Principle Guided Investing: The Use of Exclusionary Screens and Its Implications for Green Investors

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JEL Classification: G10, Q50
Keywords: Environmentally Friendly Production, Green Investments

1. Introduction

Socially Responsible Investing (SRI) has moved increasingly into the spotlight of private and institutional investors. According to the American industry organisation SIF (Social Investment Forum) "a total of USD 2.29 trillion in assets was identified in the United States in professionally managed portfolios (pension funds or public SRI funds) using one or more of the three core socially responsible investing strategies – screening, shareholder advocacy, and community investing".[1] This amounts to 9.4% of all investments. SRI assets have also grown considerably in Europe, although they do not make up as great a proportion of total assets as in the United States. The origins of principle guided investing can be traced back to the 19th century, when members of Methodist and Quaker churches thought about the consequences of their investments. The launch of the Pax World Fund in 1971 can be seen as the starting signal for modern SRI products. In Europe in the 1980s many funds were launched which focussed on investment in firms developing clean technology (so-called "Umwelttechnologiefonds"). These funds, geared towards ecologically-motivated investors, concentrated mainly on smaller companies working on backstop technologies for exhaustible energy resources. In 1992 the Business Council for Sustainable

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1 www.socialinvest.org/areas/reserchtrends/sri_trends_report2005.pdf

Development (BCSD) coined the term "eco-efficiency" for "a process of adding ever more value, while steadily decreasing resource use, waste and pollution" (Schmidheiny and Zorraquin, 1996). Whether big or small, working in a polluting industry or not, any company could strive for eco-efficiency. Because of the flexibility in applying the concept most SRI funds therefore emphasized eco-efficiency. The drawback however, is how to clearly measure it.

Despite the gain in importance of SRI, there are still open questions with regard to current methods and procedures in particular with respect to financial and environmental performance, and transparency. SRI usually aims to achieve simultaneous ecological, social and financial goals. In the following paper we have chosen to focus on only one aspect of principle guided investing, namely the use of exclusionary environmental screens. We do this primarily to keep the analysis tractable but also for the following reason: while methods exist to differentiate between clean and polluting production processes, the clear definition of goals in the the social dimension is generally impossible. This is because stakeholder theory, the basic tenet of SRI, recommends the maximization of stakeholder value instead of shareholder value, but provides no concise definition of which of the conflicting goals of the different stakeholder groups should be attained or of who (board of directors, CEO, etc.) should take such decisions (Sundaram and Inkpen, 2004).

The terms "negative" and "positive" screens are frequently used in the literature. On an abstract level and in the context of the model used in this paper, the terms "negative" screens and "positive" screens refer to the same thing: Firms which are excluded by "negative" screens are, by the same token, not included by "positive" screens. Simply put, screens as criteria define a universe of included firms and a universe of excluded firms. In order to avoid any possible confusion we will just use the term exclusionary environmental screens in what follows.

This paper thereby sheds light on questions of performance, transparency and the possible achievement of ecological goals (implying less pollution), under the assumptions that firms aim to maximise only firm value and do not pursue eco-efficiency as a goal and that "green" investors (e.g. investors interested in investing in clean firms) use exclusionary environmental screens. It is shown how polluting firms can indirectly be induced to switch to a clean technology. Chances of success mainly depend on the size of abatement costs, the distribution of green and neutral investors and the size of the covariances between shares of clean and polluting firms. Also, if shares of clean firms have lower risk, the transformation to a less polluting economy becomes more likely. Because abatement is not free of charge, the return on shares of clean firms is lower than the return on shares of polluting firms and since principle guided investors buy only shares of clean firms, they have a lower return on their portfolios for an extended investment horizon.

The model presented here is a two agent model (green and neutral investors) in a static one-period context. The agents can invest in riskless assets or in shares of firms working with clean or polluting technology. Green investors use exclusionary environmental screens and invest in stocks only if they are from firms with clean technology. Some firms with polluting technology will switch to using a clean technology, incurring additional abatement costs, when green investors are numerous. It can be shown, given normal microeconomic assumptions (firms as shareholder-value maximising entities), that a small population of principle guided investors can only be effective if abatement costs are also very low. If abatement costs are substantial, then the proportion of green investors has to be almost half of the population. Furthermore principle guided investors must be willing to accept a reduction in achievable returns. In all these cases success requires that green investors have homogenous beliefs with regard to the use of exclusionary environmental screens. The paper also clarifies how neutral investors indirectly influence the success of the outcome, both in the case where shares of clean firms form a different asset class and in the case where they do not. Additionally, the paper investigates the case where firms switching to a clean technology produce an additional positive externality in the form of learning effects concerning in the clean technology. If these learning effects are confined to the group of clean firms then the transformation to clean technology takes place with a higher probability at all proportions of green investors.

The model presented here builds on the model of Heinkel, Kraus and Zechner (2001); in fact, it is a general version of what they term "the alternative model". In their model it is assumed that half of the firms have a clean technology. Green investors can then only force some firms of the other half to reform.[2] In the model presented here, firms switch to a clean technology by investing in abatement. We therefore assume a change not only in the expected return but also in the risk characteristics, which is intuitively more plausible. As a side effect, an additional diversification effect occurs, in contrast to the model of Heinkel, Kraus and Zechner (2001). Under certain conditions, this additional

2 Since Heinkel, Kraus and Zechner (2001) assume that so called reformed firms do not change their characteristics with regard to original risk, they have to introduce a no-arbitrage condition in order to impede neutral investors from making riskless arbitrage between reformed firms (which are more expensive) and still polluting firms, which both have still the same risk characteristics.

diversification effect can have a big impact on the occurrence of switches. For example when abatement costs are relatively low and only a few green investors are present, neutral investors will invest in shares of clean firms not because of principle-guided beliefs but for risk reduction reasons.

Beltratti (2005) investigates a two-period general equilibrium model with production, externalities and heterogeneous agents. One group of atomistic investors discriminates against the financial assets of firms in which production gives rise to a negative externality, because the utility of the investors as consumers is negatively affected by the pollution in the second period. Beltratti comes to the conclusion that the set of firms producing negative externalities (e.g. polluting or behaving unethically) is affected only when the group of discriminating investors owns a big portion of all wealth and/or if stocks from firms producing a negative externality are not important for portfolio diversification.

This paper contributes to the literature regarding the relationship between ecological and economic performance by more closely examining how switches to a cleaner production technology take place and by drawing conclusions for principle guided investors. It investigates the case where clean firms have different risk characteristics from polluting firms. Numerical simulations show under which circumstances the diversification motive of neutral investors can either support or hinder goals of principle guided investors. Additionally, the paper examines when and how the presence of positive spill-over effects can support the "greening" of firms. The presented model with heterogeneous agents remains static due to technical difficulties with a dynamic extension of this setting of heterogeneity of agents and heterogeneous portfolios. It can be conjectured though, that qualitatively the results would be the same in a dynamic setting.

The remainder of the paper is organised as follows. In Section 2, the purpose and functions of exclusionary screens in today's SRI world are briefly described. Section 3 describes the model in detail. In Section 4 the equilibrium and comparative statics are given while Section 5 provides numerical examples. The connection between the use of exclusionary screens and the investment return which green investors can achieve will be elaborated in Section 6. In Section 7 theoretical considerations and practical implications will be given. Finally, Section 8 concludes.

2. Exclusionary Environmental Screens: Purpose and Applications

Principal guided investors can use exclusionary screens for ethical reasons or in order to force firms to meet certain social or environmental thresholds. Exclusionary screens, which by their nature either include or exclude certain firms are transparent, because they can be checked and verified by third parties. If principle guided investors use exclusionary ethical screens, then the firms affected have no chance to react – except to shut down their business. If principle guided investors have for example an exclusionary ethical screen on weapon manufacturing or on the tobacco industry, then they will not invest in shares of such firms even if such firms are producing in an environmentally and socially sound way. The action set of firms is bigger in the case where principle guided investors use exclusionary environmental or social screens by undertaking an investment. Here, affected firms have the chance to surpass the specific environmental or social threshold that triggers the negative screen. It is also interesting to note, that the motivation of principle guided investors is most likely double-sided: on the one hand, these investors get a certain satisfaction from not investing and therefore not profiting from environmentally or socially unsound firms, while on the other hand they attempt simultaneously to force such firms to undertake some investment for a purely environmental or social reason. By applying these exclusionary screens, principle guided investors want to raise the cost of capital for environmentally or socially unsound firms. Higher capital costs will raise relative prices of products and reduce sales. In the process products of boycotted firms or industries should be substituted for goods of clean firms or industries. As explained in the first section, we will address in the following paper only exclusionary environmental screens. Criteria for the application of exclusionary screens for environmental reasons could for example be chosen with regard to excessive environmental damage (resource extraction, CO_2-emissions), which are mostly caused by certain industries.

By using exclusionary screens principle-guided investors want to raise the cost of capital for shunned firms to the extent, that these firms undertake additional investments in order to correct the environmental or social deficiency. As Wall (1995) pointed out, principle guided investors can only be successful if they can cause a substantial, long-run change in stock price of targeted firms. But as we will see, a substantial deviation from the stock price from the underlying value of the firm is only possible if aggregate demand is not perfectly elastic. This occurs only in the case where principle guided investors are numerous, since neutral investors want to profit from stock prices lower than the underlying (intrinsic) value and will therefore invest more heavily in such stocks.

The same logic can be applied to the opposite case where principle guided investors apply positive screens and invest heavily in companies which are distinguished on an environmental and/or social dimension. If market prices of such stocks considerably surpass the underlying value neutral investors will unload a portion of these expensive stocks. This is most likely to occur with stocks of large firms. Also if the firms which are preferred by principle guided investors have close substitutes, implying similar risk/return characteristics, it will be less likely that principle guided investors can have an impact by applying positive screens.

Since people do not have homogeneous opinions on social goals, in what follows we discuss only exclusionary environmental screens, although the model would be appropriate for exclusionary social screens. We assume that principle-guided investors have homogenous beliefs about what is environmentally unsound and which discrete investments in abatement would be a corrective measure.

In practice exclusionary screens are seldom put in place. According to Statman (2000), the Domini Social Index, an index of stocks of socially responsible companies modelled on the S&P500 Index and initiated in May 1990 by Kinder, Lydenberg, Domini & Company (KLD) uses exclusionary screens only for military weapon systems, alcohol and tobacco and gaming products or services. Very often exclusionary screens are chosen for the sole reason of producing portfolios which are consistent with the belief of the sponsor. But exclusionary screens also have their caveats: firstly, conglomerates produce in many different industries (and sometimes also operate partially in “sin” fields), so SRI analysts have to use an arbitrary cut off point (usually a percentage of revenues) in order to judge if the relevant company should be included or excluded; secondly, if a green investor wants to use exclusionary screens in order to avoid investments in e.g. resource extractive industries, but still invests in industries in which products are mainly based upon that one critical resource, the positive effect on the environment will not be significant, being only to the extent that capital costs for those products have increased.

The model in this paper assumes that green investors work with exclusionary environmental screens, e.g are not willing to invest in firms which have a polluting technology. Green investors therefore restrict their stock investment universe to shares of clean companies.

3. The Basic Model

The model assumes a one-period world in which three categories of assets are available: riskfree assets, shares of companies producing with a polluting technology (*P*) and shares of companies which work with a clean technology (*C*). The total number of firms *F*, consists of F_P polluting firms and F_C clean firms.

In the model there are *I* investors, namely I_N neutral and I_G green investors. Green investors only invest in the risk free asset and (if available) in shares of clean companies, since they use exclusionary environmental screens (no investments in shares of polluting firms). Neutral investors have no principle guided investment preferences and optimise their portfolios considering both risk free assets as well as all shares in the investment universe.

An F_P firm can invest in abatement and by doing this, switch to the group of F_C firms. An F_P firm will incur transformation costs of *A*, if enterprise value can be raised. Each F_C firm uses a clean technology and has a normally distributed expected firm value with mean μ_C and variance σ_C^2. The expected values of F_C firms are perfectly correlated with each other. Accordingly, each F_P firm uses a polluting technology and generates a normally distributed expected value with mean μ_P and variance σ_P^2. Also the expected values of F_P firms are perfectly correlated with each other. The covariance between the expected values of F_C firms and F_P firms is σ_{PC}. The expected value of a firm can be conceived as the sum of the discounted cash flows over the "lifetime" of the firm. Since the basic model is static, the factor time is not included, and therefore the label "expected value" was chosen.

The following two equations describe the utility functions of neutral (I_N) and green (I_G) investors. The utility functions consist of the expected (and not discounted) return (expected value minus price of shares) from which the weighted risk of the portfolio is subtracted. As usual in this literature, both groups of investors have a constant absolute risk aversion (CARA) with a risk tolerance parameter τ.

$$u_N = x_{NP}(\mu_P - P_P) + x_{NC}(\mu_C - P_C) - \frac{x_{NP}^2\sigma_P^2 + x_{NC}^2\sigma_C^2 + 2x_{NP}x_{NC}\sigma_{PC}}{2\tau} \qquad (1)$$

$$u_G = x_{GC}(\mu_C - P_C) - \frac{x_{GC}^2\sigma_C^2}{2\tau} \qquad (2)$$

where x_{IF} is the number of shares of firms of category $F \in [P,C]$, held by type I investor ($I \in [N,G]$) and P_F is the price of shares of category F.

Equation (1) shows that neutral investors will regard the full set of assets in order to find their optimal portfolio. They consider investments in riskfree assets, the rate of which is determined exogenously under the assumption of a perfectly elastic supply, investments in firms with polluting technology as well as potential investments in firms with clean technology.

As principle guided investors, green investors will confine themselves only to investments in the risk free assets and in shares of firms with clean technology, as can be seen from equation (2). Firms with clean technology exist when some of the firms (instantaneously) invest in abatement. Equation (3) depicts the exogenous condition for the switch of polluting firms to a clean technology:

$$\text{invest in abatement} \begin{cases} \text{yes,} & \text{if } P_C > P_P + A \\ \text{indifferent,} & \text{if } P_C = P_P + A \\ \text{no,} & \text{if } P_C < P_P + A \end{cases} \qquad (3)$$

where A is the cost of investment in abatement.

When no green investors exist and abatement costs are sizeable, all firms work with a polluting technology and therefore all have the same expected value characteristics (μ_P,σ_P). When abatement costs are not negligible and the number of investors applying exclusionary environemental screens is very small, then these principle-guided investors can only invest in the risk free asset, since no clean firm exists. An increase in the proportion of green investors raises the chances that some polluting firms implement a cleaner production technology, because the higher the proportion of green investors, the lower will be the share prices of polluting firms. If the share price of polluting firms P_P is lower than the share price of clean firms P_C minus abatement costs A, than some polluting firms will invest in abatement until the equilibrium is reached, as given by equation (3). By investing in abatement, the reforming firms can raise firm value and will then have the expected value characteristics of clean firms (μ_C,σ_C). This transition is central to the model and is possible because green and eventually also neutral investors buy shares of firms with clean technology. But the switch to a cleaner production process (or the investment in end-of-pipe abatement) can be expensive, and shares of firms which switch to a clean technology will provide a lower return than the shares of polluting firms.

4. Equilibrium and Comparative Statics

In order to calculate the proportion of clean and polluting firms, we first compute the optimal portfolio holdings of each investor group. By taking the derivatives of μ_N with respect to x_{NP} and x_{NC}, we derive the first order conditions for optimal portfolio holdings of a neutral investor

$$\tau(\mu_P - P_P) - (x_{NP}\sigma_P^2 + x_{NC}\sigma_{PC}) = 0 \tag{4}$$

$$\tau(\mu_C - P_C) - (x_{NC}\sigma_C^2 + x_{NP}\sigma_{PC}) = 0 \tag{5}$$

By employing (4) and (5), we can solve for a neutral investor's optimal portfolio holdings of shares of firms with polluting technology (x_{NP}^*) and of shares of clean firms (x_{NC}^*):

$$x_{NP}^* = \frac{\tau}{\phi}[(\mu_P - P_P)\sigma_C^2 - (\mu_C - P_C)\sigma_{PC}] \tag{6}$$

$$x_{NC}^* = \frac{\tau}{\phi}[(\mu_C - P_C)\sigma_P^2 - (\mu_P - P_P)\sigma_{PC}] \tag{7}$$

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

By inspecting (6) and (7), we see that the optimal holdings of shares of neutral investors will increase with the risk tolerance of investors and will fall when ϕ rises. ϕ takes a higher value, the higher the risk of shares of clean and/or polluting firms. Equation (6) shows that optimal holdings of shares of polluting firms by neutral investors will be higher, the higher the expected returns of shares of polluting firms, the higher the risk (variance) of shares of clean firms, the lower the return of shares of clean firms and the lower the covariation of shares of both groups. As we can see from (7), optimal holdings of shares of clean firms by neutral investors will be higher, the higher the expected returns of shares of clean firms, the higher the risk (variance) of shares of polluting firms, the lower the return of shares of polluting firms and the lower the covariation of shares of both groups.

Since a green investor invests only in shares of clean firms, we get one first order condition for a green investor. By taking the derivative of u_G with respect to x_{GC}, we have

$$\tau(\mu_C - P_C) - (x_{GC}\sigma_C^2) = 0 \tag{8}$$

and by solving for x_{GC}^*, we obtain a green investor's optimal portfolio holding of shares of clean firms as:

$$x_{GC}^* = \frac{\tau}{\sigma_C^2}[(\mu_C - P_C)] \tag{9}$$

The optimal portfolio holding of shares of clean firms of a green investor will be higher, when these shares have a higher expected return and/or lower risk. When the risk tolerance of investors is higher, they will also hold more shares of clean firms.

Since principle guided investors only buy shares of clean firms, whereas neutral investors buy shares of both groups, the following two market clearing conditions must hold:

$$I_N x_{NC}^* + I_G x_{GC}^* = F_C \tag{10}$$

$$I_N x_{NP}^* = F_P \tag{11}$$

By substituting the optimal portfolio holdings [eq. (6), (7) and (9)] in the market clearing conditions [(eq. (10) and (11)], we can solve for the equilibrium share prices of clean firms (P_C) and polluting firms (P_P)

$$P_C = \mu_c - \frac{1}{I\tau}(F_C\sigma_C^2 + F_P\sigma_{PC}) \tag{12}$$

$$P_P = \mu_p - \frac{1}{I\tau}(F_C\sigma_{PC} - F_P\frac{\sigma_{PC}^2}{\sigma_C^2}\frac{I_G}{I_N} + F_P\sigma_P^2\frac{I}{I_N}) \tag{13}$$

Equations (12) and (13) describe the equilibrium prices of shares of firms working with a clean or polluting technology. The share prices of each category will be higher, the higher their respective expected values and/or the higher the risk tolerance of investors. Equation (12) shows that the share price of a clean firm is independent from the distribution of neutral or green investors, because both investor groups will invest in shares of firms with clean technology. The price of such shares will be smaller, the more firms with clean technology exist and/

or the higher their risk. When covariation of shares of clean and polluting firms is high and simultaneously a big number of polluting firms exist, then this will lead to a lower price of shares of clean firms. Equation (13) shows that the share price of polluting firms depends upon the distribution of neutral and green investors. If the number of green investors is zero, then the second term in the brackets vanishes and the third term is analogous to the first term in equation (12), since $I = I_N$. The second and the third term will gain in importance with a rising number of green investors and are therefore very important for the probability of the conversion of polluting firms to clean technology. The third term basically shows that a higher risk of shares of polluting firms makes those shares relatively less attractive for neutral investors, which leads to a lower share price and to a faster conversion of some polluting firms. The sign of the second term depends upon the sign of the covariation of shares of clean and polluting firms. If covariation is negative, then clean shares are very valuable for neutral investors, because they offer excellent diversification. This effect will be strengthened when the risk of clean shares is low.

Equation (3) defines the equilibrium condition for the switch of polluting firms to a clean technology, by imposing the condition that the price of shares of clean firms has to be equal to the price of polluting firms plus the additional abatement costs. If we solve (12) and (13) for F_C and taking (3) into account, we get

$$F_C = \max\left[0, \frac{I\tau(\mu_C - \mu_P - A) + F\left(-\sigma_{PC} - \frac{I_G\sigma_{PC}^2}{I_N\sigma_C^2} + \frac{I\sigma_P^2}{I_N}\right)}{\sigma_C^2 - 2\sigma_{PC} - \frac{I_G\sigma_{PC}^2}{I_N\sigma_C^2} + \frac{I\sigma_P^2}{I_N}}\right] \tag{14}$$

As equation (14) shows, the number of firms with clean technology (F_C) will be higher, the higher the expected value of clean firms relative to the expected value of polluting firms and abatement costs, and the higher the risk tolerance of investors. Also, the lower σ_C and σ_{PC} and the higher σ_P, the higher will be the proportion of clean firms. The same obviously holds true for any rise in the number of green investors (I_G).

5. Numerical Examples

After having examined the analytical results, we take a closer look at how several exogenous variables will influence the outcome of the proportion of clean and polluting firms. By examining the impact of different parameter constellations, we can draw conclusions with regard to sensitivities. This is important not only for green investors, whose aim is to reduce pollution with their principle guided investments, but also for neutral investors, who want to attain optimal portfolios with respect to return and risk. From inspecting equation (3) it is easy to see that the size of abatement costs A is a parameter of central importance for the process of switching to a clean technology. In this context it can also be shown that the magnitude of covariation is of tremendous importance.

In the first subsection we introduce and discuss the baseline set of parameters. In this base case, green investors have to constitute about 40% of all investors in order to induce the first polluting firm to switch to a clean technology. In subsection 5.2, we will examine how differences in the magnitude of abatement costs will influence results. Since this relationship is of primary interest, it will be examined in depth. It will be shown that if abatement costs are low, many switches to clean technology take place. In cases of higher abatement costs, though, the population of green investors already has to be much higher than today's, in order to induce first positive effects. If abatement costs are prohibitively high, then either the population of green investors has to be the dominating group or policy has to set stricter regulations in order to introduce a switch to a clean production technology. In subsection 5.3 we will examine how the "greening" of the economy proceeds if shares of clean firms are viewed as a different asset class. When shares of clean firms have a low covariation with regard to shares of polluting firms and/or if they have lower risk (standard deviation), they can be regarded as a different asset class, which makes them more interesting from the point of view of neutral investors. In subsection 5.4 we will examine how the occurrence of switches to a clean technology will be affected if we assume positive externalities of expected values of clean firms.

5.1. Baseline Set of Parameters

The following baseline set of parameters was chosen:

Table 1: Baseline Set of Parameters

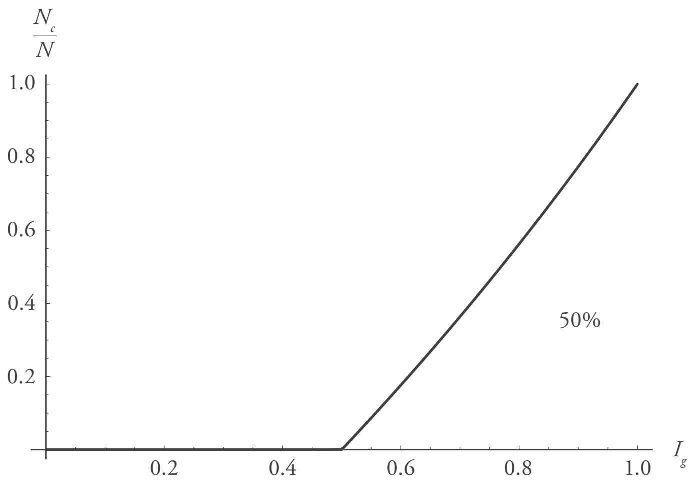
Expected value:	$u_P = u_C = 10$
Standard deviation of expected values:	$\sigma_P = \sigma_C = 10$
Covariance of expected values:	$\sigma_{PC} = 50$
Aggregate risk of tolerance of investors:	$\tau = 100$
Abatement costs:	$A = 1.0$ (10% of expected value)

With one exception (abatement costs A) all parameter settings were selected in line with the model of Heinkel, Kraus and Zechner (2001), in order to compare results. They chose this parameter setting in order to produce what they call "reasonable cost of capital" of firms (or expected rates of return from the point of view of investors). The resulting cost of capital of about 8% translates to an "expected equity risk premium" of the same size, since the riskless rate is assumed to be zero. But it has to be mentioned that this is not a "normal" risk premium, which usually represents the extra return of stocks vs. a riskless rate *per year*. In this case time does not enter the model, and the term "required return" represents more an "expected return or profit" (expected value minus share price divided by share price). The expected values could represent the sum of undiscounted cash flows of the firms. The "cost of capital" or "expected return" corresponds to the amount by which the expected value (sum of undiscounted cash flows) surpasses stock prices. This will be further elaborated on in Section 6.

For the economic calibration of the model abatement costs are not central. In the base case of the presented model abatement costs are set twice as high as in Heinkel, Kraus and Zechner (2001), for the simple reason that their model assumes that at least half of the firms work with clean technology in any case, whereas in the presented model this restrictive assumption is not made. Calculations with assumption of their abatement costs of 0.2, 0.5 and 2.0 will be shown in the next subsection.

Figure 1 shows the ratio of firms with clean technology to all firms with the assumption that abatement costs $A = 1$, corresponding to 10% of expected value of firms. When the number of green Investors I_G is below 40% then no polluting firm switches to a clean technology. At 40% the first switch takes place. It has to be noted that this number is much higher than the current proportion of green investors. If investors applying negative environmental screens become more

Figure 1: Ratio of Clean Firms to All Firms with Abatement Costs of 1.0



populous, the ratio of clean firms to all firms (N_C/N) monotonically increases. When all investors are green, all the firms are working with clean technology, because no neutral investors exist buying shares of firms working with polluting technology.

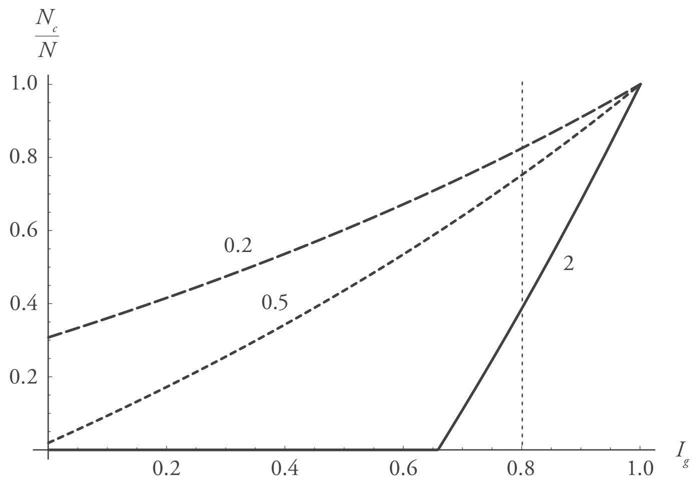
5.2. Different Abatement Costs

To show the influence of the size of abatement costs, we assume the following different levels:

Abatement costs: $A = 0.2$ (2% of expected value), $A = 0.5$ (5%), $A = 2.0$ (20%).

The case where abatement costs A are 0.5 (5% of expected value), corresponds to the base case of Heinkel, Kraus and Zechner, (2001). If abatement costs are that low, the first switch takes place already in the absence of green investors. When abatement costs are practically negligible (A corresponding to only 2% of expected value), and when no green investors are present, more than 30% of companies switch to clean technology, since it is in the interest of neutral investors for risk reduction reasons. Of course neutral investors in this case are accepting only a slight reduction of return. As soon as green investors become more numerous, the proportion of clean firms immediately and steadily increases.

Figure 2: Ratio of Clean Firms to All Firms in Dependence of Abatement Costs



When abatement costs are economically very sizeable (*A* corresponding to 20% of expected values), than the vast majority of investors have to apply identical exclusionary environmental screens before the first firm will switch to a clean technology. If abatement costs are that high, one can assume that only policy can improve the environmental situation, by imposing stricter laws and regulations concerning polluting production technologies. The dashed vertical line at $I_G = 0.8$ shows that the proportion of clean firms strongly depends upon the size of abatement costs; if abatement costs are 20% of expected value, the proportion of clean firms is only just under 40%, whereas in the other two cases it is slightly below and above 80%.

5.3. Different Risk Characteristics: Clean Firms as a Different Asset Class

When shares of clean firms have the same risk characteristics (standard deviation and perfect correlation) as shares of polluting firms, neutral investors will not buy such stocks, as they offer lower return without a reduction of total portfolio risk. On the other hand, as the case of low abatement costs in the previous example showed, the switch to a clean technology can happen even in the absence of green investors, due to the motivation of neutral investors to optimise the risk-return relationship of their portfolios. Since the diversification motive of neutral investors has such a big impact on results, we want to consider first the influence of different covariances of firms with clean and polluting technology and afterwards examine the case of lower standard deviations of shares of clean firms.

All parameters are set as in the baseline example, except the covariance of expected values: $\sigma_{PC} = 50$, $\sigma_{PC} = 10$, $\sigma_{PC} = 90$.

Figure 3: Different Levels of Covariances

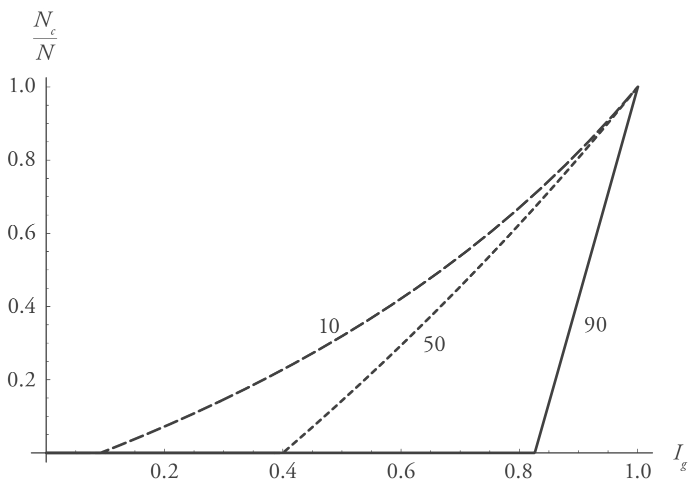
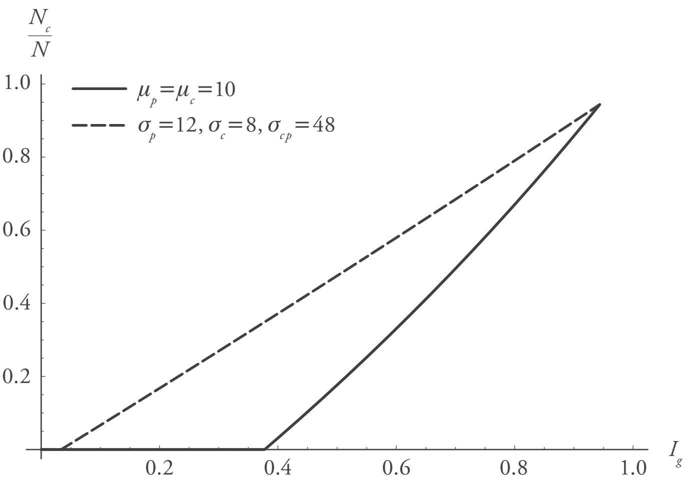


Figure 3 shows how the covariance of the expected value of shares of clean and polluting firms determines the proportion of each group. When shares of clean and polluting firms are highly correlated (covariance of 90), green investors have to constitute 80% of the population in order to induce the first firms to switch to a clean technology. This is, of course, due to the fact that the expected return of shares of clean firms is lower because of the abatement cost of 10% of the original price and so offers little diversification (risk reduction) benefits. When covariance is markedly lower (10), then the switch happens with a much lower population of green investors, since neutral investors will invest in shares of clean firms for diversification reasons, in order to get a better risk-return relationship. Since the diversification motive of neutral investors can play such a decisive role, it is worth discussing here the baseline value for σ_{PC} of 50. This value corresponds to a correlation coefficient of about 0.7, which can be regarded as a “normal number” for stocks belonging to different industries. A covariance of 90 is certainly very high and would mirror the co-movement of shares of firms within a homogenous industry. A covariance of 10 would depict the (unrealistic) case where stocks of clean and polluting firms would show lower correlation than that observable between stocks and bonds in "normal times", and would even come close to the hedge funds case (asset class unrelated to other asset classes).

The second component to consider for calculation of total portfolio risk is the standard deviation of shares of clean firms. For any switches to occur, shares of clean firms have to exhibit lower risk (standard deviation) than their counterparts of polluting firms. The importance of this factor is demonstrated in Figure 4. While the solid line in Figure 4 represents the base case, the dotted line represents the situation in which firms with polluting technologies have higher risk ($\sigma_P = 12$) and firms with a clean technology have lower risk ($\sigma_P = 8$). In order to eliminate the (small) impact from the induced change of correlation, covariation was slightly reduced to 48.

Figure 4: Case where Clean (Polluting) Firms Have Less (More) Risk



When shares of clean firms have lower risk, clean firms will come into existence at a much lower level compared to the base case. And afterwards the number of clean firms is consistently higher than in the base case, regardless of how many green investors exist. This is due to the obvious fact that c.p. the (clean) firms with less risk are also more attractive for neutral investors.

Environmental risks of publicly traded firms can translate into financial risks as well. Hamilton (1995) could in an event study report that stocks of publicly traded firms showed significantly abnormal negative returns after the firms had released their first TRI (toxic release inventory) pollution figures. Neutral investors incorporated this new information in their portfolio consideration and were probably concerned about the possible "cost of future liabilities arising pollution cases, regulatory compliance costs associated with emission reductions, and loss of goodwill connected with high pollution figures" (Hamilton, 1995).

5.4. Positive Externalities on Expected Value of Clean Firms

Very often SRI proponents assume that earnings of SRI firms could initially be lower than those of polluting firms, but will grow faster in the long term. This can be interpreted as the existence of intertemporal positive externalities, maybe due to learning effects. Such positive externalities can only work in favour of clean firms if they do not simultaneously positively affect polluting firms.[3] If we assume that such positive effects are not confined to each single clean firm, but raise respectively the value or the knowledge pool of all clean firms at the same time, we can incorporate the existence of such effects by introducing a parameter λ which represents a degree of positive externality for the expected value of clean firms. The expected value of clean firms will then be, according to equation (15)

$$u_C = u_P(1 + \lambda \frac{F_C}{F}) \tag{15}$$

where λ has to fulfil the following condition

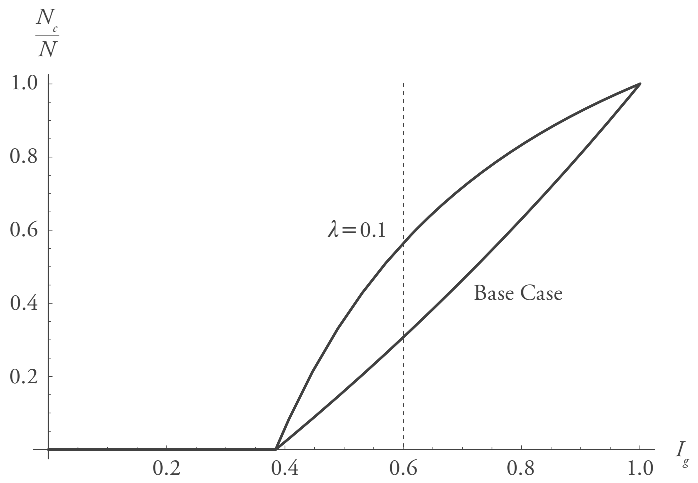
$$0 \leq \lambda \leq \frac{A}{u_P} \tag{16}$$

If $\lambda = 0$, we have the model which was implicitly used so far. If λ surpasses the upper bound, the transformation "explodes" after appearance of the first clean firm, since the positive externality dominates abatement costs. Equation (15) can be substituted into the utility functions [equations (1) and (2)] and then the model can be solved accordingly.

3 If we assume that externalities affect expected value of both clean as well as polluting firms this obviously has no impact on the relative valuation. If we assume that externalities affect expected value of clean firms in just a linear way, then this equals only a change in abatement costs *A*.

As Figure 5 shows, the curvature changes from convexity to concavity. With the onset of the first clean firm, switches happen with higher frequency. If such positive externalities exist, the transformation to clean technology takes place with a much higher probability at all proportions of green investors. The dashed straight vertical line at point 0.6 shows that the proportion of clean firms in this case has doubled.

Figure 5: Case Where Shares of Clean Firms Have Higher Expected Values Due to Positive Externalities: $\lambda = 0$ (Base Case) and $\lambda = 0.1$



The nature of this externality is such that only firms with clean technology profit from it. There are different possible interpretations for this. First, knowledge simultaneously produced when investing in abatement could be the reason for such an externality. And that knowledge must be part of a common knowledge pool, only available to clean firms. Or we could assume that clean firms have a higher reputation in the view of green and neutral investors alike: both investor groups are willing to assign a higher expected value to shares of clean firms and additionally that value increases slightly the more clean firms exist. In this regard it is important to note that expected value is synonymous with future value. And this future value depends upon two factors: (i) earnings or cash flow development (not further addressed in this paper) and (ii) the interest rate used for discounting, incorporating appraisal of risk and time preference of consumption. This will be discussed now in the following section.

6. Expected and Required Return, Time Horizon and Risk Tolerance of Investors

As already emphasised, the expected (and not discounted) return in the utility functions of neutral and green investors does not correspond to a normal equity risk premium. But it is possible to compute indirectly such a premium, which gives the return per annum, if we assume that investors use a finite time horizon in their calculations. Investors calculate the expected and required future value of their investment (u_F), according to the following formula:

$$u_F - P_F = (1 + g_i)^n - 1 \tag{17}$$

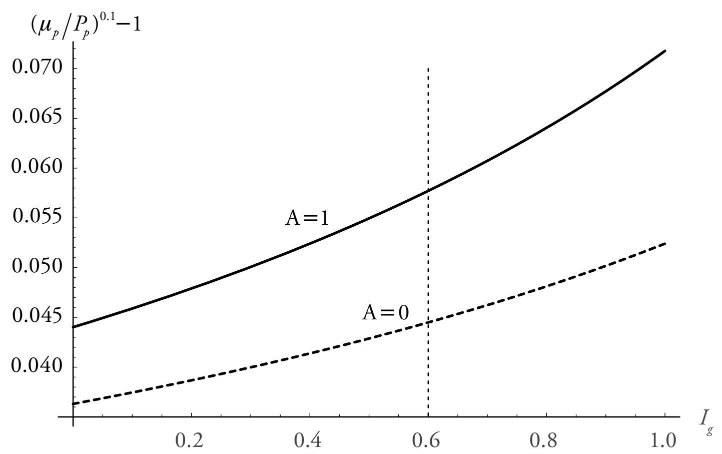
where P_F is the current stock price of firm F, g_i the implied and required growth rate and n the investors' time horizon in years. The term $u_F - P_F$ corresponds to the cost of capital or required rate of return in the terminology of the article of Heinkel, Kraus and Zechner, (2001).

If we take the calibration value for "cost of capital" of 8% of Heinkel, Kraus and Zechner, (2001) and assume that investors discount future cash flows over the next 10 years ($n = 10$), than this 8% translates to an implicit risk premium of about 0.77% p.a ($= g_i$) a value which is too low in light of historical experience. A risk premium of 3.75% of equity returns surpassing the return of a risk free asset (which in this case could be a 10-year government bond) is better suited for calibration and is in line with historical evidence. If we assume that neutral investors demand a risk premium of 3.75%, then in 10 years the expected value of shares has to be $(1 + 0.0375)^{10} \approx 1.445$ higher than the current share price (abstracting from the appreciation of the bond in the following). But this implies also that the parameter τ for the risk tolerance has to be changed. Since the expected value has to surpass the share price not only by 8% but by about 45%, this is only possible if τ, the measure for risk tolerance of all investors, is much smaller. This reduced risk tolerance leads to the effect that stock prices P_P and P_C are both much lower. In the case that the expected share price (expected value) in 10 years has to surpass the price investors are willing to pay today by about 45% this translates into a sensible value of τ of 25. The calibration values of τ of 25 and the assumption that investors discount firm values of 10 years are closely intertwined: the longer the discount function, the lower the τ has to be in this model, where time is not directly included. But the line of reasoning always stays the same.

The aim of this section is to elaborate on differences in the required returns which neutral and green investors expect, i.e. to quantify the implicit costs of application of exclusionary screens by green investors. One remark should be made at this point though: green investors have the same risk aversion τ as neutral investors, but since they do not want to invest in shares of polluting firms at all, they are holding portfolios consisting only of stocks of clean firms, thereby foregoing higher possible investment returns at the same risk level. In fact, green investors use a lexicographical procedure (Dupré, Girerd-Potin and Kassoua, 2004), and through the use of this investment principle, they raise return possibilities for neutral investors in all the cases.

In the following, we assume that risk tolerance τ takes a value of 25. This corresponds to an equity premium of about 3.75% of the stock market vs. return of risk free assets per annum. One has to take into account that with such parameter values abatement costs are relatively less important and switches occur even with a lower population of green investors. For example with parameters of the base case of subsection 5.1 (except the change to a lower τ) switches already occur when green investors are less than 1%.

Figure 6: Required Return per Annum of Polluting Firms when Abatement Costs Are 0% Resp. 10% of Expected Value



As a starting point, we assume that abatement costs are zero ($A = 0$). In this case firms can somehow switch from polluting to clean technology at no charge and green investors can somehow perceive this even in the absence of abatement activities. As can be seen in Figure 6 (line with $A = 0$), when no green investors (I_G)

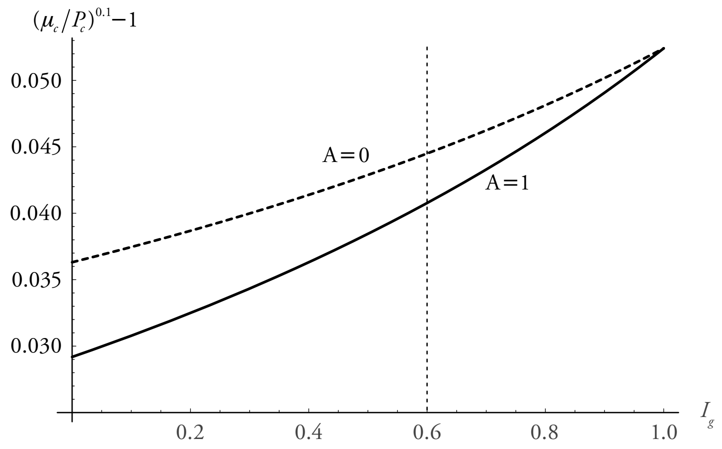
are present, the required return (synonymous to capital costs from the view of firms) for shares of polluting firms is lowest, amounting to a 10 year equity risk premium of about 3.7% per annum. Since green investors refrain from purchases of shares of polluting firms, the required returns of polluting firms are higher, the higher is the proportion of green investors. When all investors are principle guided, the required return of the last polluting firm has risen to more than 5% p.a. This rise is entirely due to the fact that green investors hold undiversified portfolios and since they have the same risk tolerance as neutral investors, shares have to offer a higher return (which implies a lower share price), in order to be placed in the portfolios.

The ($A = 1$) line describes the case when abatement costs amount to 10% of expected value. Here the return which neutral investors can expect from shares of polluting firms is higher for any level of green investors. The return of the last polluting firm will surpass even 7% p.a., more than 2.5% higher than in the absence of any green investors. When green investors constitute 60% of the whole population, a rise of abatement costs from 0 to 1 leads to an increase in the return of shares of polluting firms from about 4.5% p.a. to about 5.7%, as can be seen by the dashed line. Neutral investors can therefore reap a positive externality in the form of higher returns of polluting firms, since green investors shun this type of stock.

Figure 7 presents returns of shares of clean firms dependent on the number of green investors and again for two different levels of abatement costs. When abatement costs are zero, the return of shares of clean firms is logically exactly the same as the share return of firms with polluting technology. If abatement costs are 10% of expected value, share returns of clean firms are lower. Shares of the first clean firms offer a return of less than 3%. The higher the proportion of green investors, the less the return difference will be in comparison to the situation where abatement costs are zero. When green investors constitute 60% of all investors, the return difference is reduced to about 0.5%.

How is the required return of clean firms affected in a situation where externalities positively influence the expected values of the shares of clean firms? When green investors are less than 40% of the total population, the required return is slightly higher in the case where λ equals 0.1 compared to the case of no positive externalities, as Figure 8 shows. But it has to be remembered from Figure 5, that the first clean firm only appears when green investors constitute more than 40% of the population, so the required return is still not high enough to overcome the risk deduction of equation (2) and therefore is still hypothetical, because no realisation of an investment in abatement takes place. And when green investors surpass the 40% threshold level, the greening of the industry happens at about

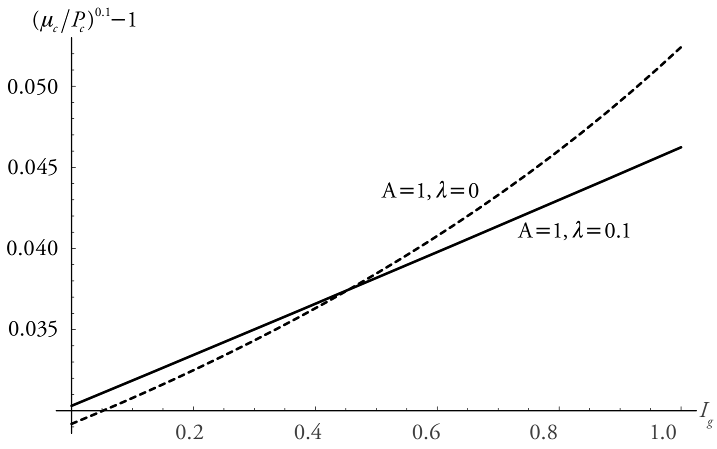
Figure 7: Required Return per Annum of Clean Firms when Abatement Costs Are 0% or 10% of Expected Value



double the speed, due to these positive externalities. Not only green, but also the "free riding" neutral investors acquire shares of clean firms with higher probability. In the end the expected return of shares of clean firms rises more slowly than in the case of the absence of externalities. As we saw in subsection 5.4 the existence of positive externalities leads to "faster" greening, since neutral investors aim to profit from higher expected values of shares of clean firms. This effect on total demand even reduces expected return when green investors are the majority.

When abatement costs are 10% of expected value, the return of shares of clean firms is about 1% to 2% lower per year than the return of shares of polluting firms. This return disadvantage of green investors versus neutral investors seems to be not that big, but the wealth of neutral investors will grow much more strongly than the wealth of green investors due to the compounding effect. It has to be mentioned that abatement takes place only once at the beginning of the 10 year time period. Several rounds of introducing cleaner technology would lower return possibilities more. Since neutral investors optimise their portfolios only with regard to return and risk, they can profit from the appearance of green investors, who shun shares of firms with polluting technology. Required return for such firms will rise, whereas the required return for shares of clean firms will be lower. Neutral investors therefore profit indirectly from strategies of principle guided investors. This holds true also for the case of positive externalities on the expected value of clean firms.

Figure 8: Required Return of Clean Firms when Abatement Costs Are 10% of Expected Value and in the Presence of Positive Externalities $\lambda = 0.1$



7. Implications for the Application of Exclusionary Environmental Screens

The presented model operates with a clear and observable differentiation between firms regarding technology: clean (F_C) or polluting (F_P) firms differ only because of abatement (A). One could argue that neither of these terms is defined precisely. As already mentioned in Section 2, F_C and F_P could alternatively stand for a totally different dimension, e.g. socially acceptable behaviour in which case A would be an investment in a societal cause. In the case of focussing on either dimension (environmental or social), A could also be just a marketing activity to give the impression that the firm belongs to the class of companies which would be bought by principle guided investors. But such window-dressing would only show effects if no objectively verifiable variable is available which can be traced by outsiders. And the aforementioned argument can also be countered by the consideration that the crucial point of view from economics is the question of whether F_C or F_P firms differ with respect to expected return and risk.

An implication of the model results is that principle guided investors can only have an impact if their number surpasses a (variable) threshold level, which is mainly determined by the size of the abatement costs. And this result holds only if, additionally, the condition is fulfilled that green investors hold homogenous beliefs about what differentiates clean from polluting firms. Therefore we conclude that for the application of exclusionary environmental screens, only a clearly defined, objectively measurable dimension for the differentiation between clean and polluting firms should be used. This derives from the implicit assumption of the model that all green investors have unilaterally agreed about which firms are clean or polluting, e.g. have homogeneous beliefs and observations. If they have heterogeneous beliefs about which companies are clean or polluting, the effectiveness of principle guided investments will be weakened. In this situation green investors could agree on a few standard-setting agencies (sustainability rating agency analogous to bond rating agencies), in order to form homogeneous beliefs or could agree on well-accepted methods of evaluating firms concerning their environmental impact.

This aforementioned abstractness of the model has the advantage of flexibility: the results of the model can be applied to the stock market as a whole, or to any subsegment of it, as, for example, on the industry level. If the exclusionary screen is used in an intra-industry sense, green investors could focus on the most important dimensions (e.g. reduction of CO_2-emission, reduction of energy input, etc.). This would not only reduce monitoring costs immensely, but would also have the benefit that the knowledge of analysts could be used to the fullest extent with regard to defining the most important negative externalities of industries and identifying better existing technologies. In certain cases, environmentally better and economically feasible technology is not put in place for reasons of short term cash flow optimisation, as for example in the steel industry in the nineteen seventies (Härtel, Matthies and Mously, 1987).

In the case of almost negligible abatement costs, investment returns to green investors are not that much less than investment returns to neutral investors. In such cases, the application of exclusionary environmental screens is clearly sensible. If the number of green investors is limited, only very few firms will work with clean technology and additionally green investors will have a noticeable return disadvantage. In this situation a collective mutual action of investors using a exclusionary environmental screen, which is focused on just one or few companies in a highly polluting industry, could be undertaken and/or principle guided investors could additionally focus on political action concerning changes of laws, regulations and introduction of taxes on negative externalities (Statman, 2000).

8. Summary and Conclusions

The paper investigates the effectiveness of the application of exclusionary environmental screens by green investors. The presented 2-agents, 1-period model shows, that mainly the size of abatement costs and the number of green investors determine if some firms switch to a clean production technology or not. When shares of clean firms form a clearly distinguishable asset class (not only with regard to return but also with respect to standard deviation and covariation), the positive effect on environmental quality will be higher, because neutral investors will then also invest meaningfully in such shares of clean firms. In any case, the model unequivocally predicts that principle guided investors incur opportunity costs by having portfolios which consist only of shares of clean firms, which deliver less return. If these opportunity costs are too high (which they most likely are for example in the case of pension funds, which have to fulfill their fiduciary obligations vis-a-vis their beneficiaries) the only open channel for change of the green investors' community would be the political channel as STATMAN (2000) already suggests.

Under the assumption that avoidance of pollution incurs abatement costs, the presented model shows that the proportion of firms working with a clean technology highly depends upon the distribution of green and neutral investors. The model also implies that green investors have to forego some investment returns when implementing principle guided investment strategies. Assuming even relatively low abatement costs, the population of green investors has to be sizeable, in order to induce some polluting firms to switch to a clean technology. The model implies that green investors using exclusionary environmental screens will be more successful, the lower the covariation of shares of clean and polluting firms, the lower the risk tolerance of neutral investors and the less risky (standard deviation) shares of clean firms are, and the more homogeneous the beliefs of principle guided investors are.

Event studies provide some empirical support for the argument that shares of clean firms carry less risk then those of polluting firms. Implementing these findings in the assumptions of our model leads to a higher proportion of clean firms, since neutral investors can find shares of clean firms attractive for reduction of risks despite their lower return. If investment in abatement produces a positive externality on expected values of clean firms, than this will result in a higher proportion of clean firms as soon as the first switch has occurred. It could be better reputation or deepened knowledge about production possibilities which could be responsible for the existence of this positive externality. But the economic rewards of these positive externalities will have to be shared between green and neutral investors.

The accurate description of the nature and effectiveness of such positive externalities is still open for further research. In a dynamic context, the fact that the wealth of green investors will grow at a slower pace than that of neutral investors could bring additional fruitful insights on if and how the application of exclusionary screens can be successful.

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SUMMARY

This paper examines how "green" investors can induce firms to invest in clean production technology. The 1-period model incorporates heterogeneous agents – Markowitz investors and green investors – and two groups of firms working either

with clean or polluting technology. Since green investors apply exclusionary environmental screens, some firms will invest in abatement technology in order to switch to a clean technology and thereby raising firm value. The number of firms working with clean technology will be larger, the higher the proportion of green investors, the lower costs of abatement technology, the higher diversification benefits of stocks of clean firms and if positive spill-overs for clean firms exist.