreasing the diversification possibilities between the technologies raises all firms' cost of capital.

4 Numerical Examples

While the analytical results provide a number of insights, they do not give a feel for the magnitudes of the endogenous variables. For example, a critical variable is I_g^*, the number of green investors required to induce the first unacceptable firm to reform, defined in (18).

The parameters used in our base case are:

- Technologies
  - Mean Cash Flows: $\mu_P = \mu_C = 10$
  - Standard Deviation of Cash Flows: $\sigma_P = \sigma_C = 10$
  - Covariance of Cash Flows: $\sigma_{CP} = 50$
  - Reforming Cost: $K = 0.5$
  - Total Number of Investors: $I = 1$
  - Total Number of Firms: $N = 1$
  - Number of Firms With Each Technology: $N_P = N_C = 0.5$
- Investors: Aggregate Risk Tolerance: $\tau = 100$.

These parameters were chosen to produce reasonable firm costs of capital, i.e., expected rates of return. In addition, the variance-covariance matrix of cash flows was chosen to produce empirically reasonable results for the standard deviation of rate of return.

We examine the effect of varying I_g, the number of green investors, on three endogenous variables: (i) $N_R/(N - N_C)$, the number of reformed firms, as a percentage of the number of originally polluting (unacceptable) firms, (ii) $(\mu_P/P_U) - 1$, the cost of capital of unacceptable firms, and (iii) $(\mu_P/P_R) - 1$, the cost of capital of reformed firms.

Figures 1 through 3 show these relationships for the base case. Figure 2 shows that, when there are no green investors, the cost of capital for all firms is about 8%. Since the riskless rate has been normalized at zero, this expected return should be thought of as an equity risk premium. Figure 1 shows that green investors must constitute roughly 25% of the investor population in order to induce the first unacceptable firm to reform. At that point, Figures 2 and 3 indicate that the cost of capital for unacceptable firms is about 9.5%, while for reformed firms, the cost of capital is only 3.9%. This large difference in costs of capital is required to induce an unacceptable firm to incur the cost of reforming, making it acceptable to green investors.

The curve in Figure 1 is convex, indicating that the marginal effect of additional green investors on reformed firms is increasing. Figures 2 and 3 show that more green investors raise the cost of capital of both unacceptable and reformed firms. As noted above, fewer neutral investors results in a lower price for unacceptable firms, and thus for reformed firms as well, pushing up both firms' costs of capital.

Figure 4 shows how varying the reforming cost affects the number of reformed firms. At a reforming cost of 1% of the expected cash flow ($K = 0.1$), I_g^* is zero, i.e., even a small number of green investors will produce some number of reformed firms. By contrast, a switching cost of 10% ($K = 1.0$) of expected cash flow prevents any reforming until there are more than 60% green investors. At that point the difference in the cost of capital between unacceptable and reformed firms is quite large at approximately 13%, as opposed to a difference of only 5.6% in the base case.

Figure 5 shows how the number of reformed firms is affected by N_C, the number of originally acceptable firms. The base case has $N_C = 0.5$, which represents 50% of all firms. If there were no green investors, P and C technologies had identical risk-return features, and firms could costlessly select their technology, then 50% of firms, i.e., $N_C = 0.5$, would choose the green technology. Figure 5 also shows the cases of $N_C = 0.25$ and $N_C = 0.75$. One interpretation of N_C is the proportion of all firms that green investors find acceptable for investment before the green investors begin restricting their investments (i.e., $I_g = 0$). Figure 5 indicates that if investors perceive 75% of the firm population to be acceptable, so that a very significant 25% are not, then no unacceptable firms will reform until more than 60% of investors are green.

While Figures 2 and 3 show the effects of varying I_g on the cost of capital of unacceptable firms and on the cost of capital of reformed firms, they do not indicate what happens to the weighted average cost of capital across all firms in the economy. This is because the proportions of unacceptable and reformed firms are changing as I_g varies. The weighted average cost of capital across all firms is of interest because if, in the simplest case, all firms face the same investment opportunity set, then the weighted average cost of capital determines the total level of investment in the economy. The weighted average cost of capital is:

$$N_C \frac{\mu_C}{P_A} + N_R \frac{\mu_P}{P_R} + N_U \frac{\mu_P}{P_U} - 1.$$

Figure 6 shows how the weighted average cost of capital (WACC) varies with I_g, for three different starting values of N_C. We now provide some intuition for why the curves appear as they do.

First, we indicated in Section 3 that if $K > 0$ then $I_g^* > 0$. That means that if $I_g = 0$, then both N_R and $\frac{dN_R}{dI_g} = 0$. That is, with no green investors there are no reformed firms, and adding a small number of green investors does not increase the number of reformed firms above zero. This implies that, at $I_g = 0$, $N_U = N_P$.

We use the above to show that the derivative of WACC with respect to I_g, when evaluated at $I_g = 0$, changes only due to a change in P_U. In the above equation, N_C and N_U are constant, $N_R = 0$ and P_A is unchanged because acceptable firms are held by both green and neutral investors. However, as I_g increases from zero, the risk-sharing opportunities are lessened because of the green investors' boycott of unacceptable firms, and so P_U decreases, meaning that the WACC increases with I_g at $I_g = 0$.

We also note that, at $I_g = 0$, WACC becomes $N_C \frac{\mu_C}{P_A} + N_P \frac{\mu_P}{P_U} - 1$ where, from the WACC definition above, the middle term is zero and the last term has $N_U = N_P$.

Next, we evaluate WACC at $I_g = 1$. In this case, all polluting firms become reformed ($N_R = N_P$ and $N_U = 0$), so that the third term in the WACC equation above becomes zero. Thus, WACC becomes $N_C \frac{\mu_C}{P_A} + N_P \frac{\mu_P}{P_R} - 1$. Moreover, P_R at $I_g = 1$ equals P_U at $I_g = 0$, since in both cases all investors are willing to hold all available firms. Therefore, WACC at $I_g = 0$ equals WACC at $I_g = 1$, as reflected in the numerical examples in Figure 6.

Finally we indicate why the curves for $N_C = .50$ and $N_C = .75$ in Figure 6 appear different from the curve for $N_C = .25$. When N_C is large (e.g., 0.75), I_g^* is also large, meaning that there must be many green investors before the first polluting firm switches to being reformed. For I_g below I_g^* (about 0.60 for $N_C = .75$ in Figure 6), the only effect of increasing I_g is to lower P_U, causing WACC to increase at an increasing rate. The rate of increase in WACC is reduced for $I_g > I_g^*$ because then, while P_U is still decreasing, firms are now switching, thereby ameliorating the effect of the worsening risk-sharing. Thus, the WACC function appears convex when $I_g < I_g^*$, but becomes concave after that. As demonstrated above, the WACC at $I_g = 1$ must return to what it was when $I_g = 0$.

5 Empirical Evidence in the Literature

Both the analytic comparative statics and the numerical examples indicate that the number of green investors in an economy does affect the proportion of acceptable, unacceptable and reformed firms in the economy and the costs of capital of those firms. Our model indicates that acceptable and reformed firms have lower costs of capital, i.e., lower expected rates of return, than unacceptable firms when there are sufficient green investors in the market. For small proportions of green investors, acceptable and unacceptable firms have similar expected rates of return. As the number of green investors grows, the expected returns of unacceptable firms will be higher than the expected returns of reformed firms, given the same systematic risk for each firm.

In our numerical example we can calculate the expected returns and betas (relative to the market portfolio) of unacceptable, acceptable and reformed firms and plot them relative to the market portfolio, consisting of the equilibrium proportions of the three firms. This is the equivalent of the

CAPM security market line. For any number of green investors, the implications of the altered risk-sharing lead to all three firms plotting *off* the security market line. Of course, these abnormal returns are not due to "superior" investment opportunities, but rather to the different "market prices of risk" investors demand from all three types of firms.

Because of the increased risk borne by neutral investors holding all the unacceptable firms, those firms lie above the security market line. In our base case numerical example, acceptable and reformed firms lie below the security market line. If there are a significant number of green investors, these deviations from the security market line should be detectable as risk-adjusted abnormal returns ("Jensen's alpha"), positive for unacceptable firms and negative for acceptable and reformed firms.

Are green investors having an impact on expected rates of return and corporate behavior? Here we review existing evidence of the level, and performance, of socially responsible investing in the US. Harrington (1992, page 41) cites an estimate from the Social Investment Forum of \$625 billion invested in all portfolios that apply "ethical screens" as of the end of 1991. *The Economist* (3 September 1994, page 74) cites the Social Investment Forum in reporting that \$650 billion is managed according to ethical guidelines in 1994. That article notes that the \$650 billion represents about one-tenth of total U.S investments.[6]

Using a proportion of assets under management of 10% as an empirical estimate of I_g, the fraction of green investors, we can roughly calibrate our model parameters. In our base case, for example, no unacceptable (polluting) firms would reform (i.e., pay to become acceptable to green investors) if the proportion of green investors was 10% (see Figure 1, where I_g^* is roughly 20%). If, however, we reduce the cost of reforming from 5% of expected cash flow to 1% of expected cash flow, then Figure 4 indicates that a proportion of 10% green investors would lead to about 10% of originally polluting firms reforming to be acceptable to green investors.

Thus, an important determinant of the impact of green investing is the cost of reforming. However, it would appear quite difficult to measure K empirically. First, even if we could measure

[6] Weigand, et.al. (1996) also cite the Social Investment Forum, using an estimate of \$639 billion, which they claim represents 9 percent of the \$7 trillion in U.S. funds under management.

all "reforming" investment, it might be that some fraction of that investment would have been made regardless of the presence of green investors, as part of normal modernizing capital expenditures. A parallel case is the fact that some "Y2K" investment would have been made even if it wasn't Y2K, inflating the true impact of the turn of the century. Second, some firms might see non-pecuniary benefits to reforming, effectively reducing their cost, K. So, empirical estimation of K seems difficult.

A downside to a 10% proportion of green investors in our model can be seen in Figure 6. Raising the proportion of green investors from 5% to 10% in our model will actually raise the economy cost of capital, while not encouraging any firms to reform.

Our base case also assumed that the fraction of acceptable to unacceptable firms before introducing green investors was .50. If we assumed that the first green investor, when applying an ethical screen, found only 25% of firms to be acceptable, then a 10% proportion of green investors would induce about 5% of the originally polluting firms to reform to be acceptable to green investors. We have some indirect evidence on the proportion of firms that would pass ethical screens. Luck and Pilotte (1992) report on the construction of the Domini Social Index, which is a portfolio of 400 ethically-screened stocks constructed by the social investment research firm of Kinder, Lydenberg, Domini and Co. (KLD). In choosing the 400 ethically-acceptable stocks, KLD first screen the stocks in the S&P500 index. Of those 500 stocks, 257, or about 51%, passed the KLD ethical screen. Thus, it might be reasonable to assume that any set of stocks, chosen randomly, could result in about 50% passing through an ethical screen, as we assume in the base case.

The example of the KLD ethical screen points out another empirical difficulty not dealt with in the theory. In practice, different "ethical investors" apply different ethical screens. For example, the Fidelity Select Portfolio / Environmental Services Fund selects firms in waste management and power production. The PAX World Fund combines environmental and other social screens. The Progressive Environmental Fund concentrates on alternative energy producers and firms with socially-focussed objectives. If a particular polluting or otherwise socially unacceptable firm is screened out only by a fraction of "ethical investors," this will reduce the risk-sharing impact on that firm. In that case, its cost of capital will not rise as much as it would have if all ethical investors had excluded it. Our model indicates that this reduces the impact of exclusionary investing.

Several papers have examined the relative performances of green mutual funds compared to funds without ethical or social screens, or the performances of companies identified as clean or polluting.

Most investigations of the relative stock market performance of green and neutral mutual funds find little difference. Hamilton et.al. (1993) examine the monthly performance of US equity mutual funds. The number of SRI funds increased from six in 1981 to 32 in 1990. They find no difference in the performance between conventional and "green" funds. Similarly, White (1995a) examines the performances of six U.S. and five German green mutual funds over 1990 to 1993. He finds negative abnormal performances for most of the green funds.

Several papers identify individual firms as "clean" or "polluting" and look at the performances of portfolios formed according to that classification. Diltz (1995) examines daily returns over three years from 1989 to 1991 of portfolios formed by applying "ethical screens." Of fourteen portfolios formed according to different ethical screens, Diltz finds abnormal returns in only three of the portfolios.

Alternatively, Herremans, et.al. (1993) find that clean firms have higher profits and lower stock market risk. In addition, they find significantly (at 5%) superior stock price performance for clean versus polluting firms in years 1984 through 1986 in idustries they classify as having "more social conflict." Years 1982, 1983 and 1987 are not significant at the 5% level, and no years are significant for firm comparisons in industries classified as having "less social conflict."

White (1995b) classifies 97 NYSE or AMEX firms as "green," "oatmeal" or "brown" based upon their environmental reputation. He finds that the green firms have positive abnormal stock returns, but that the oatmeal and brown firms do not. Cohen, Fenn and Naimon (1995) get similar results.

Hart (1996) examines emission reductions accomplished by firms in 1989 and examines subsequent accounting profits for the firms. He finds, for example, that more emission reductions in 1989 lead to higher return on equity two and three years later.

Hart (1996) points out the problem of causality in these types of tests. Does being "clean" raise profits and stock prices, or do successful firms, with higher profits and stock prices, undertake more "clean" activites because they can be afforded? It is hard to argue with the point that, if going "clean" raises profits, why doesn't every firm do just that?

As indicated above, few studies find abnormal returns, and some that do find positive abnormal returns for the acceptable and/or reformed firms. In general, the results of no abnormal returns are consistent with our model only if there are few green investors, so that both unacceptable and acceptable firms have similar (i.e., not empirically discernably different) expected returns.

An interesting implication of our model concerns the impact of future growth in green investing. As noted above, more green investors implies a growing gap between the expected returns to neutral investors and green investors in a way that favors the neutral investors. If higher average returns shift wealth to neutral investors, then new green investors could be seen as engaging in self-defeating behavior: more green investors yields higer average returns to neutral investors, shifting more wealth over time back to neutral investors. This "wealth effect' diminshes the impact of green investors.

6 Conclusion

Exclusionary social investment strategies are shown to alter risk sharing opportunities so that polluting (unacceptable) firms' share prices are lowered. When the price differential between acceptable and unacceptable firms grows large enough, it becomes optimal for unacceptable firms to pay the (assumed) fixed cost of reforming (i.e., making themselves acceptable to green investors). Thus, social investing *can* affect corporate behavior.

Our paper indicates, in an equilibrium model, that social investing can impact firm's environmental and other ethical behaviors. An important factor determining the number of reformed firms is the fraction of the population that boycotts socially irresponsible firms. We calibrate our model with empirically reasonable parameters and find that roughly 25% of investors going green are necessary to overcome a firm's cost of reforming. However, existing empirical evidence indicates that roughly 10% of investable funds are invested socially responsibly. In our model, a 10% fraction does not encourage firms to go clean, but it does raise the economy-wide cost of capital. A doubling of the amount of green investing would begin to impact corporate behavior in our model.

A change in risk sharing as green investing increases causes the economy-wide cost of capital to change in a non-monotonic way, with the cost of capital reaching a maximum when investable funds are equally split between green investing and non-green investing.

As noted above, our model requires a short selling restriction on neutral investors because reformed firms retain the same technology as unacceptable firms, but have a different price than unacceptable firms. The necessity for the short selling restriction is removed if we assume that reformed firms take on the clean technology. In this case, $P_R = P_A$, so that firms with the same technology have the same price; there are no arbitrage opportunities. We have solved this model and the qualitative results are unchanged.

We chose to exposit our results with the model where reformed firms retain their original technology (the "original model") because it avoids an additional factor that appears when reformed firms change technologies (the "alternative model"). In the original model, the proportion of clean and polluting technologies is fixed, regardless of how many firms reform. This fixes the diversification benefits available to investors, independent of the proportion of reformed firms in the economy. In the alternative model, however, the split between clean and polluting technologies varies with N_R. Thus, the alternative model has an additional "diversification factor" in determining how many firms will reform.

For example, if both technologies have the same expected cash flows and variability of cash flows, investors would, other things equal, prefer a 50-50 split between clean and polluting technologies (as we assume in the paper). In the alternative model, suppose we assume a 50-50 split between the technologies in the absence of green investors. There is then an additional hurdle for firms to overcome before reforming. Namely, if a firm reforms, it reduces the diversification available to investors because there will then be more clean technologies than polluting technologies. For example, using all the same parameter values in the alternative model as we do in the base case of the original model shown in the paper, the critical level of green investors that induces the first firm to reform, I_g^*, is .60, as opposed to .25 in the original model. If we changed the proportion of clean technologies in the economy without green investors to .1, then investors want reformed firms to bring the technology split back closer to .50. In this case, I_g^* is .15, lower than in the original model.

To avoid clouding the issue with this additional diversification effect, we use the original model with the short selling constraint.

Our simple model assumes all firms are the same. In reality, some industries are primarily clean (i.e., acceptable), and some are mostly polluting (unacceptable). This type of differentiation could be incorporated in our model by varying the cost of reforming. Mostly polluting industries would consist of firms with a high reforming cost, and mostly clean industries would contain firms with low reforming costs.

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