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*Iulie Aslaksen and Terje Synnestvedt*

# Corporate environmental protection under uncertainty

**Abstract:**
Investment in pollution prevention technologies are often made under significant uncertainty about the future pay-off from the investments. However, as time passes some of the uncertainties may be resolved by new information, implying that the timing of investments becomes an important issue for the company. This paper focuses on uncertainty about a future environmental tax, and shows, within a two period model, that a specific tax uncertainty, standing alone, does not create any incentives for early investments. However, introducing a market share increase linked to the investment, the tax uncertainty may strengthen the incentives for early investments.

**Keywords:** Uncertainty, Irreversibility, Environmental management, Tax uncertainty, Option value

**JEL classification:** D81, H25, Q20

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**Address:** Iulie Aslaksen, Statistics Norway, Research Department. E-mail: iulie.aslaksen@ssb.no

Terje Synnestvedt, Norwegian School of Management BI. E-mail: terje.synnestvedt@bi.no

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Telephone: +47 62 88 55 00
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# 1. Introduction

Environmental protection has become increasingly important in corporate decision making over the last two decades. An important issue in a company's overall environmental profile is the investment in pollution abatement technologies. The firms' choice of a certain level of environmental investments is mainly based on the incentive structure generated from the firms' different stakeholders, such as regulators, customers, competitors, the financial community etc. The economic incentives for corporate environmental protection are associated with a significant amount of uncertainty, stemming from the uncertain future behavior of key stakeholders. For example, uncertainty about future environmental taxation may motivate companies to invest in environmental protection in order to reduce the probability of this type of regulation. The investment incentives—or disincentives—might shift radically over time for instance due to new information, new regulations and changed attitudes.

Taking into account that investment in pollution abatement technology might represent significant costs, the investment decision becomes an important determinant of the relationship between corporate environmental and economic performance. The link between environmental and economic performance is currently receiving increasing attention, in the business community as well as in economic research[1]. Due to an increasing interest in environmentally and ethically screened stock portfolios this link has also become an issue of growing concern within the financial community.

On the corporate level, a large number of papers present arguments supporting the view that improved environmental performance is profitable[2], challenging the more "traditional" view that corporate environmental protection primarily increases the costs of the firm. A number of empirical studies on the relation between environmental and economic performance have also been conducted in recent years[3]. The empirical literature indicates that there is a considerable uncertainty about the relation between environmental performance and economic performance—and the relation to good management in general.

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[1] See e.g. Konar and Cohen (2001), Blacconiere and Northcut (1997), Cordeiro and Sarkis (1997), Feldman, Soyka and Ameer (1997), Lanoie, Laplante and Roy (1997), Schaltegger and Figge (1997), WBCSD (1997), Amundsen and Sæther (1996), Hart and Ahuja (1996), Klassen and McLaughlin (1996), Schmidtheiny and Zorraquin (1996), White (1996), Cohen, Fenn and Naimon (1995), Hamilton (1995), Johnson (1995), Porter and van der Linde (1995a, 1995b), Blacconiere and Patten (1994), Cormier, Magnan and Morard (1993), Jaggi and Freedman (1992), Moughala, Robinson and Glascock (1990)

[2] See e.g. Konar and Cohen (2001), Schaltegger and Figge (1997), WBCSD (1997), Schmidtheiny and Zorraquin (1996), Porter and van der Linde (1995a, 1995b).

[3] See e.g. Hart and Ahuja (1996), Klassen and McLaughlin (1996), White (1996), Hamilton (1995), Johnson (1995), Blacconiere and Patten (1994), Cormier, Magnan and Morard (1993) and Moughala, Robinson and Glascock (1990).

The empirical studies in this field investigate firms with a wide range of environmental profiles, reflecting different priorities with respect to the implementation of environmental management systems, investments in environmental protection etc. Many studies appear as statistical "measurement without theory", and more research is needed in order to explicitly link environmental decisions to microeconomic theory and to explore whether these decisions actually affect the observed link between environmental and economic performance.

In this paper we focus on one particular aspect of the environmental performance of a company, namely, how the decision to invest in an environmentally friendly technology depends on the uncertainty about future environmental taxation. The incentives to improve environmental performance in order to reduce the probability of environmental taxation are similar to the incentives created by voluntary agreements, see e.g. Schmelzer (1999), Hansen (1999) and Khanna (2001). We link the level of environmental performance to the theory of investments under uncertainty within an option value framework, focusing on uncertainty about future environmental taxation. The firm's decision is based on the perceived investment incentives, formalized as the expected net benefit of the investment.

The option value approach captures the irreversible nature of the investment decision. Under the assumption of uncertainty and irreversibility, Dixit and Pindyck (1994) show that there exists an option value of delaying the investment because new information resolving the uncertainty may arrive along the road. This option value creates a modification of the conventional net present value calculation of an investment project. Abel, Dixit, Eberly and Pindyck (1996) develop a more general option model including both a call option and a put option and show that the combination of the two options leads to ambiguous results regarding the effect of uncertainty on investments.

Within the environmental preservation literature the concept quasi-option value was introduced by Arrow and Fisher (1974) and Henry (1974) and can be interpreted as a value of information about future environmental damages, conditional on refraining from making early investments. Although developed within somewhat different settings, the two types of option value coincide under certain conditions (Fisher 2000). The option value approach highlights the managerial challenge concerning both the decision to invest or not, and the timing of investments.

The main topic of this paper is to analyze the incentives to invest in environmental improvements within an option value context. In Section 2 we given an informal discussion of the perceived

investment incentives of a company, considering three types of uncertainty about possible stakeholder responses: Customer reactions, the investment strategies of other companies and the probability of environmental taxation. The focus in Section 2 is to informally motivate that the probability of taxation may be reduced if companies invest in environmental improvements, whereas in the formal analysis of the option value model in Section 3 we assume a given and constant probability of taxation. The analysis in Section 3 applies a two period option value period model where uncertainty about future environmental taxation is resolved at the beginning of the second period. The question raised here is whether the tax threat alters the incentives to invest early, as compared to the situation with no tax threat. Further, in Section 4 we elaborate on the implications of the outcome of this analysis for the somewhat unclear link between environmental and economic performance.

# 2. Perceived investment incentives and probability of taxation

Let us now consider the incentives of a company to invest in environmentally friendly technologies in order to reduce the probability of future environmental taxation. From the viewpoint of the government, the objective is to keep aggregate emissions within an industry below a certain level. If the level is exceeded in period 1, the government will impose a tax at the beginning of period 2. Assume that actual emissions in period 1 are dependent on aggregate investments in green technology, denoted by $I$, and the level of green demand, denoted by $D_g$. A high $I$ contributes to reduced environmental impact from all companies who have invested in new technology, and a high $D_g$ contributes to a further reduction in the environmental impact, by a reallocation of demand towards the green companies of this particular industry. Total demand is fixed. Moreover, we assume that there is "super-profit" on each unit produced due to imperfect competition.

The link between green demand and emission can be illustrated as follows. Assume that the prices on products from green companies (defined as companies having invested in environmentally friendly technologies) and brown companies (defined as companies without environmentally friendly technologies) are equal. Assume further that only green companies cover green demand, whereas residual demand is covered both by green and brown companies with equal market shares for all companies. Assuming that production equals demand in all firms, an increase in green demand would increase green production and thus reduce the probability of taxation.

The probability of taxation depends on whether $I$ and $D_g$ are sufficiently large to keep emissions below the critical level. Thus, from the viewpoint of a particular firm the probability of a tax in period 2, denoted by $q$, depends on the critical value for aggregate emissions, aggregate investments in the

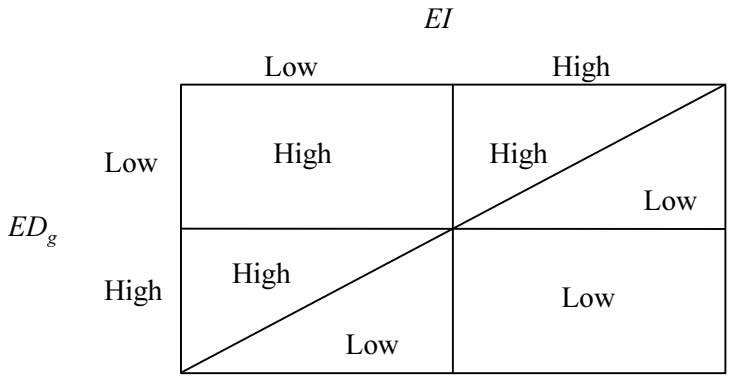
industry and the level of green demand. Assuming that the threshold value for emission is known we get

$$q = q\left(D_g, I\right) \tag{2.1}$$

where $q$ is decreasing in both $D_g$ and $I$.

The perceived investment incentives for a particular company depends both on its perception of the expected levels $EI$ and $ED_g$ and the perceived impact of $EI$ and $ED_g$ on the probability of environmental taxation and. Figure 1 illustrates how the perceived probability of taxation depends on the expected level of green demand and the expected level of aggregate environmental investments in four stylised cases. Each case illustrates a possible scenario of high or low probabilities of environmental taxation. In each case we also discuss the perceived investment incentives for this particular company. Assuming that each company is small, a high level of aggregate investments corresponds to a high level of investments in other companies.

**Figure 1. Perceived probability of environmental taxation**




$EI =$ expected aggregate investments in environmental improvements

$ED_g =$ expected level of consumer demand for green products

In the case where the company expects a low level of green demand ($ED_g$ is low) and further assumes that few other firms invest in environmentally friendly technologies ( $EI$ is low), the company anticipates a high probability of taxation, because aggregate emissions may exceed the target level. Since the expected level of green demand is low, environmental investments may not lead to increased market shares. Hence, if the company has any investment incentive in this case, it would mainly be linked to reducing the probability of taxation.

In the opposite case with high expected levels of green demand and green investments in other firms, the firm anticipates a low probability of taxation. A high expected level of green demand could create an incentive to invest to capture market shares. On the other hand, expecting that many other firms will invest reduces the prospect of increases in market shares. Hence, investment incentives are small in this situation.

In the case where expected green demand is high and expected green investments are low there is considerable uncertainty about whether the tax is imposed or not. A high expected level of green demand together with the perception that few other firms actually investing gives a strong incentive for investing. In the case where the company perceives a high probability of taxation the incentives for investing, in order to reduce the probability of taxation, are further strengthened. In the case where the company perceives a low probability of taxation the incentive to invest is mainly linked to possibility of a large market share.

In the case where expected level of green demand is low and the expected investments in other companies are high, there is a larger uncertainty about whether a tax will be imposed or not. In this case there are weak investment incentives from the market, as there are no prospects of higher market shares. If the firm perceives a high probability of taxation, the incentives are linked to reducing the probability of taxation. In the case where the company perceives a low probability of taxation there are weak incentives to invest.

These four stylized cases highlight the role of consumers[4], companies and government in the "greening" of an industry. In the first case, with low levels of green demand and green investments, the high probability of taxation reflects that the government assumes the role of regulator in order to achieve the environmental standard. In the second case, with high levels of green demand and green investments, the low probability of taxation reflects that both consumers are companies are proactive and that the externalities may be internalised by the market. The third case, with high level of green demand and low level of green investments, illustrates a situation where consumers have the proactive role, demanding green products, whereas companies lag behind.

However, if the companies perceive a stable green demand, it is likely that they will invest, and case three may coincide with case two, where both consumers and companies are proactive. Case four, with

[4] The market gain from increased consumer demand can be looked at as a special case of a more broad range of possible benefits/cost reductions

low level of green demand and high level of green investments, illustrates a situation where companies may have the proactive role, investing in order to reduce the probability of taxation. The low demand for green products may be due to weak preferences for green products or lack of information.

Under the assumption of a large number of companies involved, the game-theoretical element of the incentive model disappears, and we may analyze the investment decision within the framework of a probabilistic model. In the following we will assume that the probability $q$ is given and constant and analyze how the probability of taxation influences the investment incentives of a company. Within a two-period model we discuss whether the tax uncertainty creates any incentives for early investments.

# 3. Investment incentives in a two-period model

In a dynamic context, the company has the option to postpone its investment, depending on the outcome of taxation. Assume that at the start of period 1 the regulator announces that a tax will be imposed in period 2 if aggregate emission exceeds a certain level. If taxation is imposed, all companies that have not invested in green technology have to pay a fixed amount. Let us further assume that the companies at the start of period 2 observe whether a tax is imposed or not before their period 2 investment decision. This means that the firms can avoid taxation by investing either in period 1 or period 2. The question raised here is whether the tax threat alters the incentives to invest in period 1, compared to the situation with no tax threat.

As seen from the beginning of period 1, the companies have to assess (subjective) probabilities to the different outcomes. With probability $q$ taxation will be imposed on companies that have not made an environmental investment. With probability $1-q$ the government will announce that the tax will not be imposed after all. As discussed above, the probability of taxation depends on the critical value for aggregate emissions, aggregate emissions in the industry and the level of green demand. The probability $q$ is now considered given and constant.

Denote the output of a company that invests by $X$ and the output of a company that does not invest by $X_0$ and we assume that $X > X_0$, due to consumers preferring products from green companies. The lump-sum tax level is denoted by $t$. Revenue for a company in the second period is given by, depending on its investment decision and hence, choice of output level $X$ or $X_0$,

$$R = \begin{cases} X_0 - t & \text{or} \quad X \quad \text{with probability} \quad q \\ X_0 & \text{or} \quad X \quad \text{with probability} \quad 1-q. \end{cases} \tag{3.1}$$

Expected revenue in the second period is given by $X_0 - qt$ for a company that does not invest, and $X$ for a company that invests, since this type of taxation allows the company the possibility of avoiding taxation by investing in the second period and "becoming green".

In order to derive the option value of postponing the investment to the second period, we apply the option value model of Fisher (2000), see also Grønn (1996). We assume that investment is a discrete variable, where $I_1$, the level of investment in the first period, can be zero or one. Note that, if $I_1 = 1$, then by assumption $I_2 = 0$. Let the profit from investment in the first period be $B_1(I_1)$. The present value of the profit from investment in the second period is $B_2(I_1 + I_2, \theta)$, where $I_2$, the level of investment in the second period, can be zero or one, and $\theta$ is a random variable representing the tax uncertainty, with probability distribution $(q, 1-q)$. We assume risk neutrality.

Let $\hat{V}(I_1)$ be the expected discounted profit over both periods as a function of the choice of first-period investment $(I_1 = 0 \text{ or } I_1 = 1)$ given that $I_2$ is chosen at the start of the second period to maximize benefits in the second period. If $I_1 = 0$ is the optimal investment decision, we have

$$\hat{V}(0) = B_1(0) + E\left[\max_{I_2}\{B_2(0,\theta), B_2(1,\theta)\}\right]. \tag{3.2}$$

The investment decision $I_2 = 0$ yields revenue $X_0 - t$ in the event of taxation and $X_0$ in the event of no taxation, whereas $I_2 = 1$ yields revenue $X$ regardless of the outcome of taxation since the company has the possibility of avoiding taxation by investing in period 2. If investment takes place, the investment cost $c$ is incurred. Hence, we obtain

$$\hat{V}(0) = \frac{1}{1+r}\left[X_0 + q\max\left\{\frac{X_0 - t}{1+r}, \frac{X}{1+r} - c\right\} + (1-q)\max\left\{\frac{X_0}{1+r}, \frac{X}{1+r} - c\right\}\right]. \tag{3.3}$$

If taxation is imposed, the company will invest at the beginning of period 2 if

$$\frac{X}{1+r} - c \geq \frac{X_0 - t}{1+r}$$

or, equivalently, $X - X_0 \geq c(1+r) - t$, that is, if the increase in market share $X - X_0$ is sufficiently large relative to the investment cost minus tax. If the market gain from investing is small relative to

the investment cost minus tax, so that the inequality is reversed, the company will not invest at the beginning of period 2 even if a tax is imposed.

Similarly, if taxation is not imposed, the company will invest at the beginning of period 2 if $X - X_0 \geq c(1+r)$, and not invest at the beginning of period 2 if $X - X_0 < c(1+r)$. Combining these conditions, we find the following investment criteria for investment at the beginning of period 2. If

$$c(1+r) - t \leq X - X_0 < c(1+r), \tag{3.4}$$

the company will invest in period 2 if taxation is imposed but not otherwise. If

$$X - X_0 \geq c(1+r), \tag{3.5}$$

the company will invest in period 2 regardless of the outcome of taxation. If

$$X - X_0 < c(1+r) - t, \tag{3.6}$$

the company will not invest in period 2 regardless of the outcome of taxation.

If $I_1 = 1$ is the optimal investment decision, we have

$$\hat{V}(1) = B_1(1) + E\left[B_2(1,\theta)\right] = \frac{1}{1+r}\left[X + \frac{X}{1+r}\right] - c. \tag{3.7}$$

Here investment takes place at the beginning of the first period, and the investment cost is not discounted. Investment in the first period locks in investment in the second period, since $I_1 = 1 \Rightarrow (I_1 + I_2) = 1$, and by having invested in the first period, the company avoids tax regardless of the outcome of the tax uncertainty.

To get the decision rule for the first period, $\hat{I}_1$, compare (3.2) and (3.7):

$$\hat{V}(0) - \hat{V}(1) = B_1(0) - B_1(1) + E\left[\max_{I_2}\left\{B_2(0,\theta), B_2(1,\theta)\right\}\right] - E\left[B_2(1,\theta)\right] \tag{3.8}$$

and choose

$$\hat{I}_1 = 1 \text{ if } \hat{V}(0) - \hat{V}(1) < 0 \tag{3.9}$$

and $\hat{I}_1 = 0$ otherwise.

In the case where it is profitable to invest in the second period in the event of taxation, but not otherwise, that is, (3.4) applies, we apply (3.3), (3.4) and (3.7) to (3.8) and obtain

$$\hat{V}(0)-\hat{V}(1)=\frac{1}{1+r}\left[rc+(1-q)\left(c-\frac{X-X_0}{1+r}\right)-(X-X_0)\right]. \tag{3.10}$$

Then (3.9) becomes

$$\hat{I}_1=1 \text{ if } X-X_0\geq\frac{1+r-q}{2+r-q}(1+r)c \tag{3.11}$$

and $\hat{I}_1=0$ otherwise. If the increase in market share from investing is larger than the critical value given by (3.11), the profitability of the investment is so large that it pays off to invest early. If the market gain is smaller than the critical value, it pays to wait until the beginning of the second period and invest in the event of taxation and not invest otherwise. In the special case where the probability of taxation equals the discount rate, $q=r$, early investment is profitable if the market gain exceeds one half of the capitalized investment cost, that is,

$$\hat{d}_1=1 \quad \text{if} \quad X-X_0\geq\frac{1}{2}(1+r)c \quad \text{for} \quad q=r.$$

In the case where the company will invest regardless of the outcome of taxation, that is, (3.5) applies, it follows immediately that it is profitable to invest in the first period. We find from (3.3), (3.5) and (3.7) that

$$\hat{V}(0)-\hat{V}(1)=\frac{1}{1+r}\left[rc-(X-X_0)\right]<0. \tag{3.12}$$

Hence, it follows from (3.9) that $\hat{I}_1=1$ under assumption (3.5). In this case there is no option value from postponing investment as the outcome of taxation will not influence the second period decision.

In the case where the company will not invest in the second period, that is, (3.6) applies, the company may nonetheless consider investing in the first period, if the increase in market share over two periods is sufficiently high. From (3.3), (3.6) and (3.7) we obtain

$$\hat{V}(0)-\hat{V}(1)=\frac{1}{1+r}\left[(1+r)\left(c-\frac{X-X_0}{1+r}\right)-\frac{X-(X_0-qt)}{1+r}\right] \tag{3.13}$$

and (3.9) becomes

(3.14) $$\hat{I}_1 = 1 \text{ if } X - X_0 \geq \frac{(1+r)^2}{2+r} c - \frac{qt}{2+r}$$

and $\hat{I}_1 = 0$ otherwise. If the market share increase from investing is larger than the critical value given in (3.14), the market share increase is so high that it pays to invest early and obtain the increase in market share over two periods even if it would not be profitable to invest in the second period. The larger is the expected tax, the larger is the expected gain of investing early.

In order to interpret the critical value for first period investment, consider the case of no discounting, $r = 0$. Then early investment is profitable if the market gain exceeds half the investment cost minus the expected tax, that is,

$$\hat{I}_1 = 1 \quad \text{if} \quad X - X_0 \geq \frac{1}{2}(c - qt) \quad \text{for} \quad r = 0 .$$

In order to derive the option value of postponing the investment to the second period, we need to compare $\hat{V}(0)$ given by (3.2) with the expected discounted value over both periods in the case where we suppose that, instead of waiting for the resolution of uncertainty about future benefits before choosing $I_2$, we simply replace the uncertain future benefits by their expected value. This would be appropriate if we did not expect to receive information, over the first period, that would permit us to resolve the uncertainty. The expected discounted value over both periods $V^*(0)$, for the corresponding investment strategy $I_1^* = 0$, is

(3.15) $$V^*(0) = B_1(0) + \max_{I_2} \left\{ E\left[B_2(0,\theta)\right], E\left[B_2(1,\theta)\right] \right\},$$

which becomes

(3.16) $$V^*(0) = \frac{1}{1+r}\left[ X_0 + \max_{I_2} \left\{ \frac{X_0 - qt}{1+r}, \frac{X}{1+r} - c \right\} \right]$$

since expected net discounted revenue is $-c + X/(1+r)$ under assumptions (3.4) and (3.5) and $(X_0 - qt)/(1+r)$ under assumption (3.6). Second-period investment, $I_2^*$, is in effect chosen in the first period, to maximize expected benefits in the second period, because we do not assume that further information about second-period benefits will be forthcoming before the start of the second period. For $I_1^* = 1$, we have,

(3.17) $$V^*(1) = B_1(1) + E\left[B_2(1,\theta)\right] = \frac{1}{1+r}\left[X + \frac{X}{1+r}\right] - c = \hat{V}(1)$$

As before, investment in the first period locks in investment in the second, that is, the green technology is available in both periods. Comparing (3.15) and (3.17), we find

(3.18) $$V^*(0) - V^*(1) = B_1(0) - B_1(1) + \max_{I_2}\left\{E\left[B_2(0,\theta)\right], E\left[B_2(1,\theta)\right]\right\} - E\left[B_2(1,\theta)\right]$$

and

(3.19) $$I_1^* = 1 \text{ if } V^*(0) - V^*(1) < 0$$

and $I_1^* = 0$ otherwise.

The option value is derived from a comparison of $\hat{V}$ and $V^*$. First, notice that $\left[\hat{V}(0) - \hat{V}(1)\right] - \left[V^*(0) - V^*(1)\right] = \hat{V}(0) - V^*(0)$ since $\hat{V}(1) = V^*(1)$. Then it follows that

(3.20) $$\hat{V}(0) - V^*(0) = E\left[\max_{I_2}\left\{B_2(0,\theta), B_2(1,\theta)\right\}\right] - \max_{I_2}\left\{E\left[B_2(0,\theta)\right], E\left[B_2(1,\theta)\right]\right\} \geq 0$$

from the convexity of the maximum function and Jensen's inequality. This difference, $F = \hat{V}(0) - V^*(0)$, has been interpreted as option value in the environmental literature, see Fisher (2000). It may also be considered a (conditional) value of information, that is, the value of information about future benefits conditional on retaining the option to invest in the future given that $I_1 = 0$.

Consider now the case where (3.4) is satisfied so that it is profitable to invest in period 2 if taxation is imposed and not otherwise. Then the expression for $\hat{V}(0)$ in (3.3) becomes

(3.21) $$\hat{V}(0) = \frac{1}{1+r}\left[X_0 + q\left(\frac{X}{1+r} - c\right) + (1-q)\frac{X_0}{1+r}\right].$$

In the case where $V^*(0)$ in (3.16) is determined by $X - X_0 < c(1+r) - qt$ we find that the difference $\hat{V}(0) - V^*(0)$ would have become negative, which is inconsistent with the requirement of a positive option value. The interpretation of this result is that there is certainly no gain from postponing investment in the case where second period investment is not profitable. However, investment in the first period may be profitable, provided that the market gain is sufficiently high.

In the case where $V^*(0)$ in (3.16) is determined by $X - X_0 \geq c(1+r) - qt$ the option value becomes

$$F = \hat{V}(0) - V^*(0) = \frac{1-q}{1+r}\left[ c - \frac{X - X_0}{1+r} \right] > 0 \quad \text{if} \quad X - X_0 < c(1+r). \tag{3.22}$$

Since $q \in [0,1]$, we have that the assumption $X - X_0 < c(1+r)$, which ensures a positive option value, is consistent with $X - X_0 \geq c(1+r) - qt$. In the case where it would be optimal to have $I_1^* = 0$ and $I_2^* = 1$, it is clearly optimal to postpone investment in the flexible strategy where the investment decision $\hat{I}_2$ can be made at the beginning of period 2, depending on the outcome of taxation.

The option value in (3.22) consists of two terms. First, by postponing investments until period 2, there is a probability $1-q$ that taxation will not be imposed, and the expected investment cost saving is $(1-q)c$. Second, the loss of not investing earlier is the expected discounted revenue loss in period 1, $(1-q)(X - X_0)/(1+r)$. It is optimal to postpone investments if $F > 0$. The larger is the probability of taxation, the smaller is the option value. Hence, the threat of taxation creates an additional incentive for early investment even if the company can avoid the tax by investing in period 2. Note that the option value given by (3.22) is independent of the tax level. Since companies may avoid taxation by investment, the tax term vanishes in the expected value as seen from the first period and in the option value.

Under the assumptions (3.5) and (3.6) we find that $F = 0$, as expected. Under assumption (3.5), where investment is profitable in period 2 regardless of the outcome of taxation, we have shown that it is profitable to invest in period 1. As discussed above, there is no option value as the outcome of taxation will not influence the second period investment decision. Under assumption (3.6), where investment is not profitable in period 2, the option to postpone investment has no value. As discussed above, the company may nonetheless invest in the first period if the market share increase is sufficiently high.

# 4. Concluding remarks

This paper is based on a model of investments under uncertainty that highlights the option value aspect of environmental investments. Our main conclusion is that a specific tax uncertainty, standing alone, does not create any incentives for early investments. However, introducing a market share increase linked to the investment, the tax uncertainty may strengthen the incentives for early investments. The investment incentive created by a positive market response can be seen as a special case of a more

general stakeholder response. Similar incentives can for instance be created by the existence of green funds through reduced capital costs.

Our analysis relies on an implicit assumption about improved environmental performance leading to increased market shares. If only a small number of companies invest, they may obtain a high market share and also eliminate the probability of being taxed; both factors contributing to better economic performance. This feature of our model predicts a positive relation between environmental investments and economic performance. However, if many companies invest, there could be an over-investment in green technologies, market shares may only be marginally improved and may not cover the investment costs. Hence, our model predicts that it pays to be green provided that not too many other companies choose to be green.

The theoretical analysis is based on a framework where the environmental tax is the only policy instrument that induces the company to change its behavior in an environmentally friendly direction, and the tax rule is quite simple. In further research we will investigate more complex tax rules within the same framework and also analyze whether the effect of tax uncertainty is dependent on public access to environmental information. In many countries release of environmental information has become an element in the environmental policy toolkit. The distinction between green and brown companies can be made through the use of environmental performance indicators (see e.g. Keffer, Shimp and Lehni (1999), Azzone, Noci, Manzini, Welford and Young (1996) and OECD (1996)) where, somewhat simplified, the company has to invest more than a certain level to be labeled as green. Provision of information about the state of the environment and firms' environmental performance might affect the perceived risk of taxation.

Relevant environmental information provided by the government might also influence the amount of capital channeled through green funds by reducing the information costs. An interesting question is whether the investment decision is affected by an anticipated stream of information during the first period. Such analysis would give further input to the understanding of the perceived incentives for both the level and timing of environmental investments, as well as improving the understanding of how environmental policies affect corporate decision making.

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