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The Effect of Tax financed Subsidies on Corporate Behaviour and Green Investment

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Lukas Schirnhofer

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1 Abstract

The aim of this work is to explore the effect of a tax financed subsidy on corporate behaviour and green investment. Based on the equilibrium model of Heinkel, Zechner and Kraus (2001), I will show that a tax financed subsidy scheme, with fixed tax rates reduces the importance of green investors on corporate behaviour of polluting firms. In addition to fixed tax rates a variable tax rate will be evaluated in more detail. In particular the number of firms that become reformed is more independent of the number of green investors, in the fixed tax rate scheme and therefore of exclusionary investment but increases the overall economic cost of capital more than in the model presented by Heinkel, Zechner and Kraus 2001. With the variable tax rate setting the effect of the subsidy is only advantageous for a specific range of green investors compared to the settings of Heinkel, Zechner and Kraus 2001.

Keywords: capital gain tax, tax financed subsidy, green investment, corporate behaviour

2 The Heinkel Zechner Kraus (HKZ) Model

In the paper *The Effect of Green Investment and Corporate Behaviour* Robert Heinkel, Alan Kraus and Josef Zechner examine the effects of exclusionary ethical investing on corporate behaviour in a risk-averse, equilibrium setting (Heinkel et al. 2001, further HKZ). They show that fewer investors hold polluting firms since green investors only buy shares of non-polluting firms. This creates a lack of risk sharing within the group of non-green investors which further leads to lower stock prices for polluting firms, thus raising their cost of capital (HKZ, 2001). In the model HKZ assume a simplified world with two types' of investors, both are risk averse. The first investors group are the neutral investors who ignore ethical investment criteria when forming their optimal portfolio. The second group of investors are the green investors who do not invest in firms that do not meet their ethical investment criteria, thus implementing ethical screens on their portfolio selection. The number of firms in this model is finite and each of the two types of firms has one of the two possible production technologies. Firms with the production technology that satisfies the needs of green investors are clean firms. Firms using the polluting technology do not satisfy the ethical criteria of green investors, thus are not taken into their portfolio until they reform their operations (HKZ, 2001). The exclusionary investment made by green investors can be seen as boycott for firms with polluting, unreformed technology. This in turn changes the risk sharing opportunities within the market. Due to the fact that there are now fewer neutral inventors in the market who would buy the shares of firms with polluting technology, the share price falls. This can be seen as a reaction due to the lost diversification possibilities. In their model, HKZ allow polluting firms to make them selves acceptable to green investors at a certain cost. What HKZ are trying to find out is if the presence of green investors is changing the behaviour of polluting firms in terms of reforming. The introduction of green investors to the market and their possible impact on firms leads to three types of firms; acceptable firms with a clean technology, unacceptable firms with polluting technology and reformed firms with polluting technology. There are just two types of technologies and in the model of HKZ technologies do not change when a firm undergoes a reforming act which is shown as paying a certain cost for being acceptable to green investor. Both, green and neutral investors hold acceptable firms. Only neutral investors hold unacceptable firms. It will later be seen that reformed firms are only held buy green investors. HKZ assume that firms act to maximize their share price. The total number of investors is held constant and the impact of various numbers of green investors is analysed. This means that neutral investors demand a higher expected return to be compensated for holding more firms with polluting technology than they want to. Due to the higher expected return of neutral investors the share price of polluting firms falls below the share price of acceptable firms. It can then be seen that the cost of reforming marks a critical variable because if the difference in price exceeds the cost which accrue for a polluting firm to reform and become valuable for green investors, then some firms will reform. This again will broaden the risk sharing opportunities and lower the stock price difference (HKZ). In my work I will show how the implementation of a tax-financed subsidy will influence the behaviour of investors and firms. Throughout section 2 I present the model of HKZ from their paper *The Effect of Green Investment and Corporate Behaviour*. Section 3 presents the extension of the HKZ model. The structure of the presented extension model is the same as the HKZ model in order to get a better comparison. Within section 4 I compare the findings from HKZ with the findings from the extension model.

2.1 Model settings

Heinkel et al. (2001) assume a one period model in which three categories of firms exist. The first category contains acceptable (A) firms, those firms satisfy the investing criteria of green investors. The second category contains unacceptable firms (U), which only satisfy the investing criteria of neutral investors and do not satisfy the criteria of green investors. The third category consists of reformed (R) firms, which did not satisfy green investors previously but after taking a certain cost they are now acceptable to green investors too. All firms work with the same production technology and (U) and (R) firms share a common technology. This means that if a firm wants to switch from category (U) to category (R) switching cost accrue that make the firm acceptable to green investors but the original technology is retained. *N* is the total number of firms and can be split into N_A acceptable firms, N_U unacceptable firms and N_R reformed firms. Firms out of category (*A)* use the clean technology and generate a normally distributed cash flow with mean μ_C and variance σ_C^2. Between (*A)* firms the cash flows are perfectly correlated. Firms (*U)* and (*R)* use the polluting technology; those firms generate a normally distributed cash flow with the mean μ_P and the variance σ_P^2. Again the cash flows are perfectly correlated with each other. The covariance between (*A)* firms, (*U)* firms and (*R)* firms is σ_{CP}. The HKZ model contains a riskless asset in addition to the risky production technologies; the rate of return of the riskless asset is normalized to zero and in perfect elastic supply. Because of the simplifying assumption that the cash flows of (*U)* and (R) firms are perfectly correlated, short selling of shares is prohibited. Borrowing is allowed.

HKZ assume two types of investors $i \in \{n, g\}$ which differ in their tolerance of environmental damage. Green investors (*g*) do not hold shares of unacceptable firms; whereas neutral investors (*n*) have no preferences for one category of firms over the other. The total number of *I* investors contains I_n neutral investors and I_g green investors. Both types of investors exhibit constant absolute risk aversion (CARA) and a risk tolerance parameter τ.

The total number of firms *N* consists of N_P firms that use the polluting technology and N_C firms that use the clean technology. Firms with the polluting technology have the opportunity to reduce their environmental damage at a certain cost *K* this means that the firms become reformed. Due to the fact that the firm is now a reformed firm it becomes eligible for the inclusion into the green investors portfolio selection. HKZ assume that reformed firms retain their original risk return characteristics. The number of firms that pay the reforming costs of K is denoted with N_R. The total number of firms consists then of: $N_C = N_A$ the originally clean firms that have the risk and return σ_C and μ_C; firms N_U the unacceptable and polluting firms with the risk and return σ_P and μ_P, and further the reformed firms N_R that have the same risk and return as the polluting firms σ_P and μ_P. HKZ now divide the total number of firms by technologies as

$$N = N_C + N_P$$

Further the firms are classified by their acceptability to green investors that gives

$$N = N_A + N_U + N_R$$

Acceptable firms do not change their production technology, which gives

$$N_C = N_A \quad and \quad N_P = N_U + N_R$$

The utility functions are given by the combination of CARA and normally distributed cash flows

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

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

Where x_{ik} represents 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 and ω_{ik} is the endowment of shares in firms of category k of a type i investor.

Investors of type I_n choose between acceptable and unacceptable firms. Due to the same risk-return characteristics between unacceptable and reformed firms and the higher share price of reformed firms, it is not optimal for neutral investors to hold reformed firms. Unacceptable firms will only invest K to become reformed firms if the share price subsequent to the investment needed, exceeds that of unacceptable firms by the amount K (HKZ, 2001). There for, neutral investors optimize their utility with respect to x_{nA} and x_{nU}. Setting x_{nR} = 0 reflects the short selling restriction which prohibits neutral investors from gaining an unlimited arbitrage profit due to the fact that reformed firms retain their technology. HKZ point out that the unlimited arbitrage profits are due to the fact that in equilibrium the price for reformed firms is higher than the price for unacceptable firms. In a model with reformed firms assuming the clean technology, no short selling restriction is required (HKZ, 2001). HKZ get the first order condition for neutral investors' optimal portfolio holdings by taking the derivation of U_n with respect to x_{nA} and x_{nU}. This can be rewritten as

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

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

HKZ solve now simultaneously to get neutral investors' optimal portfolio holdings,

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

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

Where $\Phi = \sigma_C^2\sigma_P^2 - \sigma_{CP}^2$

Green investors only buy shares from acceptable and from reformed firms and therefore optimize over x_{gA} and x_{gR}. The first order conditions for green investors are,

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

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

Solving simultaneously again yields to green investors' optimal portfolio holdings,

$$(9) \qquad x_{gA}^* = \frac{\tau}{\Phi}\left[(\mu_C - P_A)\sigma_P^2 - (\mu_P - P_R)\sigma_{CP}\right],$$

$$(10) \qquad x_{gR}^* = \frac{\tau}{\Phi}\left[(\mu_P - P_R)\sigma_C^2 - (\mu_C - P_A)\sigma_{CP}\right],$$

HKZ derive the equilibrium share prices by substituting the optimal portfolio holdings into the following market clearing conditions.

$$(11) \qquad I_n X_{nA}^* + I_g X_{gA}^* = N_A = N_C$$

$$(12) \qquad I_n x_{nU}^* = N_U$$

$$(13) \qquad I_g x_{gR}^* = N_R$$

The results from the substitution provide the equilibrium share prices shown in equations (14), (15) and (16).

$$(14) \qquad P_A = \mu_C - \frac{1}{I\tau}\left[N_C\sigma_C^2 + N_P\sigma_{CP}\right],$$

(15) $$P_U = \mu_P - \frac{1}{I\tau}\left[N_C\sigma_{CP} + N_U\sigma_P^2 + N_U\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} + N_R\frac{\sigma_{CP}^2}{\sigma_C^2}\right],$$

(16) $$P_R = \mu_P - \frac{1}{I\tau}\left[N_C\sigma_{CP} + N_U\frac{\sigma_{CP}^2}{\sigma_C^2} + N_R\sigma_P^2 + N_R\frac{I_n}{I_g}\frac{\Phi}{\sigma_C^2}\right],$$

HKZ note that the price of an acceptable firm P_A is independent of the number of green investors, I_g. This can be verified if by taking the total derivative of the first market clearing condition in equation (11) through equation (13) with respect to I_g. If we look on equation (12), which is $N_U = N_P - N_R$, we can see that the change in demand by investor *n* for unacceptable firms must equal, with opposite signs, the change in demand by investor *g* for reformed firms. Taking a look at the equilibrium it shows that the change in the demand function for unacceptable firms by investor *n* is equal to the change in the demand by investor *g* for reformed firms. In the case of an acceptable firm, the demand functions of investors' *n* and *g* change with the price in the same way. The price of an acceptable firm must remain unchanged to balance the change in demand of acceptable firms held by investors' *n* and *g.* HKZ continue now to look at the optimal corporate acceptability choice. To get the number of reformed firms, N_R, by taking into account that the number of unacceptable firms that can get reformed by paying the price *K,* will either be zero or adjust until the price of reformed firms is equal to the price of an unacceptable firm plus the reforming costs *K.* This can be written as, $P_R = P_U + K$. If we solve this equation now for N_R we get,

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

HKZ now define a crucial variable, I_g^*, which is the number of green investors that apply ethical screens that is required to induce the first unacceptable firms to reform and become attractive to green investors.

This crucial variable depends on the number of firms acceptable, the risk tolerance of investors and the covariance between the cash flows produced by the two technologies the cost of becoming reformed. In the basic model I_g^* is defined as the value of I_g at which N_R becomes positive in equation (17). This can be written as,

(18) $I_g^* : N_R > 0 \quad for \quad I_g > I_g^*$

HKZ focus on how the change of the model's parameters influences the number of reformed firms by using comparative statics. They show that N_R is monotonic in I_g. In equation (17) as I_g goes to zero, also N_R does, further as $dI_g + dI_n = 0$ it can be seen that N_R goes to $N - N_C$ as I_g goes to I. HKZ take now the total derivative of N_R with $dI_g + dI_n = 0$, this yields $dN_R / dI_g \geq 0$. It emerges that whenever N_R is greater then 0, an increase in the number of green investors leads to an increase in the number of reformed firms. The total number of investors is held constant, thus a higher number of green investors means that the number of neutral investors who are willing to hold unacceptable firm's shares is fewer. The resulting lower demand for unacceptable firm's shares leads to a downward price pressure that decreases the share value of unacceptable firms. This downward pressure now induces more unacceptable firms to pay the cost of reforming, *K,* to become a reformed firm and acceptable for green investors. HKZ show now that an increase of the cost of reforming, *K*, in equation (17) leads to fewer unacceptable firms becoming reformed, as the downward pressure must be higher. Further the increase in the risk tolerance parameter, τ, results in a decrease of the number of reformed firms. This is due to the fact that reformed firms increase the diversification possibilities for the green investors; this matter is not strong if green investors are more risk tolerant. Next HKZ state that the number of reformed firms is a concave function of the covariance and the correlation between the cash flows of the polluting technology and the clean technology that has its unique maximum where the covariance is zero.

This can be seen in the special case where the two technologies have the same risk-return features and the number of firms of each technology is equal. HKZ consider now the case where the correlation is minus one. In this case the neutral investors can own all firms without having any risk and there are no incentives for unacceptable firms to reform. The case of the other extreme, when the cash flows are perfectly positively correlated shows that all possible portfolios have the same risk-return features and there are no incentives for unacceptable firms to reform as in the case of a correlation of minus one. Next HKZ consider the case of a correlation between these two extremes, there arise now diversification gains for unacceptable firms reforming; these gains increase as the correlation goes to zero. At last the number of reforming firms varies with the number of originally acceptable firms, which comes clear from equation (17) as the number of reformed firms decreases with an increasing number of acceptable firms'. Green investors suffer a diversification loss when the number of acceptable firms is high from the beginning and the number of unacceptable firms is low. As the share price of unacceptable firms is high and this in turn provides little incentive for an unacceptable firm to reform. If the share price of an unacceptable firm is low they reform to increase their share price, for example through a reduction in of their cost of capital.

HKZ state that given expected future cash flows, $\mu_i, j \in \{C, P\}$, a firm's cost of capital $\mu_i / P_K - 1, k \in \{A, U, R\}$ is inversely related with its share price P_K. By substituting the definition of N_R given in equation (17) into the expression for P_R in equation (16) HKZ get

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

HKZ examine the comparative statics of P_R with respect to the model parameters to determine in which way reformed firm's cost of capital changes with the change of the model parameters. First they find that reformed firm's cost of capital decreases as the cost of reforming increase. This is due to the fact that a larger drop in the cost of capital is required to justify the lager reforming costs. HKZ find that more green investors imply a higher cost of capital for reformed firms. The number of investors is fixed and if the number of green investors is higher this means a lower number of neutral investors that leads to a lower price for unacceptable firms. When it comes to the equilibrium the price of a reformed firm is equal to the price of unacceptable firms plus the cost of reforming *K.* Thus HKZ state that a lower unacceptable firm price implies a lower reformed firm price that implies a higher cost of capital for reformed firms and that more risk tolerant investors could quite obviously provide a lower cost of capital for all firms. Finally HKZ find that the cost of capital for reformed firms is monotonically increasing in the covariance between cash flow of the polluting technology and the cash flow of the clean technology and that decreasing the diversification possibilities between the technologies raises all firms' cost of capital.

2.2 Numerical example

With the analytical results HKZ provide a number of insights, but they do not provide the magnitude of the endogenous variables (HKZ, 2001). To give a better understanding for the endogenous variables HKZ calculate values for critical variables like I_g^* the number of green investors required forcing the first unacceptable firm to reform. The base case parameters that were used in the base case by HKZ are the following,

Technology Parameter:

Mean Cash Flows:	$\mu_C = \mu_P = 10$
Standard Deviation of Cash Flows:	$\sigma_C = \sigma_P = 10$
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: $N_C = N_P = 0.5$

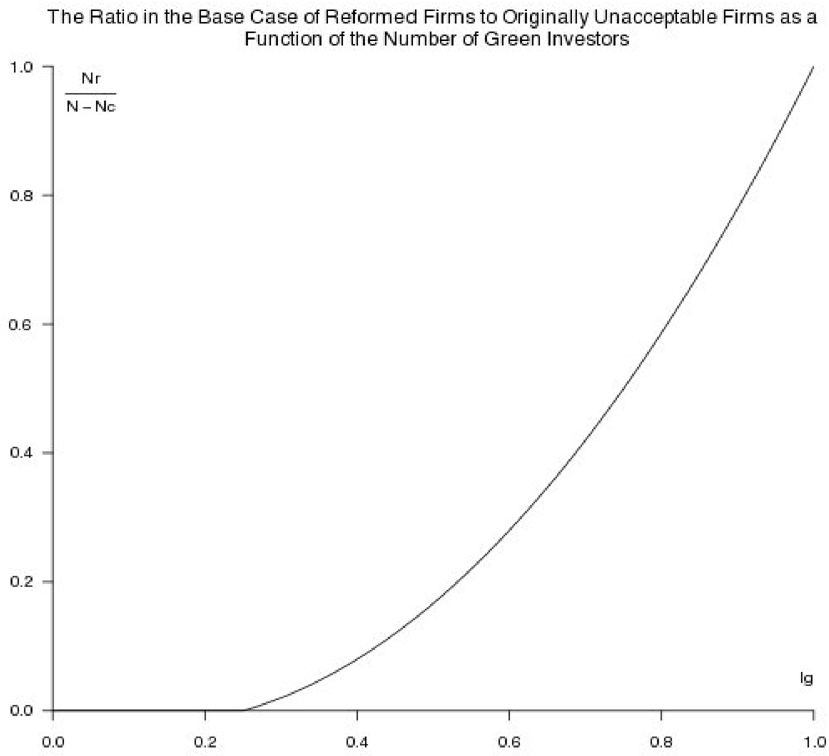
Investor's parameter:

Aggregate Risk Tolerance: $\tau = 100$

The parameters stated above were chosen in this way by HKZ to produce reasonable firm costs of capital. Additionally the structure of the variance-covariance matrix of cash flows was selected by the authors to provide the numerical examples with reasonable results for the standard deviation of the rate of return. HKZ select three endogenous variables on which they want to test the impact of varying the crucial variable I_g^*, the number of green investors required forcing the first unacceptable firm to reform. The first endogenous variable is the number of reformed firms, as a percentage of the number of originally polluting firms, $N_R/(N - N_C)$. The second endogenous variable is the cost of capital of unacceptable firms, $(\mu_P / P_U) - 1$. The third endogenous variable is the cost of capital of reformed firms, $(\mu_P / P_R) - 1$. HKZ show these effects in 6 graphs.

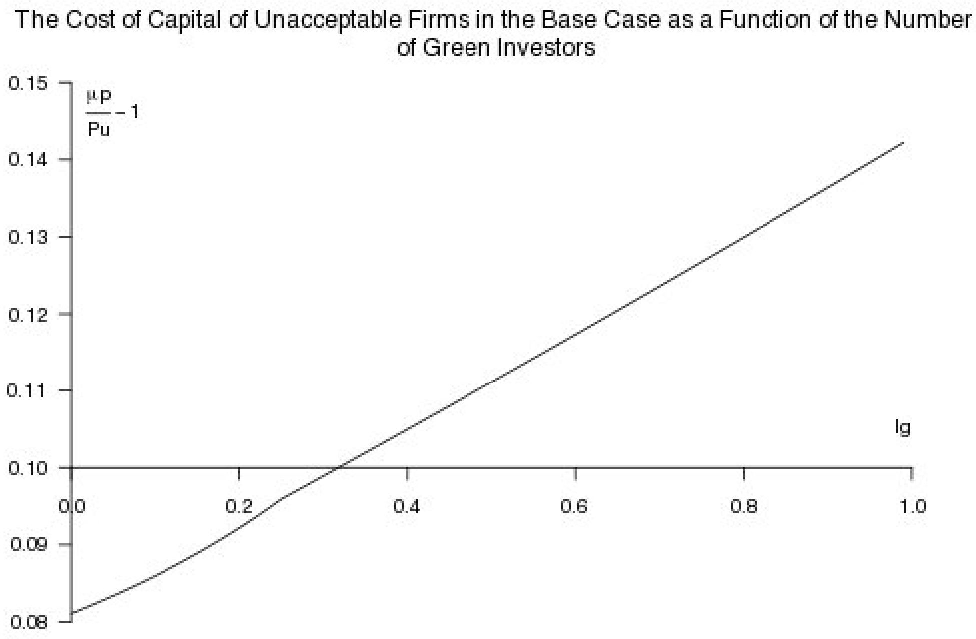
2.3 Results from the Numerical example

HKZ show their findings from the numerical example with several graphs that provide an insight in the changes that accrue on the three endogenous variables through varying the crucial variable I_g^*. Figure 1 shows that the critical value of the number of green investors where the first polluting firm is induced to reform starts at 25 % of the investors population. The axis of abscissas shows percentage of green investors of the total population. The axis of ordinates shows the ratio of reformed firms to originally polluting firms. This figure has a convex curve that indicates that the marginal effect of additional green investors on reformed firms is increasing (HKZ, 2001).

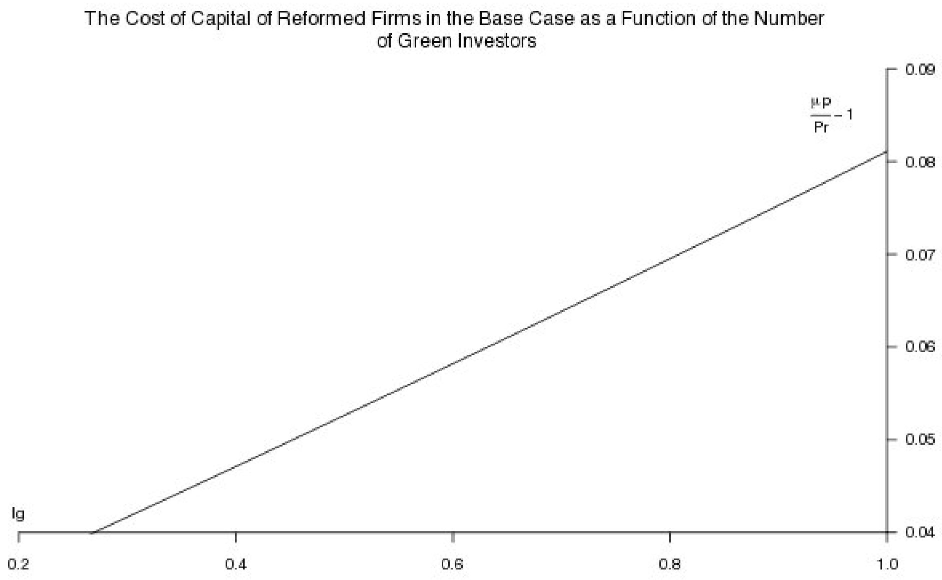


Source: Heinkel et al. (2001) Figure 1

Figure 2 and Figure 3 show the cost of capital of unacceptable firms and reformed firms respectively. The cost of capital of unacceptable firms is about 9.5 % where as the cost of capital for reformed firms are only 3.9 % in the base case of HKZ. This large difference in the cost of capital is required to induce the first firm to reform (HKZ, 2001). The axis of ordinates in Figure 2 shows the cost of capital of polluting firms and the axis of abscissas indicates the percentage of green investors of the total investor's population. The axis of ordinates in figure 3 shows the cost of capital of reformed firms and its axis of abscissas shows the number of green investors of the total investor's population. Figure 2 and Figure 3 further show that the higher the number of green investors the higher the cost of capital for polluting firms and for reformed firms. As HKZ note 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.

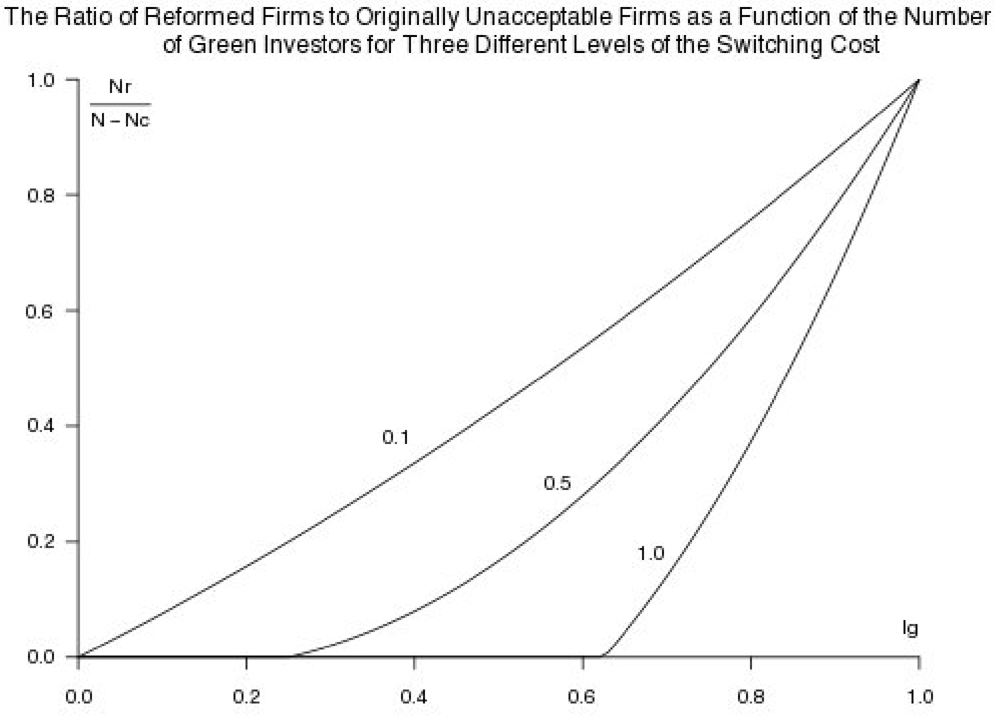


Source: Heinkel et al. (2001) Figure 2



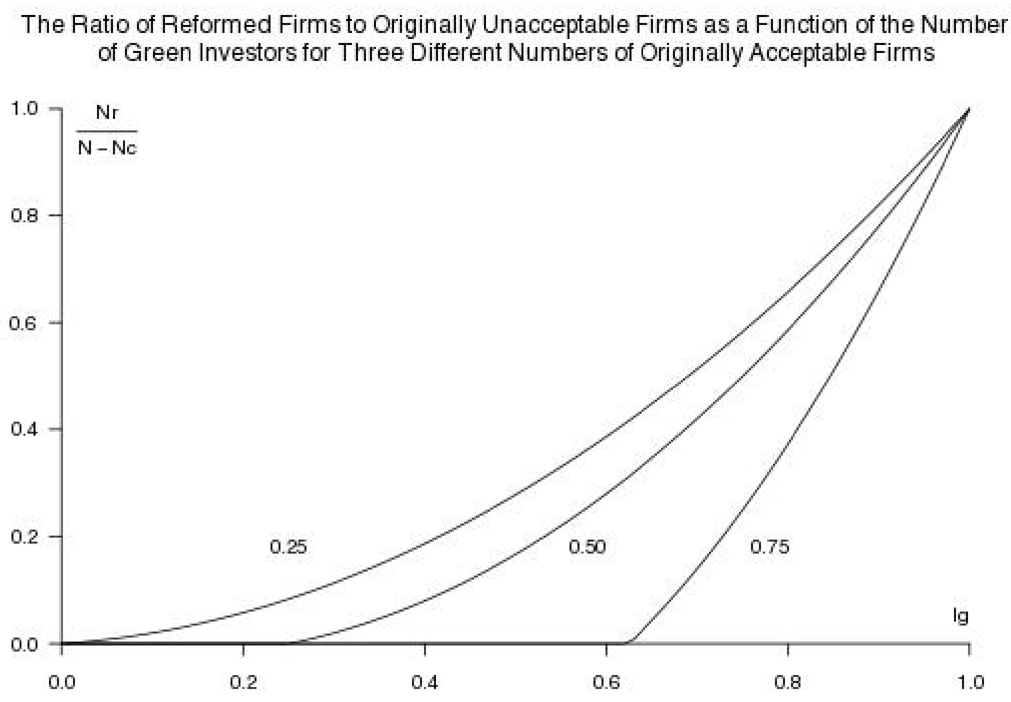
Source: Heinkel et al. (2001) Figure 3

In figure 4 HKZ show how varying the reforming costs affects the number of reformed firms. The autors look at three different leves of reforming costs, first *K* = 0, 1, second *K* = 0, 3 and at last *K* = 1. The axis of ordinates shows the ratio of reformed firms to originally polluting firms; the axis of abscissas shows the number of green investors as a percentage of the total investor's population. At reforming costs of *K* = 0, 1 the critical variable I_g^* is zero. By switching the cost of reforming to *K* = 1 the high pressure of the increased reforming costs prevents unacceptable firms to undertake reforming until the number of green investors has reached 60 % of the total number of investors. By comparing figure 2 and figure 3 it can be seen that the cost of capital of unreformed firms is more then doubled the cost of capital of reformed firms.



Source: Heinkel et al. (2001) Figure 4

HKZ show in Figure 5 how the number of originally acceptable firms, N_C, affects the number of reformed firms. The axis of abscissas shows the percentage of green investors of the total population. The axis of ordinates shows the ratio of reformed firms to originally polluting firms. Assuming that there would be no green investors and, P and C technologies would have the same risk and return features, and that firms would be able to select their technology then 50 % of firms would choose the green technology. The states of N_C = 0, 25 and N_C = 0, 75 are also shown in Figure 5. HKZ interpret the N_C here as the proportions of all firms that green investors find acceptable for their investment before they start to restrict their investment. Further this graph indicates that no unacceptable firm will reform until the number of green investors has reached 60 % if investors consider 75 % of all firms to be acceptable and 25 % not acceptable.



Source: Heinkel et al. (2001) Figure 5

So far HKZ have shown the cost of capital of unacceptable firms and those of acceptable firms. In a simple setting where all firms face the same investment opportunity set HKZ state that the weighted average cost of capital determines the total level of investment in the economy. The (WACC) weighted average cost of capital is:

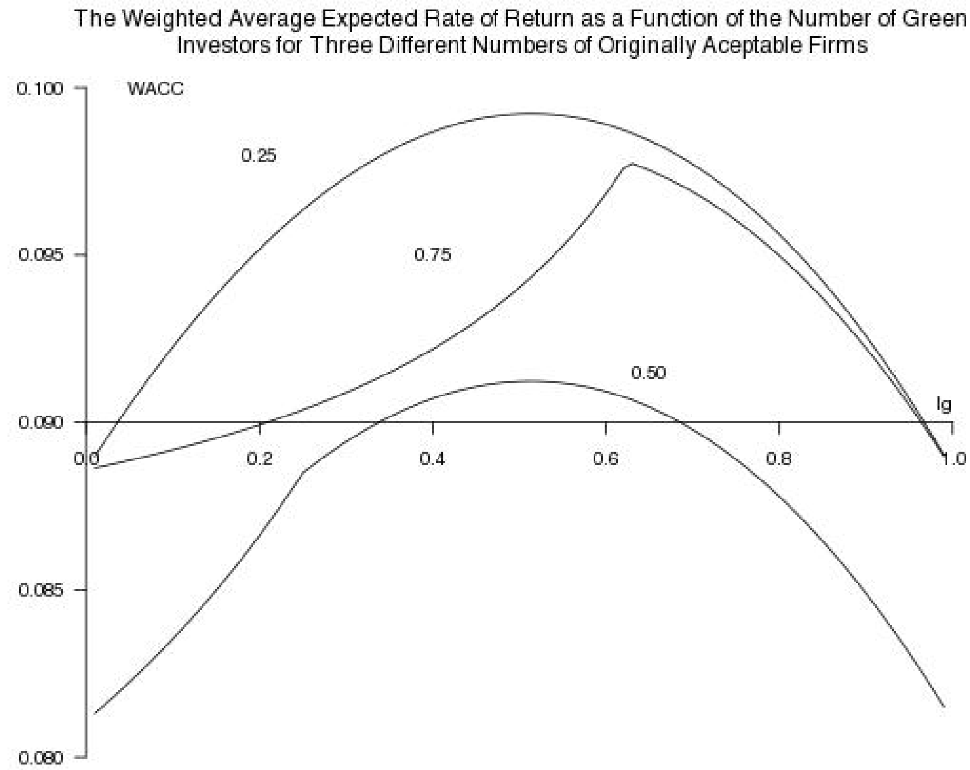
$$WACC \quad = \quad N_C \frac{\mu_C}{P_A} + N_R \frac{\mu_P}{P_R} + N_U \frac{\mu_P}{P_U} - 1$$

HKZ show in Figure 6 the WACC and how it varies with I_g for three different settings of N_C. The axis of abscissas shows the percentage of green investors of the total population. The axis of ordinates shows the WACC. In section III of their paper the authors indicate that if the cost of reforming K is bigger than zero I_g^* is also bigger than zero. This implies that if $I_g = 0$, both N_R and dN_R / dI_g are zero, so at $I_g = 0$, $N_U = N_P$. HKZ use this to show the derivative of the WACC with respect to I_g, at $I_g = 0$, changes only due to a change in P_U. The price of acceptable firms P_A as well as the number of reformed firms N_R stays unchanged if N_C and N_U are constant because both green and neutral investors hold acceptable firms. Now HKZ let I_g increase from zero which means that the risk sharing opportunities are decreasing because green investors do not buy unacceptable firms which in turn decreases the price of unacceptable firms P_U.

This implies that the WACC increases with I_g, at $I_g = 0$. At $I_g = 1$ all polluting firms have become reformed so that the third term in the WACC equation, $N_U \left(\mu_P / P_U\right)$, becomes zero. At this point P_R at $I_g = 1$ equals P_U at $I_g = 0$ because all investors are willing to buy all available firms. Thus the WACC at $I_g = 0$ equals the WACC at $I_g = 1$. At last HKZ indicate why the curves for $N_C = 0, 50$ and $N_C = 0, 75$ are different from $N_C = 0, 25$ in Figure 6.

Given a large number for N_C (0, 75), I_g^* is also large, thus there must be a higher number of green investors before the first unacceptable firms becomes reformed. The only effect of increasing I_g is that P_U becomes lower; this in turn causes the WACC to increase at an increasing rate. This increase can be reduced for $I_g > I_g^*$ because in this case when P_U is decreasing, firms are now willing to switch but through this ease the effect of the worsening risk sharing. Thus the WACC is a convex curve for I_g <

I_g^* but becomes a concave curve after that point. The curve for N_C = 0.25 also has the same WACC levels at I_g = 0 and I_g = 1.



Source: Heinkel et al. (2001) Figure 6

3 Extension of the HKZ model

In this section I present the model extension to the original HKZ model. The basic intention to extend the HKZ model was to find if it is possible to increase the number of reformed firms without relying on the number of green investors. The basic approach to reach this goal is the implementation of a state subsidy, which will be financed via a capital gain tax.

HKZ indicate in their paper that social investing can impact firms' environmental and ethical behaviour. It becomes quite clear in their findings that the population that uses exclusionary investment screens to boycott socially and environmentally irresponsible firms determines the number of reformed firms. The findings of the analytical and numerical calculations show that roughly 25 % of the total investor's population have to be green investors to overcome the cost of reforming firms bear in order to reform. HKZ also present empirical findings that indicate that in 2001 only 10 % of investable funds are invested socially and environmentally responsible. HKZ state that with their model settings a 10 % fraction of green investors does not impact firm's behaviour but increases the cost of capital in the overall economy. Based on the basic settings of the HKZ model, their findings and the empirical evidence that in 2008 12 % of investable funds where invested socially and environmentally responsible (EUROSIF Report, 2008), the aim of this paper is to survey how the 25 % of green investors can be lowered and how firms can be encouraged to reform earlier anyway. My approach is based on two basic assumptions that will be added to the HKZ model in order to survey the possible changes.

3.1 General model assumptions

HKZ show by varying reforming cost variable K that this has a significant influence on firm's decision policy. HKZ vary the cost of reforming K by using three different values for this variable $K = 0, 1; K = 0, 5$ and $K = 1$. In order to overcome the dependency of green investors in the HKZ model I implement a mechanism that overcomes this interconnection. In this subsection I will present the assumptions that compose the model extension of the HKZ model.

3.2 First assumption

The first assumption of the extended model will be a new institution. Originally HKZ use firms, acceptable and unacceptable, and the total investor population. Additionally to these settings a government or state institution is added to the model. The purpose of the government is to impose a capital gains tax. For simplicity this tax will be collected from all investor's neutral and green, in order to avoid equal treatment issues. I further assume that this introduced government does not bear any administrational cost for the collection of the tax and the distribution of the subsidy. This means that the tax is distributed directly to firms that want to become reformed. In section 3.8 I will in detail look at the restriction where the tax produce only such funds that are needed to provide a definite amount of the subsidy.

3.3 Second assumption

The second assumption is that this institution simultaneously introduces a subsidy program to encourage firms to become reformed. This program is financed directly with the capital gain tax revenues. In the original HKZ model firms have to pay reforming costs of K in order to become reformed and be attractive to green investors. In the extension model, firms still have to pay reforming cost but parts of these costs are borne by the government through the funding program. Investors have to deal now with the presence of a capital gain tax. This fact will be incorporated in their utility function in order to reflect the changes in investor's utility. Further firms will not have the same pressure on their share price if they become reformed as they have in the original model. In section 3.4 it will be shown analytically how the capital gain tax is incorporated into the utility functions of neutral and green investors and how this will influence the corporate behaviour of firms. The structure of the analytical calculations is the same as in HKZ.

3.4 Analytical survey

The original utility function of neutral Investors in HKZ is

$$U_n = x_{nA}\mu_C + (x_{nU} + x_{nR})\mu_P$$

(20) $$-\frac{x_{nA}^2\sigma_C^2 + (x_{nU} + x_{nR})^2\sigma_P^2 + 2x_{nA}(x_{nU} + x_{nR})\sigma_{CP}}{2\tau}$$

$$-(x_{nA} - \omega_{nA})P_A - (x_{nU} - \omega_{nU})P_U - (x_{nR} - \omega_{nR})P_R$$

The original utility function of green Investors in HKZ is

$$U_g = x_{gA}\mu_C + x_{gR}\mu_P - \frac{x_{gA}^2\sigma_C^2 + x_{gR}^2\sigma_P^2 + 2x_{gA}x_{gR}\sigma_{CP}}{2\tau}$$

(21)

$$-(x_{gA} - \omega_{gA})P_A - (x_{gR} - \omega_{gR})P_R$$

HKZ derive the optimal portfolio choices of neutral and green investors by taking the derivative of the utility function with respect to the corresponding x_n and x_g, and solving these equations simultaneously. In order to get the optimal portfolio choices under the assumption of a capital gains tax it is necessary to adjust the utility functions of all investors. It is important to do so in order to reflect the changes in utility due to the capital gain tax investors have to pay in the extended model.

The new utility function of neutral investors adjusted by the capital gain tax is

$$U_n = x_{nA}\mu_C + (x_{nU} + x_{nR})\mu_P$$

(22)
$$- \frac{x_{nA}^2\sigma_C^2 + (x_{nU} + x_{nR})^2\sigma_P^2 + 2x_{nA}(x_{nU} + x_{nR})\sigma_{CP}}{2\tau}$$

$$- (x_{nA} - \omega_{nA})P_A - (x_{nU} - \omega_{nU})P_U - (x_{nR} - \omega_{nR})P_R$$

$$- (x_{nA}\mu_C - x_{nA}P_A)T - (x_{nU}\mu_P - x_{nU}P_U)T - (x_{nR}\mu_P - x_{nR}P_R)T$$

The last line in the utility function reflects the tax burden neutral Investors bear. The tax to be paid is calculated by subtracting the value of the shares from the value of the expected return and multiplying it by the tax. The assumption that short selling is restricted, made by HKZ in order to prevent possible unlimited arbitrage gains, also applies in this case.

The new utility function of green investors adjusted by the capital gains tax is

$$U_g = x_{gA}\mu_C + x_{gR}\mu_P - \frac{x_{gA}^2\sigma_C^2 + x_{gR}^2\sigma_P^2 + 2x_{gA}x_{gR}\sigma_{CP}}{2\tau}$$

(23)
$$- (x_{gA} - \omega_{gA})P_A - (x_{gR} - \omega_{gR})P_R$$

$$- (x_{gA}\mu_C - x_{gA}P_A)T \; - (x_{gR}\mu_P - x_{gR}P_R)T$$

The last line in the utility function reflects the tax burden green investors bear. The tax to be paid is calculated by subtracting the value of the shares from the value of the expected return and multiplying it by the tax.
Taking into account the short selling restriction from the original model of HKZ neutral investors optimize their portfolio holdings by taking the derivative of U_n with respect to x_{nA} and x_{nU} and set x_{nR}=0.

Doing so leads to the first order conditions for neutral investors.

(24) $x_{nA}\sigma_C^2 + x_{nU}\sigma_{CP} - \tau\left[(\mu_C - P_A) - (\mu_C - P_A)T\right] = 0$

(25) $x_{nA}\sigma_{CP} + x_{nU}\sigma_P^2 - \tau\left[(\mu_P - P_U) - (\mu_P - P_U)T\right] = 0$

Solving these equations simultaneously provides the neutral investors' optimal portfolio holdings. Further I use the same subsumption as HKZ

$$\Phi = \sigma_C^2\sigma_P^2 - \sigma_{CP}^2$$

(26) $x_{nA}^* = \frac{\tau}{\Phi}\left\{\left[(\mu_C - P_A) - (\mu_C - P_A)T\right]\sigma_P^2 - \left[(\mu_P - P_U) - (\mu_P - P_U)T\right]\sigma_{CP}\right\}$

(27) $x_{nU}^* = \frac{\tau}{\Phi}\left\{\left[(\mu_P - P_U) - (\mu_P - P_U)T\right]\sigma_C^2 - \left[(\mu_C - P_A) - (\mu_C - P_A)T\right]\sigma_{CP}\right\}$

By taking the derivative of green investor's utility function with respect to x_{nA} and x_{gR} I get the first order conditions for green investors' optimal portfolio holdings

(28) $x_{gA}\sigma_C^2 + x_{gR}\sigma_{CP} - \tau\left[(\mu_C - P_A) - (\mu_C - P_A)T\right] = 0$

(29) $x_{gA}\sigma_{CP} + x_{gR}\sigma_P^2 - \tau\left[(\mu_P - P_R) - (\mu_P - P_R)T\right] = 0$

Solving these equations simultaneously provides the green investors' optimal portfolio holdings.

$$\Phi = \sigma_C^2\sigma_P^2 - \sigma_{CP}^2$$

(30) $x_{gA}^* = \frac{\tau}{\Phi}\left\{\left[(\mu_C - P_A) - (\mu_C - P_A)T\right]\sigma_P^2 - \left[(\mu_P - P_R) - (\mu_P - P_R)T\right]\sigma_{CP}\right\}$

(31) $x_{gR}^* = \frac{\tau}{\Phi}\left\{\left[(\mu_P - P_R) - (\mu_P - P_R)T\right]\sigma_C^2 - \left[(\mu_C - P_A) - (\mu_C - P_A)T\right]\sigma_{CP}\right\}$

By using the same market clearing conditions as HKZ I get the new equilibrium prices by substituting the new tax adjusted portfolio holdings into these conditions. The purpose of using the same market clearing conditions as HKZ is to increase the comparability to the HKZ model. The intermediate steps to this calculation can be found in the Appendix.

(32) $$I_n x_{nA}^* + I_g x_{gA}^* = N_A = N_C$$

(33) $$I_n x_{nU}^* = N_U$$

(34) $$I_g x_{gR}^* = N_R$$

As HKZ mention that in equilibrium the price for reformed firms is higher than the price for unacceptable firms, and both firms have the same risk and return characteristics, a short selling restriction is binding for neutral investors in this case in order to prevent them from unlimited arbitrage profits. In a model where reformed firms change their technology from polluting to clean this restriction will not be required as HKZ state in their paper. Urs von Arx in his working paper *Principle guided investing: The use of negative screens and its implications for green investors (05/45)* has surveyed the implications a change of technology will have. He sets up a model where firms switch to a clean technology by investing in abatement and therefore a change not only in the expected return but also in risk characteristics is assumed. He introduces a new asset class with this change in the risk and return characteristics. As a side effect an additional diversification effect occurs. This additional diversification effect can have, under certain conditions, 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 (Urs von Arx, 2005). In my work I will not include such a model that deals with a change in technology for firms that want to reform.

The new resulting equilibrium prices based on the basic assumptions of HKZ and adjusted by the capital gains tax are

$$(35) \quad P_A = \mu_C - \left[\frac{1}{(1-T)}\right]\left[\frac{1}{I\tau}\right]\left[\sigma_C^2 N_A + \sigma_{CP} N_P\right],$$

$$(36) \quad P_U = \mu_P - \left[\frac{1}{(1-T)}\right]\left[\frac{1}{I\tau}\right]\left[\sigma_{CP} N_C + \sigma_P^2 N_U + N_U \frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} + N_R \frac{\sigma_{CP}^2}{\sigma_C^2}\right],$$

$$(37) \quad P_R = \mu_P - \left[\frac{1}{(1-T)}\right]\left[\frac{1}{I\tau}\right]\left[\sigma_{CP} N_C + N_U \frac{\sigma_{CP}^2}{\sigma_C^2} + N_R \sigma_P^2 + N_R \frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2}\right],$$

As HKZ state in their work also here that in equation (36) the price for an acceptable firm, P_A, is independent of the number of green investors. HKZ state that 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

(38) $P_R = P_U + K$

Recalling the second assumption from section 3.3 of the extended model that the government launches a program to subsidies the cost of reforming with a tax financed subsidy, equation (38) can be rewritten as

(39) $P_R = P_U + (K-dK)$

Where *dK* denotes the tax-financed subsidy

(40) $$dK = T\left[N_C\left(\mu_C - P_A\right) + N_U\left(\mu_P - P_U\right) + N_R\left(\mu_P - P_R\right)\right],$$

The fact that *dK* is not only depending on the gain but also on the number of firms acceptable, unacceptable and reformed, secures that the collection of the tax is not dependent on the distribution of the neutral and green investors. Like HKZ, the equality equation (39) will be solved for N_R. With respect to the assumptions made in sections 3.1 and 3.2 the incorporation of the tax term into the utility function and the variable *dK* into equation (39), solving for N_R leads to a quadratic equation as solution for N_R. The complete mathematical calculus can be found in the Appendix. The fact that N_R cannot be negative leaves only one solution for the quadratic equation. Due to the fact that the original equation is very long, I have chosen to replace the last term of the original equation (41) with the Greek letter Λ.

(41) $$N_R = \frac{-2\left[1 + T(N - N_C)\right] \pm \sqrt{\left[2(1 + T(N - N_C))\right]^2 - 4 * 2 * T * \Lambda}}{2 * 2 * T}$$

(42) $$\Lambda = K(1-T)I_n \tau \frac{\sigma_C^2}{\phi} - (N - N_C)(1 + T(N - N_C)) - \frac{I_n}{I}\frac{\sigma_C^2}{\phi} T\left[N_C^2\sigma_C^2 + 2N_C(N - N_C)\sigma_{CP} + (N - N_C)^2\sigma_P^2\right]$$

The main driver for the number of reformed firms is now the variable *T* representing the capital gain tax and thereby indirectly *dK,* the subsidy.

3.5 Analytical differences of HKZ and the extended model

In section 3.1 and 3.2 I state the prime assumptions as extension of the HKZ model. The basic idea was how to decrease the number of green investors but simultaneously hold the number of reforming firms constant or even increase it. HKZ derive the optimal portfolio choices of neutral and green investors by taking the derivative of the utility function with respect to the corresponding x_n and x_g, and solving these equations simultaneously. In order to get the optimal portfolio choices under the assumption of a capital gain tax it was necessary to adjust the utility functions of all investors. It is important to do so in order to reflect the changes in utility due to the capital gains tax. This is the point in the extension where the first analytical difference appears. Due to this change every following analytical step is changed. We see this primarily in equation (24) where neutral investors, due to the incorporation of the tax in the utility function, first order condition is extended by the tax term *T.*

In the following the optimal portfolio choice equations also reflect the investor's change in utility due to the newly introduced tax.

Using the same market clearing conditions like HKZ provides comparability to the original model. This also implies that the main assumptions of HKZ stay untouched, except the extension. Following the analytical calculation to equation (39) we come to the incorporation of the tax financed subsidy. The variable *dK* is presented in equation (40). This marks the biggest difference in the analytical calculation compared to HKZ. Unlike HKZ I get a quadratic equation as solution for N_R. The full calculus for N_R can be found in the Appendix. In the main part I presented the solution for N_R, which is already solved analytically with the basic formula for quadratic equations (see Appendix).

HKZ define a variable of particular interest I_g^*, as the value of I_g at which N_R becomes positive in their equation for N_R.

Recalling the assumption made in the extended model and the mathematical calculus in section 3.4, reveals that in this model the variable N_R is primarily dependent on the variable *T*. It can be seen in equation (41) that *T* can be very small but has to be positive in order to get a solution for N_R. In the original HKZ model, the number of green investors was the most important variable to define when the first firm will become reformed.

Further HKZ showed that varying the cost of reforming *K* has a significant importance for the number of firms that choose to switch from unacceptable to reform in order to be attractive to green investors. The pressure that green investors put on the market through their increase in presence is a main driving factor in the HKZ findings. Through equation (41) it comes clear that the presence of green investors is not that important anymore in order to get the first firm to switch. The fact that the variable *K* is lowered by tax-financed subsidy also explains the reduction of the importance of green investors. The two driving factors are the tax on capital gains *T* and the reforming subsidy *dK*. HKZ state in their comparative statics that N_R is monotonic in I_g, this does not hold for the model extension. In the extension model N_R is already positive in the case of a 25 % tax even when there are no green investors present, I_g is zero. HKZ suggest that a fraction of the investment that is done in order to reform would have been done also in the absence of green investors as part of normal modernizing of capital expenditure. The favourable environment, which the tax-financed subsidy creates, is a possible explanation for this but this issue will not be further examined in this work.
Further the number of reformed firms is not going to N - N_C when I_g goes to *I.* Taking into account a variation of N_C, as HKZ, the number of reformed firms also varies in the extension model.

3.6 Numerical example

In order to show how the changes in the original HKZ model affect the results I will present a numerical example in this section. The values that I have chosen are the same that HKZ used in their paper. Additionally to the basic settings of the HKZ numerical example I added the tax variable *T.* The values that HKZ used for their numerical example are assumed to be total values and percentage values. For example taking the variable $N = 1$ does not mean that there is only one firm in the in this model it means that N accounts for the total of 100% and setting $N_C = N_P = 0.5$

means that 50 % are clean and 50 % are polluting firms. Now taking the variable $K = 0.5$ does not mean that the cost of reforming are 50 % it can be seen as a total value (for example a monetary value of 0, 5 €). This comes clear in the assumptions of HKZ. They authors state that if the cost of capital overcome the cost of reforming then polluting firms will become socially responsible because of exclusionary ethical investing. Since the costs of capital are given in HKZ as a percentage value the cost of reforming *K* must be a total monetary value. HKZ assume a fixed cost of reforming a polluting technology of 5 % of the expected cash flow of the firm. Since the expected cash flow of each firm is $\mu_P = 10$, 5 % of the cash flow has to be paid by each firm; this gives a total value of 0, 5. Due to the fact that in the scaling of the numerical example HKZ operates with percentage values, it comes clear that each firm has to pay $K = 0.5$. HKZ choose these parameters to produce reasonable results for their model. In section 3.8 I assume more fine scaled numbers to show how a variable tax affects the model.

Parameters used in the numerical example:

Technology Parameter:

Mean Cash Flows:	$\mu_C = \mu_P = 10$
Standard Deviation of Cash Flows:	$\sigma_C = \sigma_P = 10$
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:	$N_C = N_P = 0.5$

Investor's parameter:

Aggregate Risk Tolerance:	$\tau = 100$

Capital Gain Tax: $T = 25\,\%$

In the following section, I will present the findings form the numerical example. The value of the tax was chosen primarily 25 % for simplicity reasons and due to the fact that the capital gains tax in Austria is 25 %. For simplicity reasons I do not differentiate between normal capital gains and dividend income as the Austrian government does. The value of the tax will be varied (25% / 12% / 5% / 1%) throughout the numerical example to see the impact of this variable in the model. In the various figures it can be seen that firms would already reform without the presence of green investors. In the HKZ assumptions green investor buy reformed firms but neutral investor do not buy reformed firms. In order to make it possible for them to buy reformed firms, the portfolio holdings and the market clearing conditions need to be adjusted. These modifications are beyond the scope of this work and will not be worked out. After the general comparison with HKZ I look more detailed on variable tax rates. This detailed observation will be done in section 3.8.

3.7 Results and comparison of the numerical example

HKZ choose three endogenous variables, on which they test the effect of varying the crucial and also endogenous variable I_g^*, the number of green investors required forcing the first unacceptable firm to reform. The first endogenous variable is the number of reformed firms, as a percentage of the number of originally polluting firms, $N_R/(N-N_C)$. The second endogenous variable is the cost of capital of unacceptable firms; $(\mu_P/P_U)-1$ the third endogenous variable is the cost of capital of reformed firms, $(\mu_P/P_R)-1$. In my comparison I will survey the same endogenous variables and how they change with the introduction of a tax financed subsidy for unacceptable firms. It will be seen that this lowers reforming costs and increases the number of reformed firms independently of the number of green investors. Figure 7 shows the number of reformed firms as a percentage of the number of originally unacceptable firms for 4 different settings of *T, (25 / 12 / 5 / 1)*.

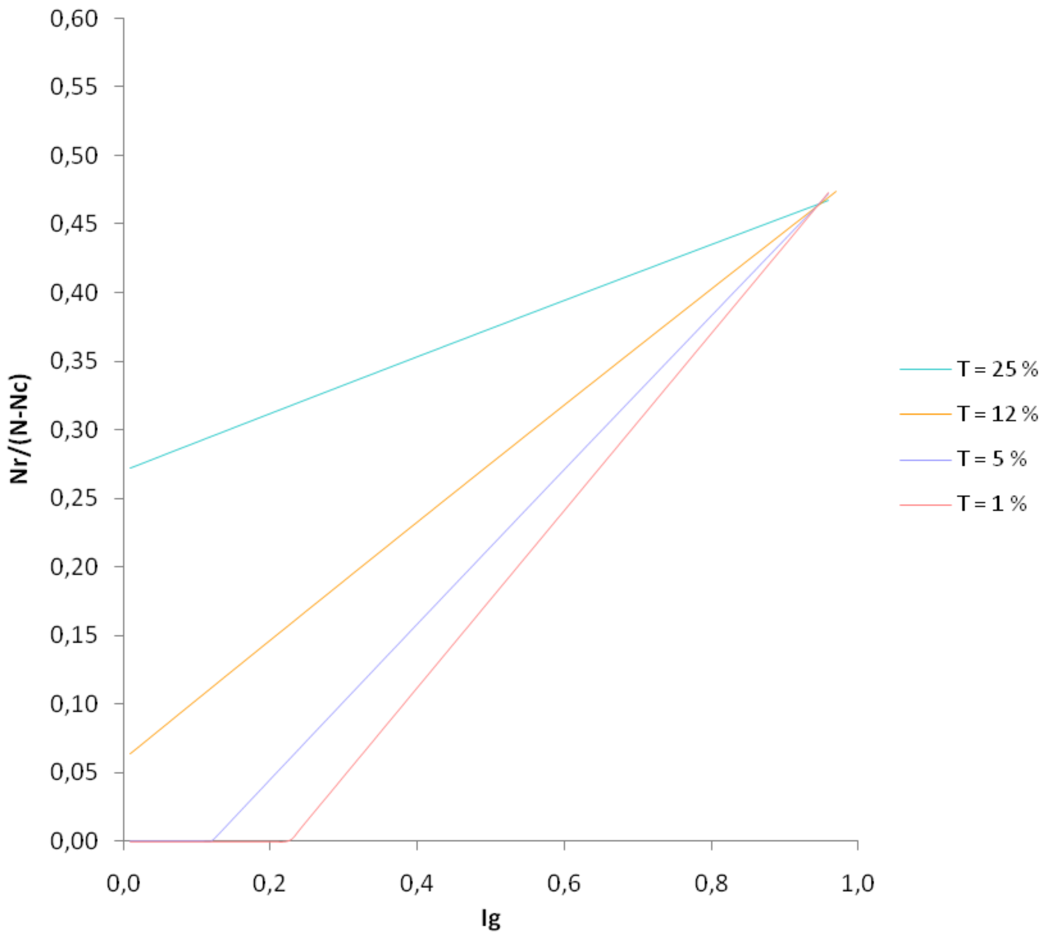


Figure 7: Lukas Schirnhofer 2010

The axis of ordinates in Figure 7 indicates the number of reformed firms as a percentage of the number of originally unacceptable firms; the axis of abscissas indicates the percentage of green investors of the total investor population. Figure 7 shows that a 25 % and a 12 % tax already leads to a higher number of reformed firms independently from the number of green investors. In the case of a 5 % tax the percentage of green investors needed for the first firm to reform is some 13 % from the total investor's population. A 1 % tax gives results that are close to the findings of HKZ for 25 % of green investors.

Figure 8 shows the cost of capital of unacceptable firms as a function of the number of green investors.

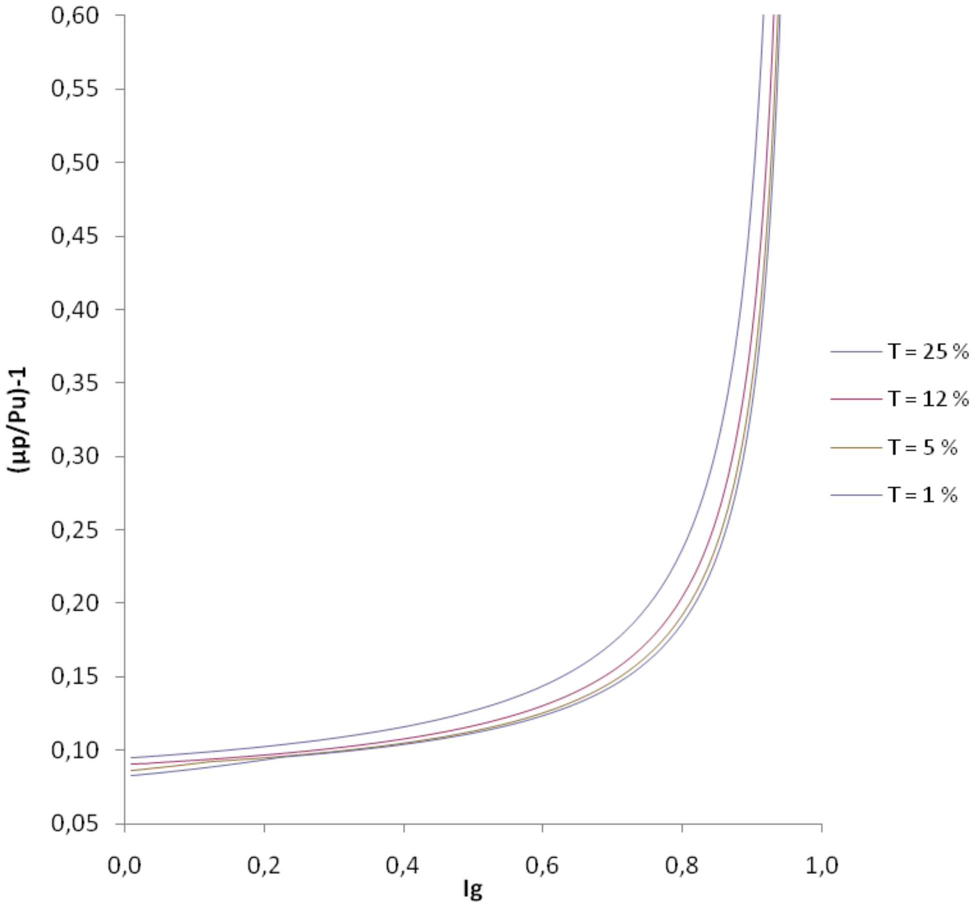


Figure 8: Lukas Schirnhofer 2010

In Figure 8 the axis of ordinates indicates the cost of capital of unacceptable firms, the axis of abscissas indicates the percentage of green investors of the total investor's population. Figure 8 indicates that the lower *T* the lower is the cost of capital of unacceptable firms. This is a significant outcome of the implementation of the tax into the utility function of neutral and green investors. The lower the tax, the lower the burden on investors utility, the lower the demand of investors to get higher gains in order to compensate for the tax loss. Figure 9 shows the cost of capital of reformed firms. The cost of capital compared with HKZ is on average higher than in the HKZ model; see Figure 2 in section 2.3.

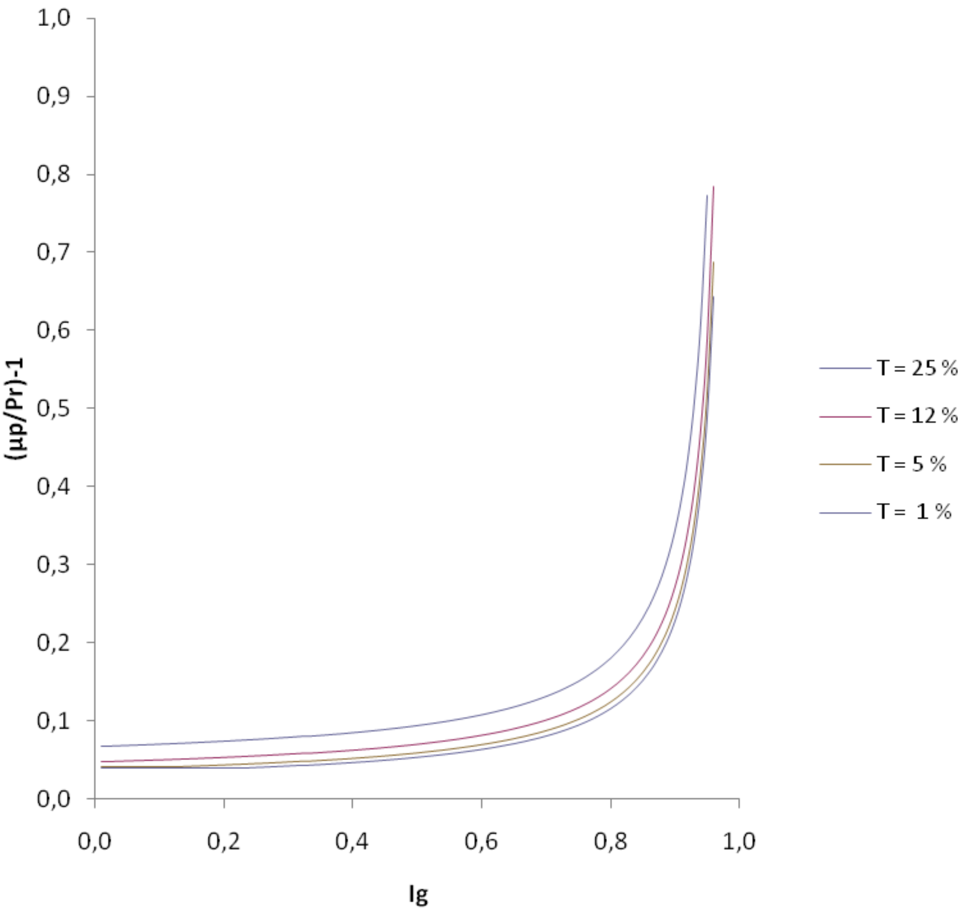


Figure 9: Lukas Schirnhofer 2010

In Figure 9 the axis of abscissas shows percentage of green investors of the total investor's population, the axis of ordinates indicates the cost of capital of reformed firms. The cost of capital of reformed firms does not increase as rapidly as the cost of capital for polluting firms. This is due to the fact that the government subsidises the cost of reforming. If we take the blue line, standing for a 25 % capital gain tax we see that in Figure 9 the cost of capital of reformed firms stays below 10 % until around 50 % of investors are green compared to the costs of capital of unacceptable firms, which are at 50 percent green investors already 12 %. Here we also see as in Figure 8 that on average the costs of capital are higher as in the HKZ paper. Again this proves that investors hand over the burden form the tax to the firms, which have to compensate investors with higher returns (see Figure 3 in section 2.3).

Figure 10 and 11 show how varying the reforming costs *K* affect the number of reformed firms. I choose the same numbers for *K* as HKZ do, *K = 1; K = 0, 5* and *K = 0, 1*, but only show the outcomes of *K = 1* and *K = 0, 1* the case of *K = 0, 5* is already presented in Figure 7. The axis of ordinates in Figure 10 indicates the number of reformed firms as a percentage of the number of originally acceptable firms, the axis of abscissas indicates the percentage of green investors of the total investor's population. Figure 10 highlights the values for $N_R / (N-N_C)$ under the assumption that unacceptable firms have to pay *K = 1* in order to become reformed.

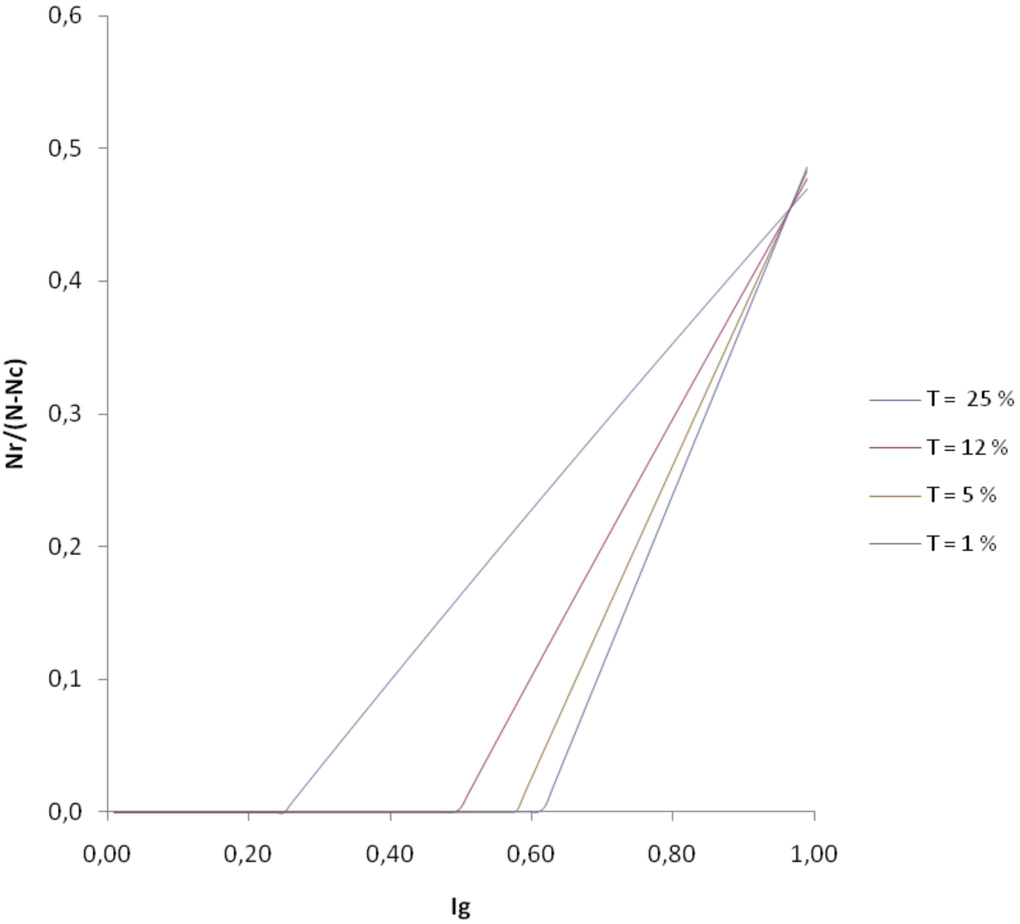


Figure 10: Lukas Schirnhofer 2010

It becomes clear that the lower the tax burden, the higher the number of investors that is needed to induce the first unacceptable firm to become reformed. In the setting with *K = 0, 5* in Figure 7 it can be seen that starting with a tax rate of 5 % the presence of green investors becomes important again. Whereas with *K = 1* the presence of green investors is already important with a high tax rate of 25 %. Compared to HKZ for a 25 % tax and *K = 1* the percentage of green investors is already higher in my model.

Figure 11 shows the values for N_R / (N-N_C) under the assumption that unacceptable firms have to pay *K = 0, 1* in order to become reformed. The axis of ordinates in Figure 11 indicates the number of reformed firms as a percentage of the number of originally acceptable firms, the axis of abscissas indicates the percentage of green investors of the total investor's population

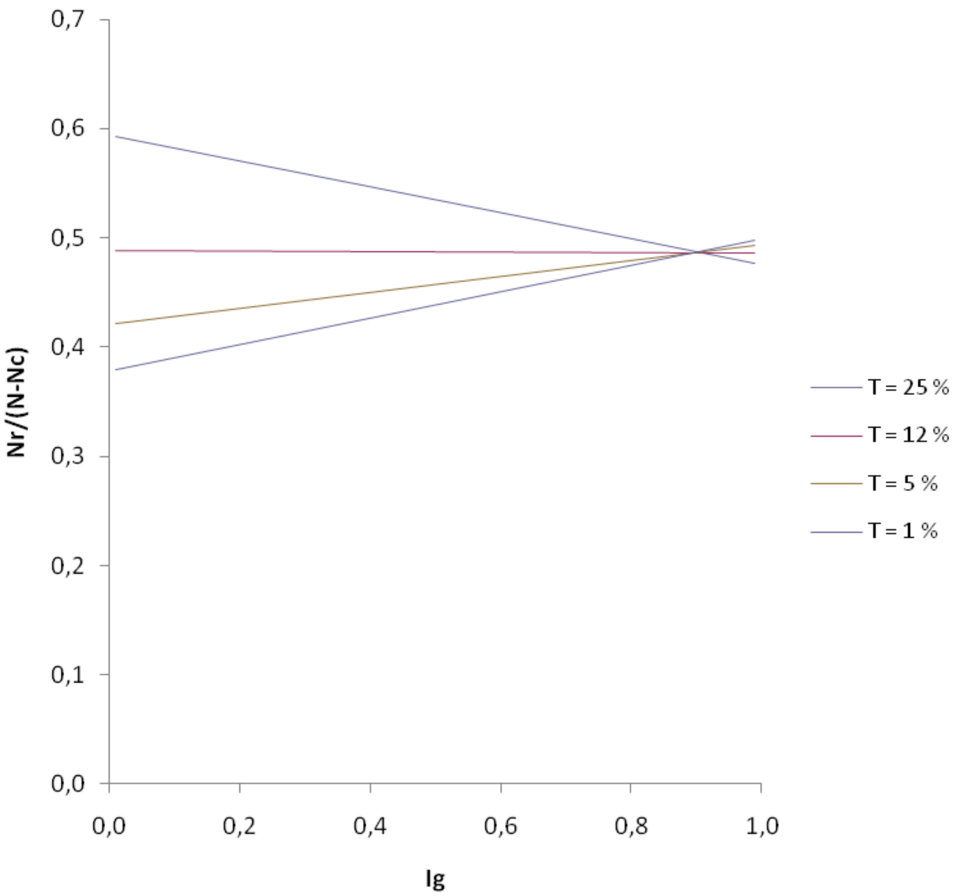


Figure 11: Lukas Schirnhofer 2010

Figure 11 clearly shows that when reform costs are considerably low, the capital gain tax of 25 % has a negative impact on the number of reformed firms as a percentage of originally acceptable firms. Starting with zero green investors and 12 % tax, around 48 % of all firms become reformed immediately in this case but unacceptable firms stay thereafter indifferent on reforming or staying unreformed with a growing number of green investors. The number of reformed firms stays constant and the presence of green investors has no impact for this setting. In contrast to the findings for *T = 25 %* and *T = 12 %*, for the number of reformed firms at *T = 5 %* and *T = 1 %,* green investors presence does have an impact. The findings show that the percentage of reformed firms is increasing with the number of green investors.

Figure 12 shows the effect that the original number of acceptable firms has on the number of reformed firms. Like HKZ I chose the following starting values for N_C. N_C = 0, 25; N_C = 0, 50 and N_C = 0, 75. The curve for N_C = 0, 50 can be found in Figure 7, for N_C = 0, 50 is the basic setting like in HKZ. The axis of ordinates in figure 12 indicates the number of reformed firms as a percentage of the number of originally acceptable firms, the axis of abscissas indicates the percentage of green investors of the total investor's population. In Figure 12 N_C = 0, 25.

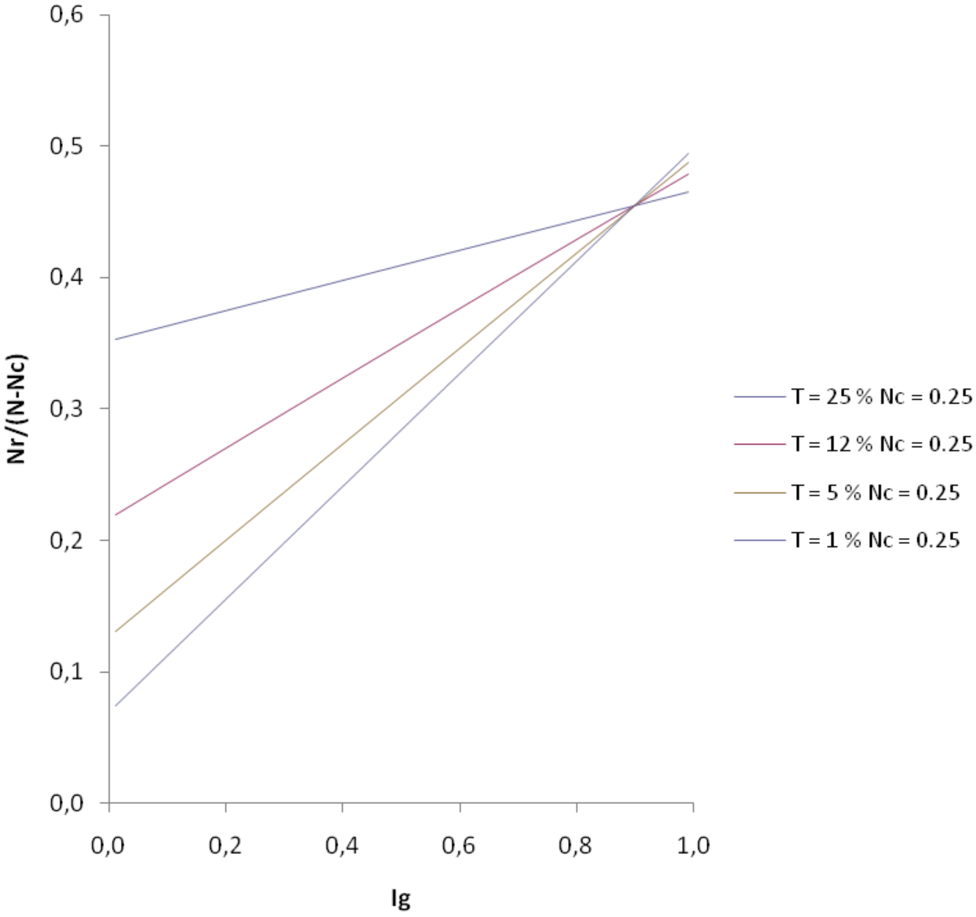


Figure 12: Lukas Schirnhofer 2010

Due to the subsidy effect firms switch before the first green investor is present. The impact of a low N_C = 0, 25 can be seen in the cost of capital where unacceptable firms have roughly 9 % and reformed firms have 7 % when no green investor is present. Compared to Figure 7 where firms do not switch in all 4-tax-rate settings without any green investor being present. With N_C = 0, 50 cost of capital of unacceptable firms are 9, 5 % and the cost of capital of reformed firms are 6, 8 % without any green investor being present and a tax rate of 25 %.

Figure 13 indicates the effect that the original number of acceptable firms has on the number of reformed firms for N_C = 0, 75. The axis of ordinates in Figure 13 shows the number of reformed firms as a percentage of the number of originally acceptable firms, the axis of abscissas the percentage of green investors of the total investors population.

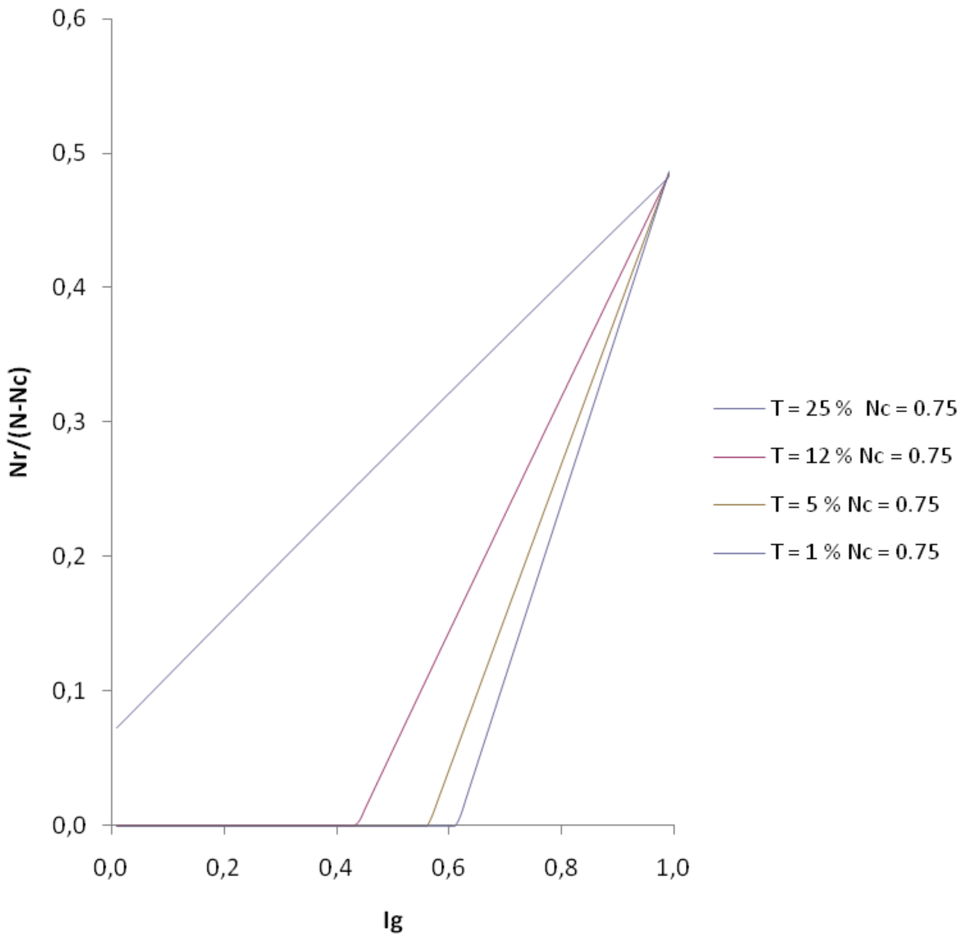


Figure 13: Lukas Schirnhofer 2010

At T = *25 %* no green investors are needed to induce unacceptable firms to reform. Already roughly 8 percent of unacceptable firms would reform with zero green investors present. Lowering the tax rate when N_C = 0, 75 leads to the case where green investors have an impact again on the reforming of firms.

Following the structure of HKZ, extended with my assumption from section 3.2 and 3.3, I have explored the cost of capital of individual firms and the number of reformed firms as a percentage of the number of originally acceptable firms under the assumption of a tax financed subsidy. Further, like HKZ I am going to look at the total cost of capital of all firms. This weighted average cost of capital gives insight in the amount of investment in the overall economy (HKZ, 2001). The so-called WACC has the same formula as in the original paper of HKZ. This is due to the fact that the tax-financed subsidy is already incorporated in the numbers that are used for the calculation of the WACC.

(43) $$WACC = N_C \frac{\mu_C}{P_A} + N_R \frac{\mu_P}{P_R} + N_U \frac{\mu_P}{P_U} - 1$$

Figure 14, 15 and 16 show the weighted average cost of capital for three different starting values of N_C respectively (N_C = 0, 25; N_C = 0, 50; N_C = 0, 75). The axis of ordinates in Figure 14, 15 and 16 show the weighted average cost of capital of the overall economy, the axis of abscissas the percentage of green investors of the total investors population, respectively.

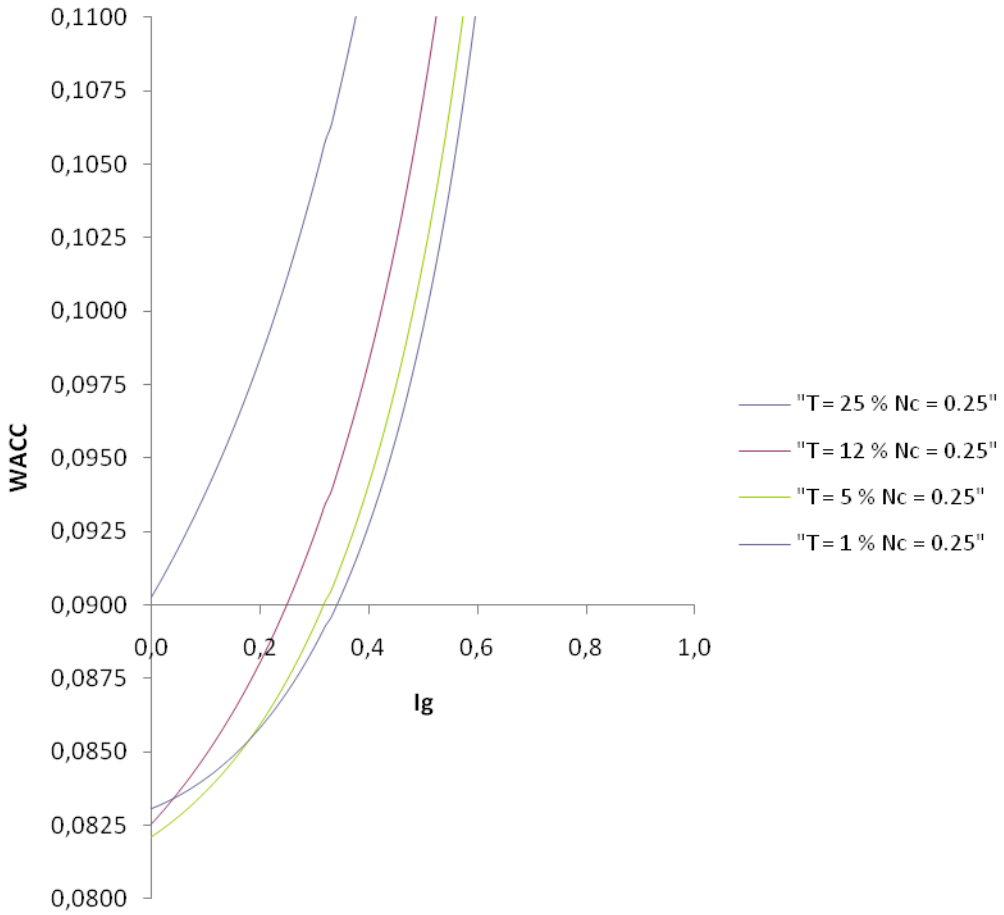


Figure 14: Lukas Schirnhofer 2010

As can be seen in Figure 14 the WACC is rising with the number of green investors introduces into the market and this already from the beginning, at a low starting value for originally acceptable firms; N_C = 0, 25. This phenomenon is due to the fact that neutral investors demand a higher return to be compensated for the tax-loss. This demand pressure drives the prices for unacceptable firms down and increases the individual cost of capital for the firm. In the N_C = 0, 25 case neutral investors count for the lot of the tax earnings. Figure 15 shows the WACC values with N_C = 0, 50.

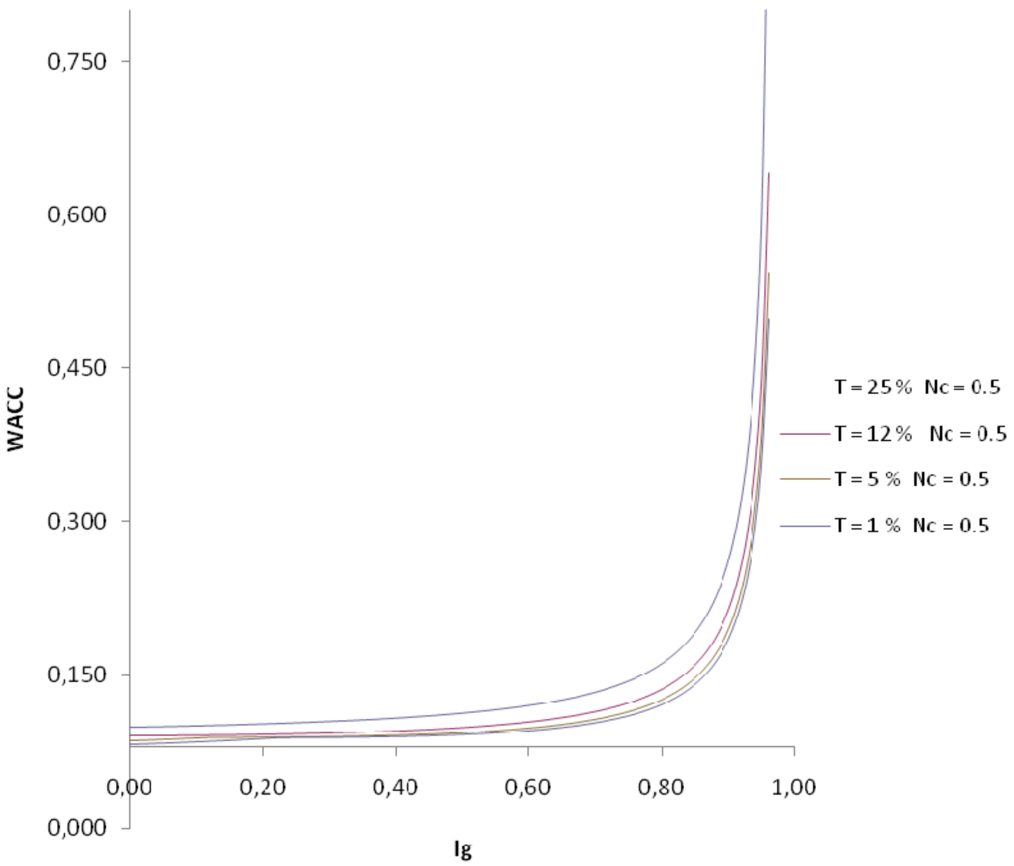


Figure 15: Lukas Schirnhofer 2010

Compared to Figure 14 it can be seen that the WACC grows only by a small ratio until around 60 % percent of green investors are in the market. Figure 16 shows the WACC numbers for N_C = 0, 75.

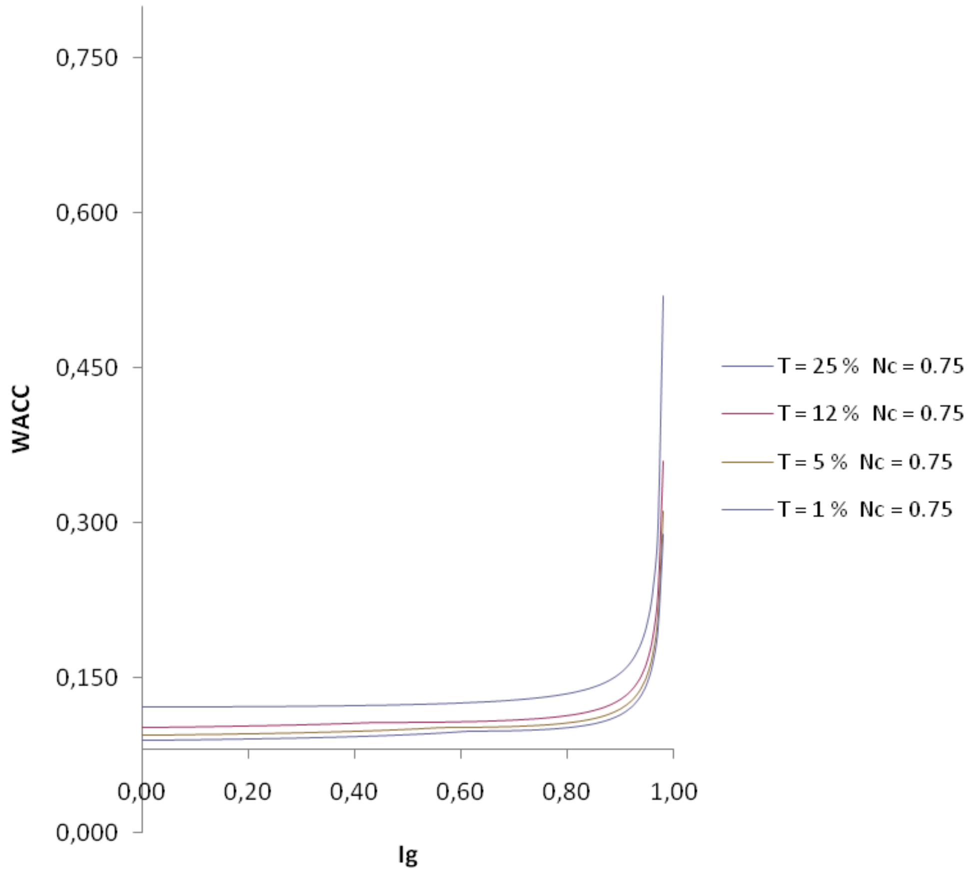


Figure 16: Lukas Schirnhofer 2010

As in Figure 15 the WACC rises only with a low rate, compared to figure 15 the jump due to the presence of high percentage of green investor's shifts back to 80 % I_g. In the extended model the WACC is considerably higher than in the original model of HKZ as can be seen in Figures 14, 15 and 16. In the HKZ model the authors state that with an increasing I_g the risk sharing opportunities are lessened because of the green investors boycott of unacceptable firms and so P_U decreases, which implies that the WACC increases with I_g at I_g =0. In my model the increase of the WACC and the on average higher WACC as to HKZ is due to the same causation with the major difference that not I_g is the driving factor. The fact that due to the tax financed subsidies most of the firms become reformed already before the presence of green investors also lowers the risk sharing opportunities for neutral investors and therefore decreases P_U which again implies an increasing WACC.

3.8 Detailed evaluation of a variable tax

The calculation of Section 3.7 showed that more taxes are earned in all 4-fixed-tax cases than are distributed as subsidies. HKZ state in their work that cost of reforming is an important determinant of green investing. In the extended model it comes clear that a fraction of investment is made regardless the presence of green investors in the market. HKZ suggest that this happens in the normal curse of modernizing capital expenditure. In this section I evaluate the impact of a variable tax. The tax rate values are chosen individually for each setting in order to show the minimum tax rate at which firms switch. Further the range of that tax is set in such a way that the tax earned by the government and subsidies spent are equal. Thus only as many firms reform as sufficient funds are available. Further I compare the findings to the standard setting of HKZ base case of N_C = 0, 5 and *K = 0, 5.* When high tax rates are introduced, the presence of green investors is not important. The former findings show that at a tax rate of 5 % the presence of green investors gets important again. The detailed evaluation with a variable tax shows that at low tax rates between 0, 25 % and 9 % the presence of green investors is a significant determinant also in the extended model.

First I show that the maximum tax that needs to be collected in order to reach the subsidy need is about 9 %. Within the range given in Figure 17 the taxes earned are equal with the subsidy distributed. Figure 17 shows that at 75 % of green investors, the pressure on unacceptable firms is high enough in order to decrease the tax but still have enough funds to subsidize firms that want to reform. The axis of ordinates in Figure 17 shows the variable tax T, the axis of abscissas shows the percentage of green investors of the total investor's population. The uneven curve originates in the individual setting of the tax rate in order to find out the minimum tax rate for each possible setting.

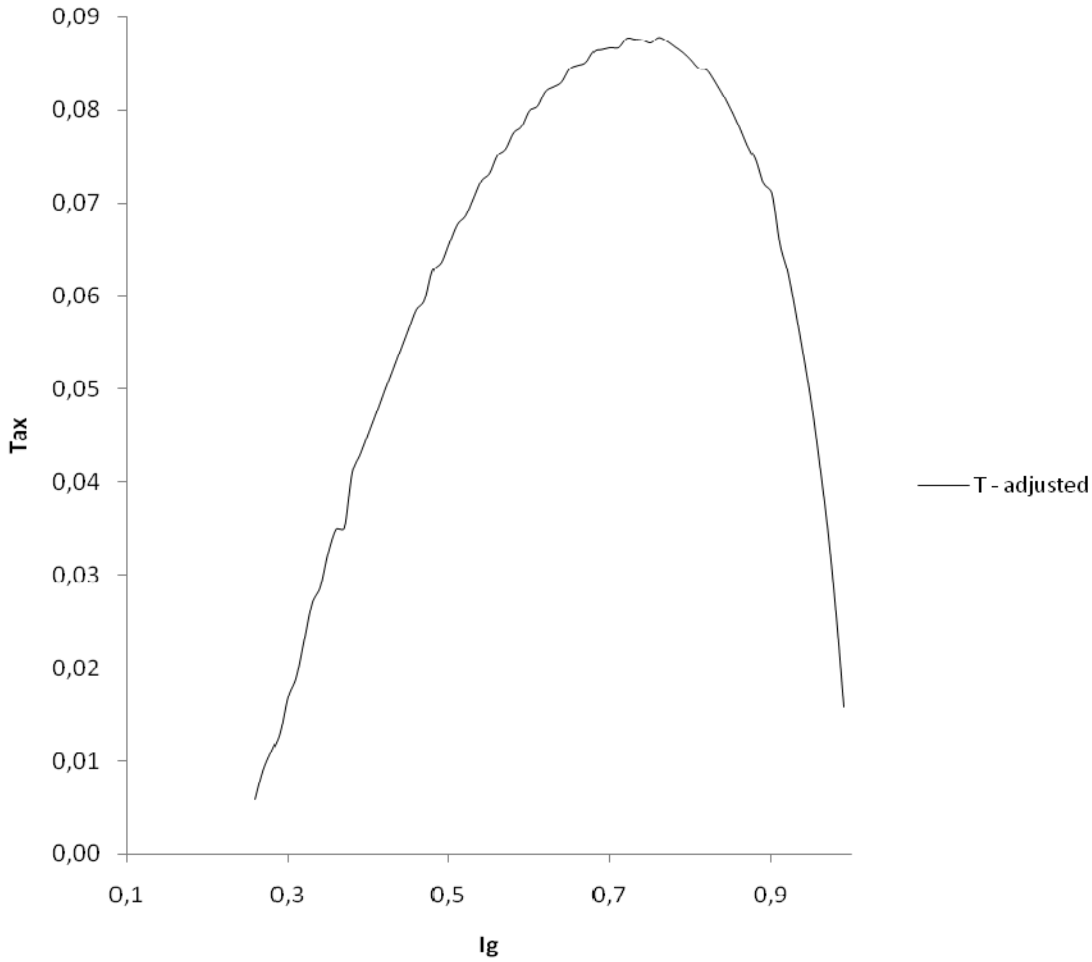


Figure 17: Lukas Schirnhofer 2010

In the case of variable taxes the presence of green investors is important again. The introduction of the tax has a positive impact on the number of firms that become reformed up to the mark where green investor's count for about 60 % of the investor's population. At this point the HKZ model is more favourable for green investment. The most significant founding in the extended model is that polluting firms switch, from unacceptable to reformed until a $N_R/(N-N_C)$ ratio of 0.5 where in the HKZ model the

$N_R/(N-N_C)$ ratio at 100% green investors is 1. Thus in the extended model with 100 % green investors, 25 % of the total firm population remain unacceptable where in the HKZ base case all polluting firms become reformed. Figure 18 compares the $N_R/(N-N_C)$ ratios of the HKZ and the extended model, where EXMO is the curve of the extended model. The axis of ordinates in Figure 18 indicates the number of reformed firms as a percentage of the number of originally acceptable firms, the axis of abscissas indicates the percentage of green investors of the total investor's population.

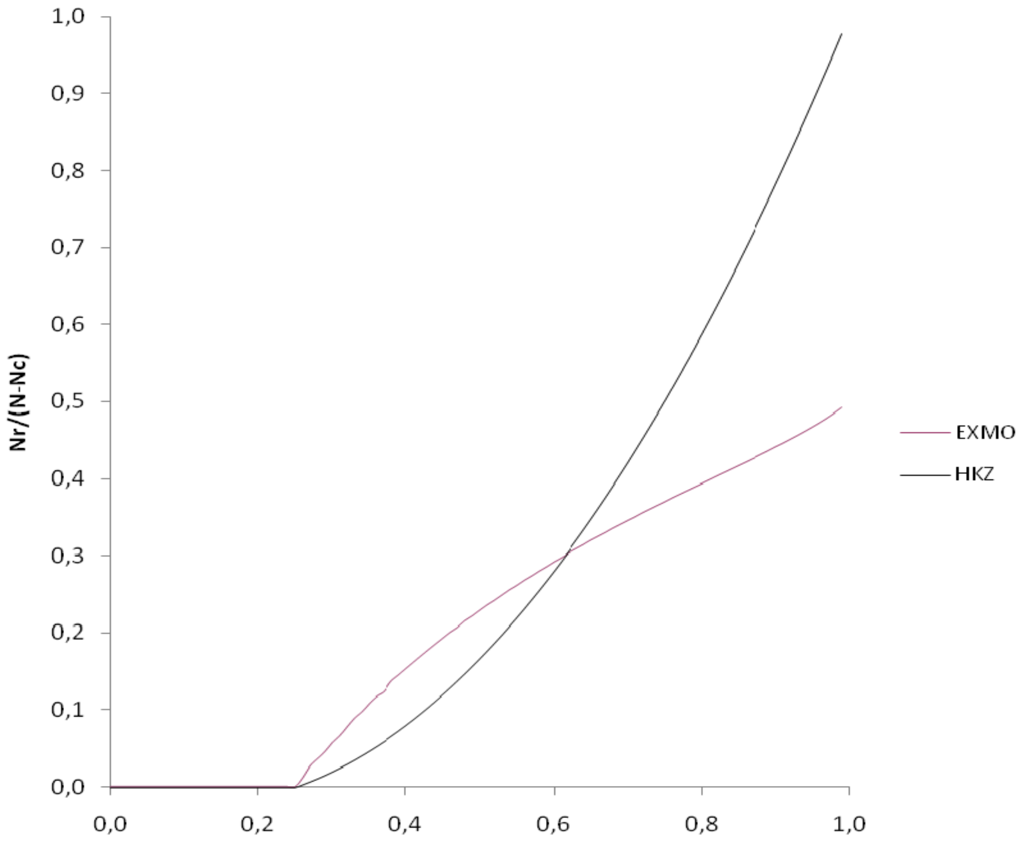


Figure 18: Lukas Schirnhofer 2010

The difference in the cost of capital of the extended model is nearly zero up to 25 % green investors in the market. In Figure 19 it can be seen that from 25 % to about 40 % of green investors of the total investor's population the extended model shows a marginal better cost of capital then HKZ.

Starting at 40 % green investors, the cost of capital of polluting firms increase more with a growing number of investors than in the HKZ basic model. In Figure 19 the axis of abscissas shows percentage of green investors of the total investor's population, the axis of ordinates indicates the cost of capital of unacceptable firms.

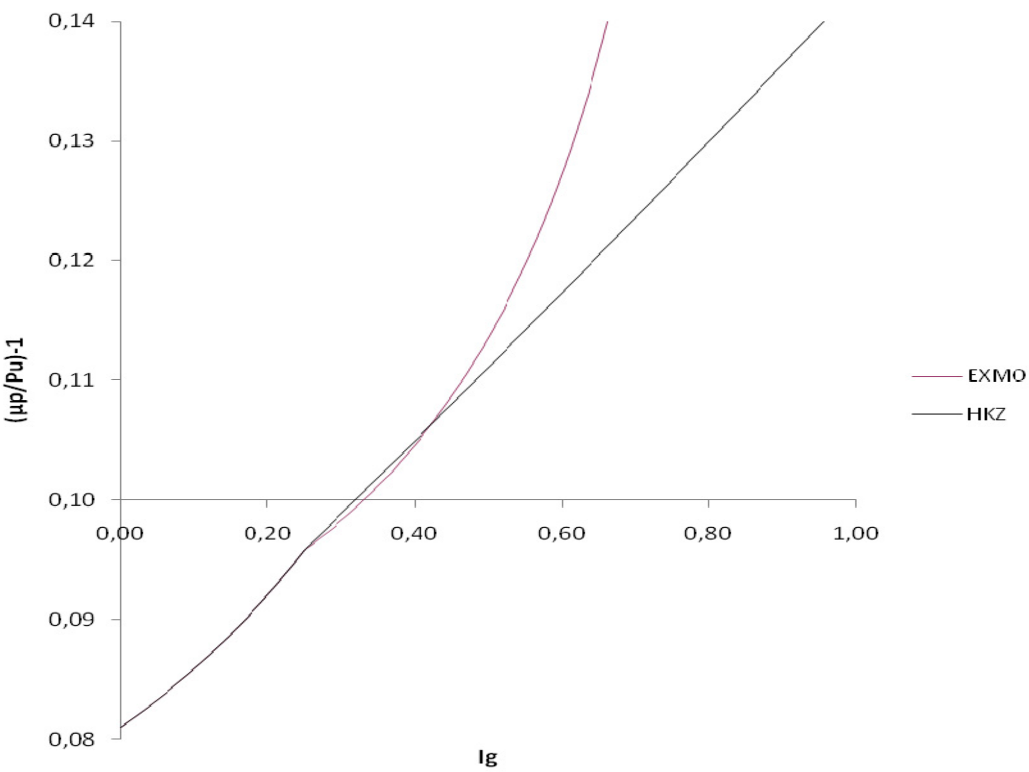


Figure 19: Lukas Schirnhofer 2010

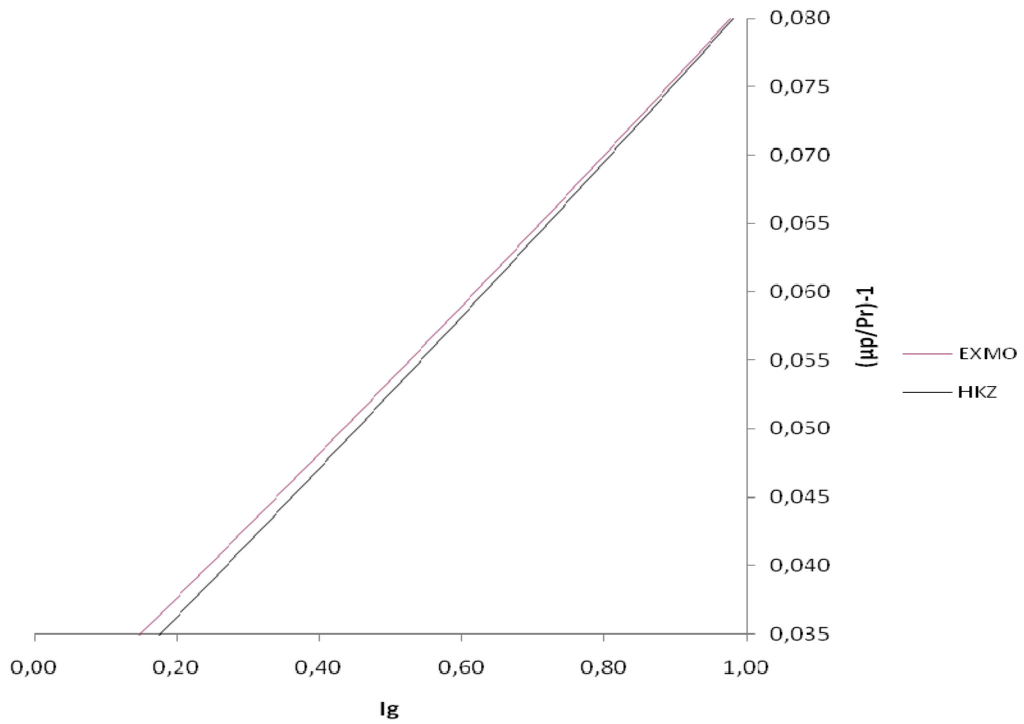


Figure 20: Lukas Schirnhofer 2010

Figure 20 shows the cost of capital of reformed firms. The axis of abscissas shows percentage of green investors of the total investor's population, the axis of ordinates indicates the cost of capital of reformed firms. The impact of the variable tax rate is only marginal in the cost of capital of reformed firms. The costs of capital in the HKZ setting are lower then in the extended model. This again reflects the fact that investors demand a lower price in the extended model in order to be compensated for the loss in utility which in turn increases the pressure on firms and their cost of capital.

Looking at the total cost of capital, the WACC, in the HKZ basic model and in the extended model it comes clear that a tax on capital gains combined with a subsidy on reforming cost is only beneficial within a short range. Figure 21 shows how the WACC increases due to the pressure of a decreasing number of neutral investors.

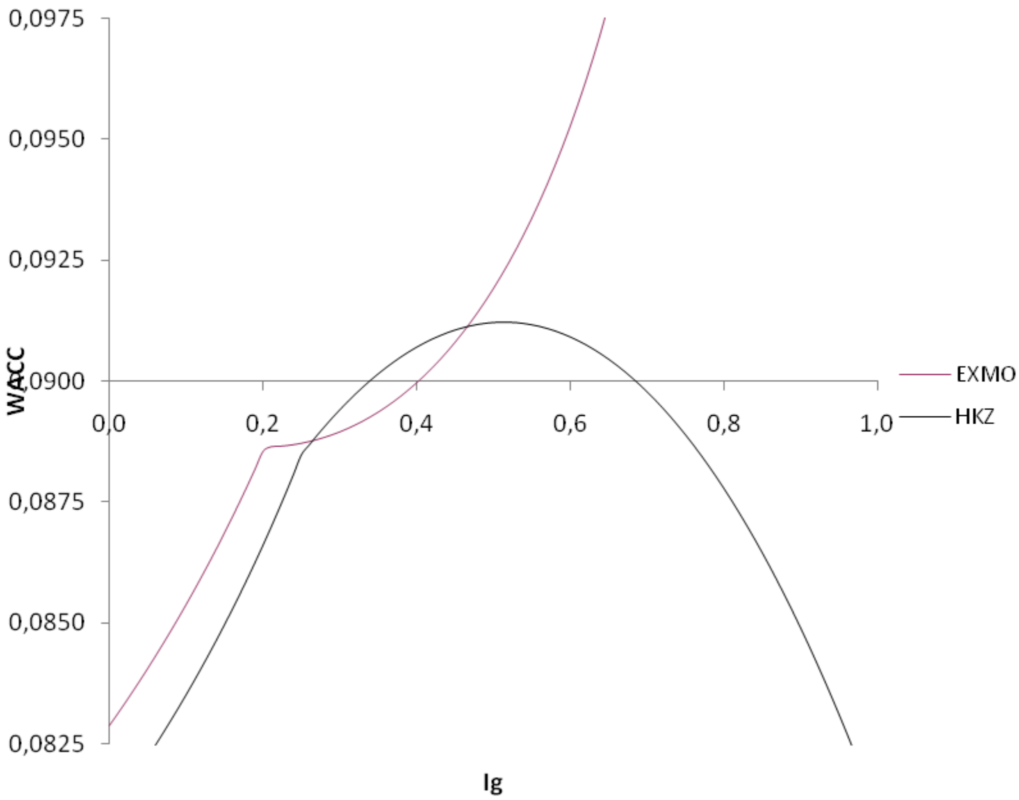


Figure 21: Lukas Schirnhofer 2010

The axis of ordinates in Figure 21 shows the weighted average cost of capital of the economy, the axis of abscissas shows the percentage of green investors of the total investor's population. The WACC at 25 % of green Investors is equal to HKZ. From 25 % until about 48 % green investors the WACC in the extended model is lower then the HKZ WACC. Above 50 % the WACC in the HKZ basic model decreases again, whereas the WACC in the extended model continues to rise. This is due to the fact that the pressure on firms still increases, thou the tax decrease, but firms do not switch anymore after 25 % of unacceptable firms have switched.

4 Conclusions

The intention of this work was to survey the impact of a capital gain tax combined with a subsidy on reforming cost within the basic model setting of the HKZ paper "*The effect of green investment on corporate behaviour*".

In order to identify these changes, I extended the basic HKZ model with a capital gain tax and a subsidy on reforming cost. In the first step the calculus of HKZ had to be modified by the incorporation of the tax into the Utility function of HKZ. During the study it becomes clear that this changes basically the initial setting in a very crucial way. The biggest difference states the equation for the number of reformed firms, which is a linear function in HKZ and a quadratic in the extended model. After the derivation of the calculus for the extended model I compared the results of the numerical example with HKZ. In the first step I chose fixed values for the capital gain tax. The outcomes in section 3.7 indicate that a high capital gain tax resulting in a high subsidy negate the importance of green investors on the switch of unacceptable firms to reformed firms. Only with a fixed 5 % and lower capital gain tax green investors gain a significant importance again. The costs of capital for fixed tax rates are slightly higher than HKZ but steady up to 75 % of green investors compared to a variable tax rate.

In section 3.8 I evaluated the impact of a variable tax rate for each possible setting of the investor's population. The tax rate values are chosen individually for each setting in order to show the minimum tax rate at which firms switch. Further the range of that tax rate is set in such a manner that the tax earned by the government and the subsidy spent is equal. The findings of this survey indicate that a variable tax rate is only advantageous for a small range of the percentage of green investors of the total investor's population. Thus the costs of capital raise significantly more out of this specific range than in the HKZ basic model. Also the overall costs of capital are higher before 25 % and after 48 % of green investors of the total investor's population. With a variable tax also the first firm’s switches from unacceptable to reformed firms at 25 % of green investors, as in the HKZ setting. From 25 % green investors up to about 60 % the extended model favours the switch of unacceptable firms compared to the HKZ settings. Thereafter the HKZ model encourages more firms to switch than the extended model, which stops the switching process at about 25 % of reformed firms of the total firm population. This fact leaves open space for further research in this direction. With a more advanced extended model, which incorporates also a change in the risk and return characteristics, and the new asset class approach of Urs von Arx, more precise results could be possible. I did not follow this direction because this would create a totally new model, which would not be as comparable to HKZ as my approach and also exceed the scope of this work.

In general the survey of the extended model indicates that the effect of social investing is not as important, in a smaller range, as in the HKZ model. This is due to the fact that the introduced tax financed subsidy annuls the effect of a growing number of green investors if and only if the tax is high enough to produce sufficient funds for the state to provide a high subsidy. In the case of a lower Tax and resulting from this a lower subsidy the presence of social responsible investing with the presence of green investors becomes more important again but not to the same extent as in HKZ. This also applies for the variable tax for specific number of green investors as indicated above. An even more general conclusion from my findings is that two ways exist in order to have more environmentally friendly firm’s in other words good corporate behaviour. The first way is the more market driven proposal of HKZ for which empirical evidence already exists (page 444-4447, HKZ 2001). This approach is mainly focused on the social attitude of Investors and their ability to influence corporate behaviour through market orientated mechanism. The second way is not to rely on the good attitude of investors and their will to undergo social responsible screening and investment but provide a subsidy program to encourage firms to become reformed. For this approach no empirical data exists yet. Taxes on gains do already exist but the collected amount is not yet used to provide reforming incentives for polluting firms. This makes also the difference form my simple model to reality. I assumed that the government has no cost of tax collection and subsidy distribution. In reality also the fact of a direct capital gain tax or anything like that is hard to reach in reality. The discussion about the Tobin tax (James Tobin, 1978) is now going on for more the 30 years but no conclusion has been reached yet. Even though politicians do discuss the importance of such a transaction tax more intensively due to the financial crisis but no link has been made yet to a possible subsidy program.

5 Appendix

(19) $P_R = P_U + (K\text{-}dK)$

Solved for N_R

$$\mu_P - \left[\frac{1}{(1-T)}\right]\left[\frac{1}{I\tau}\right]\left[\sigma_{CP}N_C + N_U\frac{\sigma_{CP}^2}{\sigma_C^2} + N_R\sigma_P^2 + N_R\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2}\right] =$$

$$\mu_P - \left[\frac{1}{(1-T)}\right]\left[\frac{1}{I\tau}\right]\left[\sigma_{CP}N_C + \sigma_P^2 N_U + N_U\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} + N_R\frac{\sigma_{CP}^2}{\sigma_C^2}\right] + K -$$

$$TN_C\mu_C + TN_C\left[\mu_C - \frac{1}{(1-T)}\frac{1}{I\tau}(\sigma_C^2 N_A + \sigma_{CP}N_P)\right] -$$

$$TN_U\mu_P + TN_U\left[\mu_P - \frac{1}{(1-T)}\frac{1}{I\tau}(\sigma_{CP}N_C + \sigma_P^2 N_U + N_U\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} + N_R\frac{\sigma_{CP}^2}{\sigma_C^2})\right] -$$

$$TN_R\mu_P + TN_R\left[\mu_P - \frac{1}{(1-T)}\frac{1}{I\tau}(\sigma_{CP}N_C + N_U\frac{\sigma_{CP}^2}{\sigma_C^2} + N_R\sigma_P^2 + N_R\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2})\right]$$

multiply with $(1-T)I\tau$

$$-\sigma_{CP}N_C - N_U\frac{\sigma_{CP}^2}{\sigma_C^2} + N_R\sigma_P^2 + N_R\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} =$$

$$-\sigma_{CP}N_C - \sigma_P^2 N_U - N_U\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} - N_R\frac{\sigma_{CP}^2}{\sigma_C^2} + K(1-T)I\tau -$$

$$TN_C(\sigma_C^2 N_A + \sigma_{CP}N_P) -$$

$$TN_U(\sigma_{CP}N_C + \sigma_P^2 N_U + N_U\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2} + N_R\frac{\sigma_{CP}^2}{\sigma_C^2}) -$$

$$TN_R(\sigma_{CP}N_C + N_U\frac{\sigma_{CP}^2}{\sigma_C^2} + N_R\sigma_P^2 + N_R\frac{I_g}{I_n}\frac{\Phi}{\sigma_C^2})$$

multiply with σ_C^2

set $N_A = N_C;\ N_U = N - N_C - N_R;\ N_P = N - N_C$

$$-(N-N_C-N_R)\sigma_{CP}^2 - N_R\sigma_P^2\sigma_C^2 - N_R\frac{I_g}{I_n}\Phi =$$

$$-(N-N_C-N_R)\sigma_P^2\sigma_C^2 - (N-N_C-N_R)\frac{I_g}{I_n}\Phi - N_R\sigma_{CP}^2 + K(1-T)I\tau\sigma_C^2 -$$

$$TN_C(\sigma_C^2\sigma_P^2 N_C + \sigma_C^2\sigma_{CP}(N-N_C)) -$$

$$T(N-N_C-N_R)\,(\sigma_{CP}\sigma_C^2 N_C + \sigma_P^2\sigma_C^2(N-N_C-N_R) + (N-N_C-N_R)\frac{I_g}{I_n}\Phi + N_R\sigma_{CP}^2) -$$

$$TN_R(\sigma_{CP}\sigma_C^2 N_C + (N-N_C-N_R)\sigma_{CP}^2 + N_R\sigma_P^2\sigma_C^2 + N_R\frac{I_g}{I_n}\Phi$$

$$N_R\sigma_{CP}^2 - N_R\sigma_P^2\sigma_C^2 - N_R\frac{I_g}{I_n}\Phi - N_R\sigma_P^2\sigma_C^2 - N_R\frac{I_g}{I_n}\Phi + N_R\sigma_{CP}^2 -$$

$$TN_R(\sigma_{CP}\sigma_C^2 N_C + \sigma_P^2\sigma_C^2(N-N_C-N_R) + (N-N_C-N_R)\frac{I_g}{I_n}\Phi + N_R\sigma_{CP}^2) +$$

$$TN_R(\sigma_{CP}\sigma_C^2 N_C + (N-N_C-N_R)\sigma_{CP}^2 + N_R\sigma_P^2\sigma_C^2 + N_R\frac{I_g}{I_n}\Phi) \quad =$$

$$(N-N_C)\sigma_{CP}^2 - (N-N_C)\sigma_P^2\sigma_C^2 - (N-N_C)\frac{I_g}{I_n}\Phi + K(1-T)I\tau\sigma_C^2 -$$

$$TN_C(\sigma_{CP}\sigma_C^2 N_C + \sigma_P^2\sigma_C^2(N-N_C)) -$$

$$T(N-N_C)\,(\sigma_{CP}\sigma_C^2 N_C + \sigma_P^2\sigma_C^2(N-N_C-N_R) + (N-N_C-N_R)\frac{I_g}{I_n}\Phi + N_R\sigma_{CP}^2)$$

$$-2N_R\Phi - 2N_R\frac{I_g}{I_n}\Phi - TN_R(N-N_C-N_R)\sigma_P^2\sigma_C^2 - TN_R(N-N_C-N_R)\frac{I_g}{I_n}\Phi - TN_R^2\sigma_{CP}^2 +$$

$$TN_R(N-N_C-N_R)\sigma_{CP}^2 + TN_R^2\sigma_P^2\sigma_C^2 + TN_R^2\frac{I_g}{I_n}\Phi -$$

$$T(N-N_C)\sigma_P^2\sigma_C^2 N_R - T(N-N_C)\frac{I_g}{I_n}\Phi N_R + TN_R(N-N_C)N_R\sigma_{CP}^2 =$$

$$-(N-N_C)\Phi - (N-N_C)\Phi\frac{I_g}{I_n} + K(1-T)I\tau\sigma_C^2 - TN_C^2\sigma_P^2\sigma_C^2 - TN_C(N-N_C)\sigma_C^2\sigma_{CP} -$$

$$T(N-N_C)N_C\sigma_{CP}\sigma_C^2 - T(N-N_C)^2\sigma_P^2\sigma_C^2 - T(N-N_C)^2\frac{I_g}{I_n}\Phi$$

$$-2N_R\Phi\frac{I}{I_n}-TN_R(N-N_C-N_R)\Phi-TN_R(N-N_C-N_R)\frac{I_g}{I_n}\Phi+TN_R^2\Phi+TN_R^2\frac{I_g}{I_n}\Phi-$$

$$TN_R(N-N_C)\Phi-T(N-N_C)\frac{I_g}{I_n}\Phi N_R \quad =$$

$$-(N-N_C)\Phi\frac{I}{I_n}+K(1-T)I\tau\sigma_C^2-TN_C^2\sigma_C^4-2TN_C(N-N_C)\sigma_C^2\sigma_{CP}-$$

$$T(N-N_C)^2\sigma_P^2\sigma_C^2-T(N-N_C)^2\frac{I_g}{I_n}\Phi$$

$$-2N_R\Phi\frac{I}{I_n}-TN_R(N-N_C-N_R)\Phi\frac{I}{I_n}+TN_R^2\frac{I}{I_n}\Phi-TN_R(N-N_C)\Phi\frac{I}{I_n} \quad =$$

$$K(1-T)I\tau\sigma_C^2-(N-N_C)\Phi\frac{I}{I_n}-TN_C^2\sigma_C^4-2TN_C(N-N_C)\sigma_C^2\sigma_{CP}-$$

$$T(N-N_C)^2\sigma_P^2\sigma_C^2-T(N-N_C)^2\frac{I_g}{I_n}\Phi$$

multiply with $\frac{1}{\Phi}\frac{I_n}{I}$

$$2TN_R^2-2N_R\left[1+T(N-N_C)\right] \quad =$$

$$K(1-T)I_n\frac{\tau\sigma_C^2}{\Phi}-(N-N_C)-TN_C^2\sigma_C^4\frac{I_n}{\Phi I}-2TN_C(N-N_C)\sigma_C^2\sigma_{CP}\frac{1}{\Phi}\frac{I_n}{I}-$$

$$T(N-N_C)^2\sigma_P^2\sigma_C^2\frac{I_n}{\Phi I}-T(N-N_C)^2$$

$$2TN_R^2-2N_R\left[1+T(N-N_C)\right] \quad =$$

$$K(1-T)I_n\tau\frac{\sigma_C^2}{\Phi}-(N-N_C)\left[1+T(N-N_C)\right]-\frac{I_n}{I}\frac{\sigma_C^2}{\Phi}T\left[N_C^2\sigma_C^2+2N_C(N-N_C)\sigma_{CP}+(N-N_C)^2\sigma\right.$$

---

basic formula for quadratic equations

$$ax^2 + bx + c = 0$$

$$x_{12} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$a = 2T$$

$$b = 2\left[1 + T(N - N_C)\right]$$

$$c = \Lambda$$

$$\Lambda = K(1-T)I_n\tau\frac{\sigma_C^2}{\Phi} - (N - N_C)\left[1 + T(N - N_C)\right] -$$

$$\frac{I_n}{I}\frac{\sigma_C^2}{\Phi}T\left[N_C^2\sigma_C^2 + 2N_C(N - N_C)\sigma_{CP} + (N - N_C)^2\sigma_P^2\right]$$

$$N_R = \frac{-2\left[1 + T(N - N_C)\right] \pm \sqrt{(2\left[1 + T(N - N_C)\right])^2 - 4*2*T*\lambda}}{2*2*T}$$

$$N_R \geq 0$$

$$T > 0$$

---

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7 Abstract in German

Das Ziel dieser Arbeit ist es, die Auswirkungen einer steuerfinanzierten Subvention, auf das Verhalten von Unternehmen und ethischen Investitionen zu untersuchen. Basierend auf dem Gleichgewichtsmodel von Heinkel Zechner und Kraus (2001) wird veranschaulicht, dass eine steuerfinanzierte Subvention mit fixen Steuersätzen die Bedeutung von Grünen Investoren auf das Verhalten von Unternehmen mit Umweltschädlicher Politik verringert bzw. aufhebt. Zusätzlich zu dem Einfluss von fixen Steuersätzen wird auch das Verhalten mit variablen Steuersätzen untersucht. Das bedeutet dass, dass die Anzahl der Unternehmen welche bereit ist zu reformieren und eine umweltfreundliche Politik zu verfolgen, bei einem fixen Steuersatz, weitgehend unabhängig ist von der Anzahl der grünen Investoren im Markt und deren exklusiver Investitionspolitik aber gleichzeitig die gesamtwirtschaftlichen Kapitalkosten mehr erhöht als im ursprünglichen Modell von Heinkel Zechner und Kraus 2001. Im Falle einer Variabeln Steuer ist der Subventionseffekt nur innerhalb einer limitierten Anzahl von grünen Investoren besser gegenüber den Resultaten von Heinkel Zechner und Kraus 2001.

8 Curriculum Vitae

Persönliche Daten:

Name:	Lukas Schirnhofer
Geburtsdaten:	16.10.1980, Mödling
Staatsbürgerschaft:	österreichisch
Familienstand:	ledig
Wohnadresse:	Hainfelderstrasse 48 / 2564 Weissenbach an der Triesting
Telefon:	+43 676 84910410
E-mail:	lukas.schirnhofer@polytechnik.at

Schulbildung:

1987 – 1991	Volksschule Weissenbach
1991 – 1995	Bundes - Realgymnasium Berndorf
1995 – 2000	HTL Mödling Wirtschaftsingenieurwesen
Juni 1997	Praktikum Haas do Brasil, Curitiba Haas Waffelmaschinen
Juni 1998	Praktikum Haas do Brasil, Curitiba Haas Waffelmaschinen
2001	Präsenzdienst Baden
2003, 2007, 2008	Intensiv Russischkurs in Moskau und St. Petersburg jeweils einen Monat
2005	1 Semester an der Flinders Universität Adelaide Australien
2001 – 2010	Studium Internationale Betriebswirtschaft Corporate Finance / Investment Analyse

Berufliche Laufbahn

2006 -	Polytechnik Luft und Feuerungstechnik GmbH Assistent der Geschäftsleitung

Sprachliche Kenntnisse: Englisch, Russisch