Should environmental projects be subsidised? An empirical analysis.

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Abstract

Imperfect markets, asymmetric information and transboundary pollution are all characteristics that in most cases lead to inefficient "market" outcomes, and which thus are arguments for (public) intervention in the market. On the other hand, these characteristics also imply strategic behaviour by the economic agents, and then the effects of public intervention may be different from the traditional results of e.g. subsidies.

The point of departure for this paper is the trading of an environmental project in a market with the above mentioned characteristics and where the pollution is transboundary. The trade is promoted by (foreign) authorities in that they offer a grant is trade takes place. We show that the effects of the grant strongly depend on the interests of the authorities, and that the subsidisation does not necessarily make the trading outcome more efficient.

Keywords: imperfect market, asymmetric information, transboundary pollution, subsidisation

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1 Introduction

There are several economically based reasons for subsidising environmental projects. One of the consequences of the implementation of such projects is cleaner nature. This is a collective good, and when people beyond the trading agents are positively affected by the implementation of a project it can be said to have positive external effects. From basic economic theory we know that both in the case of collective goods and when there exists external effects, the market left alone provides a suboptimal quantity of the good.

Another argument is that when there is asymmetric information in a market, e.g. that the seller of a project does not know the valuation of the buyer, one can show that under given assumptions[1] there is no efficient trading mechanism. In such a situation a subsidy may promote the efficiency of the trading outcome.

Further, when the pollution caused by economic activity is transboundary, then it can be shown[2] that when each country only takes into consideration the damage made in their own country when regulating the activity, the resulting polluting emissions will be too high compared to what is socially optimal. When the countries affected by the pollution co-operate the socially optimal emission level may be implemented, but in many cases this require a

[1] The assumptions are that there is a probability for no gains from trade and that budget balance is required. Myerson and Satterthwaite (1983) were the first to derive this result and it has been known as one of the inefficiency theorems (Fudenberg and Tirole 1993, p.275).

[2] Among these we can mention Mähler (1989), Kaitala et al (1991)

side-payment (which can be defined as a subsidy) to the country, which have to decrease its emission the most[3].

However, introducing a grant in a trading situation will have multiple and varying effects, depending on the characteristics of the market and the ex ante information structure. Hence, the aim of this paper is as follows:

I: To discuss the effects on market efficiency of a subsidy to an environmental project when the market is monopolistic, there is asymmetric information and the trading agents behave strategically.

II: To derive the optimal (public) subsidy to offer in the above situation, and discuss how this varies with the interests of the provider of the subsidy (e.g. authorities, Government).

As we see it, the market characteristics mentioned under I) are rather usual concerning the trading of environmental projects. This will be further documented in section 2. Also, a Government may have its own interests to follow in the environmental politics, and these need not coincide with welfare maximisation. Hence, we give examples of different possible interest of a Government offering subsidies to an environmental project.

The paper is organised as follows: In section two we present the empirical case on which the analysis in this paper is based. In section 3 an analytical model is presented and solved by use of a Bayesian game. In section 4 we concretise the role of the provider of the grant

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[3] For such a co-operative solution with side-payments see Kaitala et al (1991) who describes the situation between Finland and parts of the former Soviet Union.

(Government), assuming three different types of this agent. In section 5 the results from the model is discussed with respect to the empirical case, and in section 6 we conclude.

2 Background

The border area between Finland, Norway and Russia is characterised by significant environmental degradation due to pollution from an extensive industrial activity. One of the main sources of this pollution is the nickel smelter Petsjenganikel in the town of Nikel. Since 1988 there have been negotiations between Finnish, Norwegian and Russian representatives about modernising the plant and thus reducing emissions of sulphur dioxide by 90%. Both Finnish and Norwegian companies possess the relevant technology, and they have developed plans (projects) for how to transfer it to Petsjenganikel. The respective governments have attached a grant to such a project if implemented. However, neither succeeded in reaching an agreement with the Russian counterpart. Below is a short presentation of the negotiations.

A: The first phase (1990-1991)

The registration of long-transported pollution in Europe through the monitoring programmes EMAP (European Monitoring Assessment Programme) in 1976-1978 showed severe pollution streams from Russia to Finland and Norway. Later Russian-Norwegian expert groups, under the Joint Norwegian-Russian Commission on Environmental Questions explored the local environmental impacts of these pollution streams (AMAP 1997). One of the main sources of the transboundary pollution streams between Russia, Finland and Norway is the nickel-plant Petsjenganikel. In 1990 a general agreement was reached between Russian, Finnish, Swedish and Norwegian authorities about reducing the emissions of SO_2 from Petsjenganikel. The Finnish company Outokumpu developed a technological solution, involving a 90% reduction of the SO_2 emissions, based on the emission level in 1989, with costs equalling US$ 600 mill. Using a traditional cost-benefit analysis, the project was recommended to the Russian government (Kola Science Centre et al, 1992). Both the Finnish and Norwegian government attached a grant to the project. The Norwegian grant amounted to US$ 42 mill, whereas the Finnish grant consisted of deliveries of equipment and services to the project.

B: The second phase (1992-1995)

At a Nordic-Russian meeting between foreign Ministers in Kirkenes, Norway in 1992, the Russian Government, led by Jeltsin rejected the Outokumpu-project. The reason given was the very high costs of the project. In 1993 Russian authorities arranged an international competition for the modernisation-project, encompassing emission abatement and technological upgrading of Petsjenganikel. Five proposals were delivered, among them one from Outokumpu and one from a Norwegian-Swedish consortium.

The Norwegian-Swedish proposal was chosen as the winner. It amounted to US$ 297 mill, and involved a reduction of SO_2 emissions by 90%. As a consequence of further negotiations, the costs were reduced to US$ 257 mill. The costs of the winning project were to be divided between Norway, in the form of a grant, (1/6), the Russian government (1/6), and Norilsk Nickel, the mothercompany of Petsjenganikel, (2/3) (Kvaerner Technology 1996). When Outokumpu lost the competition the Finnish government withdrew all support to a modernisation project for Petsjenganikel.

In 1995, the Russian private investment bank Oneximbank bought a majority of the shares in Norilsk Nickel, the mother company of Petsjenganikel. Consequently, the responsibility for implementing the project was transferred from Russian authorities to the private owners.

Before accepting such an implementation, the leaders of the mother-company demanded that Russian authorities still share some of the costs, specifically through tax relief. In March 1996 President Jeltsin gave a general relief from export-tax. This, however, was insufficient for the company to implement the modernisation project at Petsjenganikel.

C: The third phase (1996-2001)

In December 1996 an agreement about technical details of the modernisation project was reached between the leaders of the consortium and Petsjenganikel, but the project could not be implemented before the leaders of Norilsk Nickel signed the agreement. The negotiations with the Russian government about further public subsidies to the project were continued. In 1997 the Nordic Investment Bank was employed to replace the Norwegian Government in the negotiations. The Bank worked together with representatives from Norilsk Nickel to find a feasible solution. In June 2001 an agreement on a Russian modernisation project for Petsjenganikel was reached, and in December 2001 The Norwegian Ministry of Environment signed an agreement with the Nordic Investment Bank about financial support to this project, which is assumed to cost US$ 91,5 mill. and reduce the SO_2 emissions with 90% compared to the emission level in 1999 (Norwegian Ministry of Environment, 2001).

It has been argued that the governmental grants mainly serve to support national exporting industries, and scientists both from Russia and Finland question its environmental effects (Kotov and Nikitina 2000, Hiltunen 1995). Representatives of the Regional Environmental Committee in Murmansk County also doubt the effects of the grant due to the high price of the projects offered, and of which the grant only constitutes a minor part. These are interesting viewpoints in the light of our model results, and will be discussed further in the next sections.

Concerning the theoretical basis for this paper, there is a vast literature discussing the effects of an exogenous subsidy under imperfect competition such as oligopoly, and there are also analyses in which the subsidy is treated endogenously, but then the information is symmetric. The literature relevant for this paper can roughly be divided into two categories;

i) micro-economic models with an exogenous subsidy. These are either traditional neo-classical models or models within industrial organisation, characterised by imperfect markets and/or information

ii) industrial organisation models of symmetric information and an endogenous subsidy decided by a social planner (welfare maximisation)

From the first group this paper especially has exploited the inefficiency theorem derived by Myerson and Satterthwaite (1983), and in general the theories in mechanism design presented in Fudenberg and Tirole (1993). To the degree that these introduce a subsidy, this is done exogenously. From the second group can be mentioned analyses by Laplante (1990), Herander (1995), and White (1996). These mainly assume symmetric information, and discuss the optimal subsidy or tax in order to maximise social welfare. Theoretically, this paper combines aspects from the two above mentioned categories, as it models an imperfect market structure with asymmetric information and introduces an endogenously decided subsidy. Finally, this paper is strongly inspired by and indebted to the literature on transboundary environmental problems, especially the works of Kaitala et al (1991) and Huber and Wirl (1995). Empirical work belonging to this literature is Peszko and Zylicz (1998), who has been used as an example of the relevance of the analysis. They discuss the subsidisation of environmental projects in Eastern European countries.

3 A trade model with subsidies

There are three agents in the model; buyer, seller and the provider of the grant, the latter hereafter called Government. The seller belongs to the same country as the Government, whereas the buyer is a foreign agent.

Let

$$U_B[v] = (v - P)X \tag{1}$$

$$U_S = (P - c)X \tag{2}$$

$$U_G = (W + \alpha(P - c) - G)X \tag{3}$$

be von Neuman-Morgenstern utility functions for buyer, seller and Government respectively.

Buyer's valuation, *v*, is private information, but it is common knowledge that it is distributed on [$\underline{V}$, $\bar{V}$], with distribution function $F(v)$, and density function $F'(v) = f(v)$. Throughout the analysis we will assume the uniform distribution, such that $f(v) \equiv (\bar{V}-\underline{V})^{-1}$. *P* is the price the seller offers the buyer for implementing the project, whereas *c* represents the costs of offering the project, and this we assume to be exogenously fixed. *X* is the probability that trade takes place.

The Government represents domestic consumer and producer interests. W denotes consumers' surplus of the project as assessed by the Government. This can be interpreted as the positive external effects of implementation of the project as valued by the Government. α is a fixed parameter, equal to or larger than zero, and defining the share of the seller's profit, which affects Government's utility. G is the nominal value of the grant. W and α are exogenously fixed, and these are the variables to be varied for different types of Government.

The endogenous variables to be decided within the model are the price offered by the seller, P, the grant offered by Government, G, and the probability of trade, X. Further, we introduce an endogenous variable denoted (equilibrium) efficiency loss, defined as possible gains from trade, which are not realised in equilibrium.

We now define a 2-stage game between the 3 above mentioned agents. At stage 1 the Government and the seller announces a grant and a price for the project simultaneously, and forward an offer, equalling seller's price minus grant, to the buyer. The buyer does nothing. At stage 2 the buyer either accepts or rejects the offer, and Government and seller do nothing. When the offer is accepted, the project is implemented, which results in pay-off to the players given by the utility functions (1)-(3). If the offer is rejected, all players get a pay-off equal to zero. We assume that the 3 agents all maximise utility and act strategically. The latter implies that each player takes into account the (expected) action of the other players when choosing its own behaviour. A grant is only offered, if Government's utility, when taking into consideration the expected actions of the trading agents, is higher when offering a grant compared to not offering a grant.

As a benchmark we derive the market solution in the absence of an interfering Government. This market outcome is given by (4) and (5)[4].

[4] This is the same as the outcome of the monopoly-pricing model when demand is linear.

$$P^* = \frac{(\overline{V} + c)}{2}\ ^{5} \tag{4}$$

which is accepted by the buyer iff v≥P*. The probability of trade in market equilibrium is

$$X(P^*) = \frac{(\overline{V} - c)}{2(\overline{V} - \underline{V})} \tag{5}$$

In the special case when $c=\underline{V}$, $X=1/2$. When $c>\underline{V}$ the probability of trade is below 1/2. The above solution implies inefficiencies due to the market imperfections when $v \in (c, P^*)$. Further, the existence of externalities, represented by W, contributes in another way to the inefficiency of the market solution. In total, the inefficiency, hereafter called efficiency loss and denoted Z, is given by

$$Z = \int_c^P (W + v - c)dF(v) \tag{6}$$

which in market equilibrium equals

$$Z^* = \frac{(\overline{V} - c)(\overline{V} - c + 4W)}{8(\overline{V} - \underline{V})} \tag{7}$$

When there are gains from trade Z* is positive, which means that the market equilibrium is always ex ante inefficient.

[5] Conditions for this result to be valid are that $\overline{V} > P^* > \underline{V}$, and $P \geq 0$.

The equilibrium inefficiency is higher the larger the difference between upper valuation limit and actual project costs. The reason is that the higher $\bar{V}$, the higher P^*, and thus the higher $F(P^*)$. For given v this implies a higher probability of no trade. Also, it is larger the larger the difference between costs and lower valuation limit, and the argumentation is the same as above. The higher c the higher the price offered by the seller, and, for given v, the lower is the probability of trade. That the efficiency loss increases in W is quite intuitive. On the other hand, the larger the uncertainty about the buyer's valuation, measured as the difference between $\bar{V}$ and $\underline{V}$, the smaller the expected inefficiency. The reason is that upper and lower distribution limits do not affect Z^* through v symmetrically. The higher $\bar{V}$ the higher v may be, and the higher the probability of trade for given c. This reduces Z^*. On the other hand, a lower $\underline{V}$ implies lower potential values on v. But only for v higher than c no trade cause inefficiency, such that only a part of the expected reduction in v caused by reduced $\underline{V}$ will lead to an increase in Z^*.

Letting the Government interfere in the trade by offering a grant implies that for every price offered by the seller, the buyer now has to pay

$$\pi = P - G \tag{8}$$

Consequently, when deriving X, P must be substituted by π. Seller and Government maximise (2) and (3) simultaneously, which provides the following reaction functions;

$$G = \frac{W + (1 + \frac{\alpha}{2})P - (1 - \frac{\alpha}{2})\bar{V} - \alpha c}{(2 - \frac{\alpha}{2})} \tag{9}$$

and

$$P = \frac{\overline{V} + c + G}{2} \qquad (10)$$

Solving for the reactions functions simultaneously we get

$$G^* = \frac{(4-\alpha)\left[W + (\frac{2-3\alpha}{4})(c-\overline{V})\right]}{(3-\frac{3\alpha}{2})(2-\frac{\alpha}{2})} \qquad (11)$$

$$P^*_G = \frac{(4-\alpha)(W+\overline{V}) + c\left[8(1-\alpha) + \frac{3\alpha^2}{2})\right]}{2(3-\frac{3\alpha}{2})(2-\frac{\alpha}{2})} \qquad (12)$$

The price offered to buyer in equilibrium is then

$$\pi^* = \frac{\overline{V}\left[4(1-\alpha) + \frac{3\alpha^2}{4}\right] + (c-W)(2-\frac{\alpha}{2})}{(3-\frac{3\alpha}{2})(2-\frac{\alpha}{2})} \text{ [6]} \qquad (13)$$

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[6] For π^* to be positive it must be the case that $W<c+K\overline{V}$, where $K=(4-4\alpha+3\alpha^2/4)(2-\alpha/2)^{-1}$. When $\alpha=1$, this equal $W<c+\overline{V}/2$, whereas when $\alpha=0$, it equals $W<c+2\overline{V}$.

P^*_G and G^* are best responses to the action of the other player, and thus constitute a Nash-equilibrium in the stage-1 game between seller and Government. (10) shows that when there is a grant the seller will increase the price compared to when there is no grant, and he will "confiscate" half of the grant. This result crucially depends on the distribution of the unknown variable. Assuming the uniform distribution, which indicates linear demand, the seller will always confiscate half of the grant. For the normal and right-biased distributions the confiscated share depends on the equilibrium price without a grant. The higher this price the lower the probability that the seller will confiscate parts of the grant, or, the lower the expected share she will confiscate when a grant is introduced. For market equilibrium prices below the expected value of buyer's valuation the seller will always confiscate a part of the grant. Generally, the higher the point probability for the price offered, i e the more likely that this price is forwarded, the lower is the confiscated share of the grant. Only exceptionally the whole grant is confiscated. These results are derived more formally in the appendix.

The grant is obviously increasing in W, and increasing W causes larger effects on the grant than corresponding increases in the other exogenous variables. The effects of c and $\bar{V}$ on the grant depend on the size of α. (11) shows that the critical value of α is 2/3. For α below this c has a positive and $\bar{V}$ has a negative effect on the grant, and for α above 2/3 the opposite is the case. The reason for this change in the effect of c and $\bar{V}$ on the grant is that for low α, the utility of trade to Government mainly consists of W, and the larger c the larger the grant must be in order to secure trade such that W can be received. On the other hand, the higher $\bar{V}$ the lower the grant needs to be in order to secure trade. The higher α the more important the seller's profit is to Government's utility, and the profit is higher the lower c and the higher $\bar{V}$. Thus the grant decreases in c and increases in $\bar{V}$.

Seller's price is strictly increasing in all the explanatory variables, and the size of these interdependencies varies with the size of α. Again, $\alpha=2/3$ is the critical value. For this value all the explanatory variables have the same influence on the price. For α different from 2/3 we have two situations. When α is above 2/3, denoted the "high price case", generating a high profit has positive effects as this generates a high grant, which again is an incentive for the seller to offer a high price. In this case W and $\bar{V}$ are the explanatory variables with the largest effects on the offered price. For given c we have that the higher $\bar{V}$ and W the higher is the seller's profit. When $\alpha<2/3$, denoted the "low price case", generating a high profit does not, to the same degree, have this effect, and thus the seller has less incentives to increase the profit. In this case c is the explanatory variable with the largest effect on the price. For given W and $\bar{V}$, the higher c the lower the profit.

The price the buyer has to pay increases in $\bar{V}$ and c, and decreases in W, which seem quite intuitive. It can be shown that for $\alpha>2/3$, π^* is always lower than P*, and for $\alpha<2/3$, π^* is lower than P^* when the condition for a positive grant is fulfilled. Thus, in the grant-equilibrium the seller will never confiscate the whole grant.

Both P and G increase when α increases. Knowing that Government's willingness to offer a grant increases in α, the seller will also increase her price when α increases. For a sufficiently low W and for given values on the explanatory variables, low values on α will imply that no grant will be offered, but as it rises the Government will find it profitable to offer a grant. On the other hand, it is not clear how α affects the price offered to the buyer. This depends on the size of the other explanatory variables. The higher $\bar{V}$ and c, and the lower W, the more likely that π will decrease in α, when α is large. The reason is that a large α implies that the seller's profit is important for the grant. The higher $\bar{V}$ the higher the profit, ceteris paribus, and this compensates for the negative effects of a high c on the profit. To secure trade in this situation the grant must be high such that the price offered to buyer is sufficiently low. It can be shown that the change in the grant due to changes in the explanatory variables decreases as α increases. This means that when α is large, changes in W, c and $\bar{V}$ will cause smaller changes in the grant compared to when α is large. Thus, α stabilises the grant with regard to changes in the explanatory variables.

The criterion for a grant is

$$W > \left(\frac{2-3\alpha}{4}\right)(\bar{V}-c) \tag{14}$$

From (14) it is easy to see that $\alpha \geq 2/3$ is a sufficient criterion for a grant. An α lower than this requires either a high W and c, and/or a low $\bar{V}$, for there to be a grant.

These results concerning the effects of α on the grant are interesting in the light of the "accusations" from scientists and environmentalists in the three countries, that the grant serve mainly industrial interests and to a lesser degree environmental interests. Our results show that industrial and environmental interests may be compatible, as the larger the industrial interests in this case, the higher the probability that there will be a grant, and the more stable the grant for changes in other explanatory variables.

The probability of trade in equilibrium is

$$X^*_G = \frac{(2-\frac{\alpha}{2})(\overline{V}+W-c)}{(3-\frac{3\alpha}{2})(2-\frac{\alpha}{2})(\overline{V}-\underline{V})} \tag{15}$$

It is straightforward to see that X^*_G increases in W, $\overline{V}$ and α, and decreases in c, which is also intuitive. Given the optimal strategy for the buyer (accept iff $v \geq \pi^*$), it follows from above that $X^*_G > X^*$. In other words, that a grant always increases the probability of trade.

In the 3-player game an efficient solution would imply that trade takes place when $v+W+\alpha(P-c) \geq c$, whereas in equilibrium trade takes place when $v \geq \pi^*$. Using (13) it can be shown that $\pi^* > c - W -$ $(P-c)$ when(□V+W)>c, which is the weakest condition for there to be a positive probability for gains from trade. Thus, given that there may be gains from trade, the equilibrium will always imply inefficiencies. An expression for this efficiency loss when there is a grant is

$$Z_G = \int_c^{\pi} (v-c)dF(v) + \int_c^{\pi} (W+\alpha(P-c)-G)dF(v) \tag{16}$$

When discussing this ex ante efficiency loss there are two effects, which must be taken into consideration, represented by the two terms in the expression:

i) the grant, which may be introduced by the Government, implies a lower price offered to the buyer, and this reduces the efficiency loss

ii) when a grant is introduced, and this, due to strategic behaviour, does not entirely internalise the utility of the Government from trade, there is an efficiency loss to this player, which has to be added and thus cause the total efficiency loss to increase.

When the grant fully internalises the utility of the Government from trade ii) equals zero, and the efficiency loss to Government disappears. In this case, given that G>0 and that i) implies a lower price offered to buyer, the total efficiency loss is reduced as a consequence of the grant compared to the market solution. In all other cases, the efficiency gains, which are achieved by i), must be compared to the losses, due to the strategic behaviour of the Government, given by ii). For the uniform distribution of buyer's valuation it can be shown that in equilibrium the grant is always lower than Government's gross utility of trade, leaving ii) positive.

In the grant-equilibrium derived above the efficiency loss equals

$$Z_G * = \frac{(\pi * - c)(\pi * - c + 2(W + \alpha(P - c) - G))}{2(\overline{V} - \underline{V})} \tag{17}$$

Inserting for the endogenous variables in this expression we get[7]

$$Z_G * = \left[\frac{(\overline{V} - c)(4 - 4\alpha + \frac{3\alpha^2}{4}) - W(2 - \frac{\alpha}{2})}{(3 - \frac{3\alpha}{2})(2 - \frac{\alpha}{2})}\right]\left[\frac{(\overline{V} - c)(4 - \frac{7\alpha}{2} + \frac{5\alpha^2}{8}) + W(1 - \frac{5\alpha}{4} + \frac{\alpha^2}{4})}{(3 - \frac{3\alpha}{2})(2 - \frac{\alpha}{2})}\right](2(\overline{V} - \underline{V}))^{-1} \tag{18}$$

[7] The former term on the right hand side is positive when there is a positive probability for gains from trade, whereas the latter term is positive when $(\overline{V}-c)>W(4-\alpha^2/4)(8-9\alpha+7\alpha^2/4)^{-1}$., which, when $\alpha=0$, reduces to $W<2(\overline{V}-c)$, and when $\alpha=1$ reduces to $W<(\overline{V}-c)/5$.

Comparative statics show that the ex ante efficiency loss is negatively related to W, such that the higher W the lower Z_G*. The explanation to this is that the higher W the larger the grant, which means that the more of the external valuation of the project is internalised. Further, the higher the difference ($\bar{V}$-c) the higher Z_G*. This intuitively makes sense as the higher this difference the higher the expected monopoly profit. On the other hand, the grant is less affected by changes in ($\bar{V}$-c) than is the price offered by the seller, such that the price offered to buyer increases. Consequently, the upper integral limit increases with ($\bar{V}$-c), and for given $\bar{V}$ c must obviously decrease if ($\bar{V}$-c) increase, such that the integral in total increases. The effects of α on Z_G* are ambiguous. Numerical computations show that for positive W (W=0,15), $\bar{V}$=1 and c=0,8, Z_G* increases in α when α>1,263, whereas for numbers lower than this it decreases. In other words, up to a given value the efficiency loss decreases when Government put more weight on seller's profit in its utility function. Above this value, the opposite is the case, which means that there is a unique value on α that minimises the efficiency loss. This value varies with varying values on the other explanatory variables. For example, if we assume no externalities, i e W=0, ceteris paribus, the size on α that minimises efficiency loss equal 1,5. This shows a certain trade of between W and α concerning Z_G*, and this we will go deeper into in the next section.

4 Three specifications of the model

As shown in section 3 the model results strongly depend on the assumptions made about the interests of the Government. In this section we divide between three different types of Government, each characterised by specific values on W and α. Both α and W may equal zero, which would imply that Government does not attach any valuation to the project.

If we assume that the Government is a social planner aiming at maximise social welfare, W would typically represent the consumer surplus and α the share of the producer surplus taken into account, and this parameter would be set equal to 1. Alternatively, it is possible to assume that the Government is a kind of political agent with its own interests. We will assume two different kinds of the political agent Government. The first we call an industrial promoter, and set α=1,5 whereas W=0[8]. The latter implies that the government put no weight on the consumer surplus (the externalities) in its utility function, or it assumes the externalities to be insignificant. The second type of political agent we call a populist. To this kind of government vote maximisation is the goal. We now have to redefine W, and not to bring about any confusion we denote it W_P. This is now the gross utility to Government if the project is implemented. It may be measured as the value of being in government multiplied with the change in probability for staying in this position if they can take the honour of having reached an agreement about the project.

Table I presents the equilibrium solutions for the endogenous variables for the three types of Government.

Table I.

[8] In section 3 we showed that for given numbers on the other explanatory variables, α=1,5 minimise the expected efficiency loss when W=0. Though this is not an explicit interest of the Government we assume that it is of no interest to it to increase α beyond this value.

Under the industrial promoter the grant and the price offered by the seller increase significantly in $\bar{V}$, and the former decreases equally significant in c. Thus, the price offered to the buyer increases in c and decreases in $\bar{V}$. Under the populist government the grant increases in W and c and decreases in $\bar{V}$. This means that c and $\bar{V}$ influence the grant in opposite directions in the two cases. This result also has an intuitive explanation. The higher the difference ($\bar{V}$-c) the higher is the expected profit to the seller. This contributes positively to the utility of the industrial promoter but not to the populist. Thus, the former will have a larger incentive to increase the grant in order to increase the probability of trade than has the latter when either $\bar{V}$ is high, c is low, or both. Under the social planner type of government the grant is increasing in $\bar{V}$ and decreasing in c, as was the case for the industrial promoter, but the changes are more moderate. In addition it also increases in W. The price offered by the seller increases in all the explanatory variables, but contrary to the populist case, it increases more strongly in $\bar{V}$ and W, and more weakly in c.

It has already been shown that when $\alpha>2/3$ there will always be a grant. Thus, a social planner and an industrial promoter will with certainty offer a grant. Under the assumption of linear demand the seller will never confiscate the whole grant, and consequently the price offered to buyer will be lower, which implies a higher probability of trade in these two cases. Similarly, comparing Z_G* from table I and (7) it can be shown that the efficiency loss is always lower when there is a grant when the Government is either an industrial promoter or a social planner. In other words, with these types of Government a grant will always be offered, and it will lead to a higher probability of trade and a lower efficiency loss in equilibrium.

A condition for there to be a grant when the government is a populist is $W_P>(\bar{V}-c)/2)$. When this is fulfilled the priced offered to buyer will decrease and the probability of trade will increase. However, in contrast to the above example one cannot draw the conclusion that a grant always implies a lower efficiency loss in this case. The reason is that W_P may differ from W. For low numbers on W_P, it may be the case that the efficiency loss is higher when this type of government interferes in the trade. The reason is that when W_P is very low, G will also be low, whereas the price offered by the seller increases. The latter will then cause Z_G* to rise more than the former cause it to fall. For the efficiency loss to be lower when a grant is introduced it must be the case that either W and/or W_P are of a certain significance. For given W, the higher W_P and the lower ($\bar{V}$-c) is, the higher is the probability for reduced efficiency loss when a grant is introduced. When $W=W_P$ a grant will always reduce the efficiency loss.

Comparing the effects of a grant between the different types of Government it is intuitive that the lower W and W_P, the more likely that the probability of trade is highest under an industrial promoter. And, the higher W is compared to W_P, the more likely that the probability of trade is higher under a social planner compared to under a populist. Similarly, the lower W and W_P the more likely that efficiency loss is lower under an industrial promoter compared to the two other, and the higher W is compared to W_P, the more likely that the efficiency loss is lower under a social planner compared to under a populist.

Table II presents a numerical example.

Table II

The results in table II strongly depend on the numbers attached to the exogenous variables. We have used $\bar{V}$ as a numeraire, setting it equal to 1. Setting c equal to 0,8 and $\underline{V}$ equal to 0,1 implies that the costs of the project are higher than the buyer's expected valuation. Further, it is assumed that the utility to a populist Government of an implementation of the project, W_P, is higher than the consumer surplus of the project, W. This assumption will be argued for and explained more in depth in section 5. One should be aware that small changes in these variables may cause significant changes in the endogenous variables. Therefore, one should read table 2 only as one among many possible scenarios. Also, the results in both this and the previous section strongly depend on the game form. In the appendix we have analysed the situation when the grant and seller's price is decided in a Stackelberg game.

The grant is highest when we assume an industrial promoter government. In this case also the price offered by the seller is highest, but the high grant manages to compensate for the high price such that price offered to the buyer is lower compared to the two other cases. Consequently, the probability of trade is the highest in this case. Also, the efficiency loss is the lowest. The price offered by the seller is lowest under the populist government. On the other hand, so is also the grant, and as a result the price offered to the buyer is higher in this case compared to both other cases, which include a grant. Consequently, the probability of trade is lowest under this type of government, and the efficiency loss is the highest.

The probability of trade follows automatically from the price offered to the buyer, and is strictly decreasing when this price increases. The effects on this variable of varying the explanatory variables are symmetric for all three types of government, differing only in intensity. The expression for the efficiency loss varies between the types of government, and it strongly depends on the relationship between W and α. In general there is a trade off between W (W_P) and α in Government's utility function, such that different combinations provide the same efficiency loss. The fact that the efficiency loss is lower under the industrial promoter, for which W=0, indicate that W and W_P has not been high enough in order to compensate for lower (zero) α. Given the α's in the three cases, necessary conditions for the efficiency loss under a social planner and a populist to equal that under an industrial promoter is; W= 0,15 and W_P = 0,36. On the other hand, a lower α would increase the efficiency loss under an industrial promoter. Finally, in the numerical example, the efficiency loss is lower due to the grant independent of the type of government.

5 Discussing the results with respect to the empirical case

The Nordic modernisation projects developed for, offered to Petsjenganikel and negotiated about during the years 1992-1996 were all rejected. As an alternative the mother company of Petsjenganikel launched a new, internal plan for modernisation of the plant, which would lead to a corresponding reduction in harmful emissions. This plan presupposed internal responsibility for the project, only using technical assistance and necessary input from external supporters. In spite of this change in the role of agents the Norwegian government maintained the grant originally offered. According to the model presented in section 3 this implies that α in the case of the Norwegian Government was low. In contrast, the Finnish government withdrew their grant when a modernisation project developed and offered by a Finnish company was rejected by the Russian buyer. According to the model this implies that α has been high under the Finnish government.

Sticking to the Finnish case, it is claimed that the Finnish co-operation with Murmansk region, in which the Petsjenganikel modernisation is far the most important, mainly has been stimulated by the high level of Finnish environmental technology (Kuokkonen 1993, p.19). At the same time, the Russian participants in this co-operation criticise the Finns for their strong promotion of own technology and lack of financial backing (Kuokkonen 1993, p.35). The former may be interpreted as if α, in the case of the Finnish Government, is high. The latter, however, may indicate that this does not lead to a corresponding high grant. This combination of results are inconsistent with the model results. The Finnish reply to the Russian critics was to point out the difficult economic situation in Finland at that time. Taking budget constraints into account the model may be modified by introducing an upper boundary to the grant, such that we get; $G=[\max_G U_G, \Gamma]$, where Γ is the upper limit of the grant.

W, defined as the consumer surplus of the project, is the valuation of the implementation of the project by those who live in the affected area. It is true that these people are significantly affected by the sulphurdioxide emissions from Petsjenganikel. However, as the population only count a couple of thousand, the total valuation, derived e.g. by the contingent valuation method, will be limited. On the other hand, the Petsjenganikel case received much national publicity, especially in Norway, in the mid 1990's. This raised the awareness for the case, and it became a demand from people beyond those living in the area that the Government must get involved in order to find a solution to the pollution problem. Further, in 1992 the Barents Region was founded through a Norwegian initiative. One of the targeted issues for this Nordic-Russian cooperation was the environment. From this it is easy to defend the assumption made in section 4 that W_P is larger than W.

Thus, the empirical facts tend in the direction of the following claims:

i) α for the Norwegian government was low

ii) the consumer surplus W, as derived by e.g. the contingent valuation method, was limited

iii) the valuation to the government of supporting and promoting the project, W_P, was of a certain significance

Based on the above claims, what can be said about the role of the Norwegian government in the Petsjenganikel case? Obviously, they draw in the direction of a populist type of Government. The main reasons for this is 1) the fact that the grant was maintained though the accepted project contained no Norwegian industrial interests, and thus indicate an insignificant α, and 2) the rather high value of the grant relatively to the number of affected people and compared to Norwegian support to other transboundary environmental projects.

In other words, the combination of significant publicity about the Petsjenganikel case and a government not possessing the omnipotence to act as a social planner and without strong industrial interests in this case makes it likely to assume that the Norwegian government has played the role as a populist in this case. What conclusions can then be drawn with regard to the endogenous variables? In section 4 we showed that under this type of government the valuation of the effects of the project must be of a certain size for there to be a grant. A grant would always increase the probability of trade, but the effects on the efficiency loss where not clear. As the Norwegian government did offer a grant, clearly W_P must have been of a certain size (i e larger than $(\bar{V}-c)/2$). Consequently, due to the grant the probability of trade has been increased (though not enough to secure trade). Whether the efficiency loss has been reduced or not can only be discussed conditionally. The larger W and the smaller $(\bar{V}-c)$, the larger the probability that the grant has reduced the efficiency loss in equilibrium. We have already argued that W is probably not very high. On the other hand, $(\bar{V}-c)$ may be very small, as the Russian willingness to pay for the project is obviously quite limited, and the costs of the Nordic projects were relatively high. Thus, it is not unlikely that the Norwegian grant offered if a Nordic modernisation project was implemented at Petsjenganikel, has implied reduced equilibrium inefficiency in the trading situation.

6 Conclusions

Introducing an endogenously decided grant in a trading situation characterised by bilateral monopoly and asymmetric information have effects on the probability of trade and efficiency loss in equilibrium, and these effects depend heavily on the interests of the provider of the grant. Assuming that the provider of the grant behave strategically it can be shown that the more weight it puts on industrial interests, defined as the producer surplus and measured by α, the higher the probability that it will provide a grant. Further, the higher the grant and the more stable the grant will be with regard to changes in other explanatory variables. A public grant may also be offered of pure popular reasons. In this case the valuation of the effects of the grant by the provider must be rather high in order to secure the same effects on efficiency loss in equilibrium as when there were strong industrial interests. The traditional role for a provider of a grant is that of a social planner, who takes both consumer and producer surplus into consideration when fixing the grant.

In the first and last case, when $\alpha>2/3$, a grant will always be offered. This leads to a higher probability of trade and a lower efficiency loss in equilibrium. Assuming a populist a grant will be offered if its valuation of the project exceeds a certain part of the gains from trade. Given a grant in this case the probability of trade will always be higher, whereas it is ambiguous whether the efficiency loss will be lower.

In situations with transboundary pollution, efforts from downstream countries, characterised by subsidies to national industry in order to offer abatement technology to the polluting plants in the upstream country, sometimes are accused of serving industrial interests rather than environmental interests. Our analysis shows that the more a government let national industrial interests matter in their utility function, the more likely it is that they will offer a grant, and the larger the grant will be. It also shows that this grant is not fully confiscated by the seller of the abatement technology, such that the polluting country will also be better off as a consequence of the grant.

Appendix

A: A general derivation of seller's confiscation of the grant

A general expression for seller's utility is

$$U_S = (P - c)(1 - F(P)) \tag{A1}$$

which gives the following equilibrium price when there is no grant

$$P^* = c + \frac{1 - F(P)}{f(P)} \tag{A2}$$

when there is a grant the corresponding expressions are

$$U_S^G = (P - c)(1 - F(P - G)) \tag{A3}$$

$$P^*_G = c + \frac{1 - F(P - G)}{f(P - G)} \tag{A4}$$

$$P^*_G > P^* \text{ if } \frac{1 - F(P - G)}{1 - F(P)} > \frac{f(P - G)}{f(P)} \tag{A5}$$

The left hand side of the latter inequality is always larger than 1. Hence, those distributions in which f(P) is always decreasing in P, may not fulfil the above condition. In the uniform distribution the right hand side is always equal to one, such that the inequality is always fulfilled, and it will always be optimal for the seller to confiscate only a part of the grant in equilibrium. For the normal and right-biased distributions, such as the χ^2 and Pareto distribution, we have the following property:

If $P>E(v)+G$ then $f(P-G) >f(P)$ and vice versa

Thus, we can conclude; the larger P without a grant, the smaller the probability that the inequality is fulfilled, which means that the smaller is the probability that the seller will confiscate any share of the grant. From the same argumentation we have that the probability for total confiscation is then even smaller. For small P and all P lower than $E(v)$ the seller will always confiscate a share of the grant when this is introduced, and in general we have that the lower the price offered the larger the confiscated share will be.

Similarly; in the case of uniform distribution, the seller will never confiscate the whole grant, but will always take a part of it. Assuming other distributions, both the extreme situations may be the case. If the original price (the price without a grant) is very low, the seller may confiscate the whole grant, and for high original prices, he may not confiscate any share.

B*: Analysis of the game when the grant and seller's price is decided in a Stackelberg game*

Alternatively, the negotiations about grant and price offered by seller can be formulated as a Stackelberg game. This, however, provides more limited results than in the Bertrand setting. Assuming that the seller is the leader, the model breaks down when $\alpha \rightarrow 1$. In this case the seller knows that the Government will fix the grant in order to keep any price offered within the limits for buyer's valuation. Knowing this a profit maximising seller will increase the price infinitely, and thus the grant also has to be infinitely large in order to secure a positive probability of trade.

When $\alpha=0$ solving the model provides the following results for seller's price and grant:

$$P^*_S = \frac{\overline{V} + W + c}{2} \tag{B1}$$

$$G^*_S = \frac{3W - \overline{V} + c}{4} \tag{B2}$$

Assuming that the Government is the leader, when $\alpha=0$, we get the following results for seller's price and grant:

$$P^*_G = \frac{\overline{V} + W + 3c}{4} \tag{B3}$$

$$G^*_G = \frac{W + c - \overline{V}}{2} \tag{B4}$$

In both cases price offered to seller, probability of trade and efficiency loss equals

$$\pi^*_S = \frac{3\overline{V} + c - W}{4} \tag{B5}$$

$$X^*_S = \frac{\overline{V} - c + W}{4(\overline{V} - \underline{V})} \tag{B6}$$

$$Z^*_S = \frac{(3(\overline{V} - c) - W)(5(\overline{V} - c) + W)}{8(\overline{V} - \underline{V})} \tag{B7}$$

The difference between the two formulations of the Stackelberg game is that when seller is the leader both price offered by seller and grant is higher compared to when Government is the leader. It can be shown that when $\alpha=0$, the Bertrand game provides a lower price offered to buyer, and thus a higher probability of trade compared to the Stackelberg game. Also, it provides a lower efficiency loss.

Keeping to the case when Government is the leader it can be shown that when $\alpha=1$ the grant and the price offered by seller is higher in the Bertrand setting compared to the Stackelberg setting. On the other hand, the price offered to buyer is lower in the Bertrand setting, such that the probability of trade is higher when grant and seller's price is decided in a Bertrand game compared to a Stackelberg game where Government is the leader. It can also be shown that the efficiency loss is lower in the former case.

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Table I *The endogenous variables given the three different types of Government*

Variable	Social planner W>0, α=1	Industrial promoter W=0, α=1,5	Populist W_P>0, α=0
G*	$\frac{4W+(\overline{V}-c)}{3}$	$\frac{5(\overline{V}-c)}{3}$	$\frac{2W_P+(c-\overline{V})}{3}$
P^*_G	$\frac{c+2(W+\overline{V})}{3}$	$\frac{4\overline{V}-c}{3}$	$\frac{(W_P+\overline{V})+2c}{3}$
π*	$\frac{\overline{V}+2(c-W)}{3}$	$\frac{4c-\overline{V}}{3}$	$\frac{2\overline{V}+c-W_P}{3}$
X*	$\frac{2(W+\overline{V}-c)}{3(\overline{V}-\underline{V})}$	$\frac{4(\overline{V}-c)}{3(\overline{V}-\underline{V})}$	$\frac{\overline{V}+W_P-c}{3(\overline{V}-\underline{V})}$
Z_G*	$\frac{(\overline{V}-c)(\frac{3}{4}(\overline{V}-c)-\frac{2}{3}W)}{9(\overline{V}-\underline{V})}$	$\frac{(\overline{V}-c)^2}{36(\overline{V}-\underline{V})}$	$\frac{(4(\overline{V}-c)-2W_P)(4(\overline{V}-c)+W_P)}{72(\overline{V}-\underline{V})}$

Table II Calculation of the endogenous variables for different types of Government

Type of Government Variable	*No grant*	*Social planner*	*Industrial promoter*	*Populist*
Grant	-	0,13	0,33	0,1
Price offered by seller	0,9	0,967	1,067	0,95
Price buyer has to pay	0,9	0,83	0,73	0,85
Probability of trade	0,1	0,167	0,267	0,15
Efficiency loss	0,01	0,00167	0,0011	0,004

$\bar{V}=1$, $\underline{V}=0{,}1$, $W=0{,}05$, $W_P=0{,}25$, $c=0{,}8$

Summary

An environmental project is a project, which e.g. aims at reducing polluting emissions. In many cases such projects are traded in the market and implemented in a private company. Due to the character of such projects the market will often be monopolistic. Further, the seller will normally not know the buyer's valuation of the project. On the other hand, implementing an environmental project will normally have implications for people beyond the traders, so-called external effects, in the form of cleaner nature, which is a collective good. This makes the implementation of the project more valuable to the society as a whole than to the buyer alone. The market characterisations imply that the trading situation is inefficient in that trade does not necessarily take place though it is profitable to both trading agents (and thus even more profitable to the society). Consequently, we have a situation where trade is higher valued by the society as a whole than in the market, but where trade takes place with lower probability than what is "optimal". This obviously is inefficient.

In this paper we analyse how the introduction of a (public) subsidy, in order to promote trade, effects a trading situation as the one characterised above, and we ask; i) does the grant increase the probability of trade? and ii) does it make the trading outcome more efficient? By the latter is meant whether trade to a larger degree takes place in the market when it is profitable to the society compared to when there were no subsidy.

Our results show that the probability of trade increases due to the subsidy. The results with regard to market efficiency are more ambiguous, and depend on the interests of the provider of the subsidy (authorities). An interesting result is that the more weight the authorities put on the producer surplus in the welfare function, the higher is the optimal subsidy it offers, and the less is the market inefficiency.

The empirical case, which has inspired this paper, is the rebuilding of the Petsjenganikel factory in Northwest Russia, close to the Norwegian border. The very large and polluting emissions of sulphur-dioxide from this factory caused Norwegian authorities to offer a subsidy if the factory implemented a rebuilding (environmental project), which would result in 90% reduction in the emissions. The rebuilding should be implemented by a Norwegian supplier. This latter fact caused severe critics from environmentalists on both side of the border, accusing the Norwegian authorities for trying to profit economically on a "popular" environmental issue. However, as mentioned above, our analysis show that taking industrial considerations into account may affect the environmental effects positively, because a positive link between industrial and environmental interests will increase the optimal subsidy to offer.

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