Voluntary Agreements in Environmental Policy:
-Negotiating Emission Reductions-

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Abstract

Throughout the last decade voluntary agreements have become increasingly important as one way of doing environmental policy. A voluntary agreement is either a unilateral declaration of an industry interest group or a bilateral contract between an interest group and the state to cut emissions of a specific type during a specific time period. The associations member firms reduce emissions whereas the state on the other hand agrees not to regulate, i.e. to introduce standards or taxes on the emission. Thereby the member companies of the business association save the burden of paying a tax and gain flexibility in emission reduction whereas the state saves the cost of imposing, monitoring and enforcing the tax / standard.

With every agreement two types of negotiations take place. On the one hand the association negotiates with the state the total amount of emissions to be reduced and on the other hand the member firms have to allocate this obligation between themselves. In both cases the subject of negotiations is the emission level.

The paper analyses the negotiation process between the association and the state in a game theoretic context. Game theory is particularly valuable for the investigation of voluntary agreements, because it is devoted to the analysis of optimal decisions when agents act rational. Therefore, voluntary agreements are modelled as an extensive form game with the state and the association as players in a bargaining game of complete information. It is shown, that both parties might profit from a voluntary agreement but the emission level as the outcome of the negotiation will always be lower than the one that occurs with a tax. This is particularly due to the fact, that the association has a strategic advantage insofar as it controls the emissions. However, the necessary condition for voluntary agreements to occur is the states credible threat to introduce a standard / tax if it is broken.

Introduction[†]

Under conventional economic assumptions, firms that are confronted with environmental legislation act in two alternative ways. Either they exactly meet the environmental standards prescribed by law or, given the incomplete monitoring and enforcement ability of the regulatory agency, they weigh the benefits of emitting at the status-quo against the cost of being fined and undercomply with environmental standards[1]. Thus, any voluntary overcompliance of environmental standards or voluntary emission reduction appears puzzling. However, there are substantial differences in environmental performance across industries and across firms within an industry. Some firms overcomply with environmental standards, others undercomply and risk being fined so that exact compliance seems to be the exemption rather than the rule.

While the reasons for undercompliance are relatively clear-cut, overcompliance is harder to explain. Sometimes it is simply due to economic concerns. For example, if firms use the cost-savings potential of demand side management activities, then emission reduction occurs as a by-product. But in cases where (voluntary) overcompliance is costly, one might ask which benefits are aligned with it. *Arora and Gangopadhyay*[2] explain the growth in overcompliance (and voluntary action programs of industry) by the change in consumer's preferences. If information on the environmental record of firms is readily available, consumers with significant willingness to pay for 'green' products and a high income level might switch to producers with environmentally sound products and production methods. Overcompliance might also be a strategic decision of one firm trying to raise the standards for its competitors (*Salop and Scheffmann (1983)*). By guiding the regulatory authorities to set tighter standards for the industry, the firm raises the cost of compliance for other firms and thereby restricts competition. However, corporate executives generally oppose this type of reasoning. They often argue that voluntary overcompliance stems from a firm's corporate values. According to *Smart et al.*[3], it is the management's desire that the company will be recognized as socially responsible by customers, employees and neighbors.

If some firms overcomply with environmental norms, regulatory mechanisms that encourage such overcompliance might achieve significant results. So-called

† Financial support through the German Marshall Fund of the United States is gratefully acknowledged.

1 Consider the case of Ocean State Steel, a steel company in Rhode Island, USA that managed to circumvent federal emission laws for over two years.

2 Arora and Gangopadhyay (1995b).

3 Smart (1992).

voluntary agreements[4] appear to be an environmental policy instrument that encourages firms' overcompliance with environmental norms.

The structure of this type of agreement is the same in most OECD countries. A large company (or a business association on behalf of a sector) agrees with the government to cut emissions of a specific type during a specific amount of time. The government, on the other hand, agrees not to regulate, i.e. to introduce standards or taxes during this time period[5]. Therefore, voluntary agreements might additionally stem from a bargaining process between the firm and the regulatory agency, than simply from corporate values, strategic competition or changes in consumers preferences.

In a game theoretic context, we first analyze the negotiation process between the government or the regulatory agency on the one hand and the firm or the industry interest group on the other hand[6]. It is assumed that the abatement technology is fixed, therefore emission levels can take only two values and negotiations take only one period. It can be seen that, given only one abatement technology and therefore only two emission levels (optimal and maximal emissions), voluntary agreements might be superior to standard command and control regulation. This equilibrium however holds only if the government's threat to introduce a tax if the agreement is broken is credible. In the second part of the paper emission and therefore abatement levels are assumed to be continuous, but with continuous abatement levels on the one hand and enforcement cost on the other hand, the firm always has an incentive to reduce the total abatement level during the negotiations. This holds for the static as well as the dynamic analysis. In the last part we will assume that the bargaining process might last for more than one period, depending on the exogenuous risk of negotiation-breakdown.

The model

According to standard economic assumptions, the firm is seen as a profit maximizing entity trying to avoid the internalization of external cost. Property rights are allocated to the public and the firm has to pay an amount t per emission unit,

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4 This is a contradiction, of course one cannot involuntarily **agree** on something. Thus, "voluntary agreement" should be seen as a technical term. According to the UNICE (Union of Industrial Employers' Confederations of Europe) there are currently (May 1995) about 130 of these agreements in the EU, with a duration of 5 to 10 years. Most of the current agreements have been signed in the Netherlands (70) and Germany, where an equal number has been contracted since the 1970's. However, voluntary agreements have not only attracted European governments. Canada was one of the first countries to sign the chemical industry's "Responsible Care Program" in 1985. The United States recently introduced voluntary agreements on a federal level to deal with carbon dioxide as well as toxic chemical emissions, .e.g. through the EPA's 33/50 program or the administration's Climate Change Action Plan.

5 See Potier, Michael (1994)

6 We will use both terms, government and regulatory agency synonym throughout the paper.

equal to a Pigouvian tax, leading to an efficient total amount of emissions e*. However, the government needs to employ resources to monitor the level of emissions and enforce the payment of t. Thus, with a voluntary agreement the government might avoid regulatory cost, whereas the incentive for the firm is based on the authority's threat to impose heavier regulatory penalties[7].

Let the regulator and the firm be two players. The firm, in this case, is either a single producer of a specific externality or the homogenous interest group of all producers of the externality [8]. If the firm is an interest group, it is assumed that the problem of allocating the emission reductions between the firms is solvable and that the firms reduce emissions according to the equimarginal principle[9].

The game will be played sequentially. First, the firm decides whether or not to propose an agreement. The government then decides to reject or accept the agreement or to introduce a tax if no agreement is proposed. The rejection of an agreement leads to a tax on the externality. If the government accepts an agreement, then the firm decides whether to keep or break the agreement. If the agreement is broken, the government imposes a tax or does not react. The tax is assumed to be a Pigouvian tax, $t = c_e = a_e$ [10], where c(e) and a(e) will be defined as follows:

(1a) $c(e_1, \ldots e_n) = \sum_{i=1}^{n} c_i(e_i)$ c_i being the aggregate abatement cost of firm 1,...,i,..,n

It being given that the member firms reduce emissions according to the equimarginal principle, we can rewrite (1a) as the cost minimizing abatement function *at any level of total emissions e* with $e = \sum_{i=1}^{n} e_i$:

(1b) $c(e) = \sum_{i=1}^{n} c_i(e_i)$

(1c) $c(\hat{e}) = 0$ where ê is the amount of pollution in the absence of government controls.

Given the rewritten equation (1b) it is assumed that:

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7 This view is supported by industry representatives as well. Dale Heydlauff, vice-president for environmental affairs at American Electric and the industry's co-chair of the climate change negotiating effort has said that "Industries.....will respond [with voluntary agreements]...The specter of mandatory controls is real." (Utilities, DOE Put Final Touches on Historic Greenhouse Accord, in: Environment Week, Vol.7 No. 15, April 14 1994).

8 This way, both single-firm and interest-group negotiations can be covered. In the single firm case equation (1a) is not needed.

9 For a discussion see Glachant (1994). We will discuss this point more thoroughly below.

10 Derivates will be written as indices troughout the text, $c_e = \frac{\partial c(e)}{\partial e}$

(1d) $c_e < 0$ and $c_{ee} > 0$

If we see emissions avoided as a benefit, the injured party's utility function can be written as:

(2a) $a(e) = \sum_{j=1}^{m} a_j(e)$ the aggregate benefit function with m individuals

and

(2b) $a(\hat{e}) = 0$

(2c) $a_e < 0$ and $a_{ee} < 0$

(1a-d) and (2a-c) are the usual assumptions that the higher (lower) total emissions are, the lower (higher) the firms marginal abatement cost and the higher (lower) the marginal benefit of emission reduction. Both functions are assumed to be continuous and twice differentiable. With no agreement and no tax, the emission level will be ê. It is further assumed that the externality is not a stock pollutant, thus the tax will be the same in period one and two. The government's problem now is to define the optimal abatement level ê - e* and thereby the optimal emission level e*. In Figure 2, the cost and benefit functions can be seen as line c(e) and a(e) respectively.

If the government's objective is to maximize total surplus u, its problem can be stated as

(3) $\max_{e} \; a(e) - c(e)$ s.t. e [0, ê], when the ristriction is not binding the optimal level of emissions results from the f.o.c. $a_e = c_e$,

so that e* follows as the socially optimal emission level. This solution is equivalent to the one that we obtain with the familiar Figure 1[11] , where t is the optimal tax rate to reach emission reduction ê - e*. However, introducing a tax is not costless, monitoring total emissions as well as enforcing and collecting the tax places some kind of burden on the government. By shifting monitoring and enforcement ability to the industry, these costs are shifted as well. This does not establish an advantage of voluntary agreements as opposed to Pigouvian taxation because, according to the government's maximization problem (3), it does not matter whether the control cost occur on the firm's level or on the regulator's level. In addition, a voluntary agreement must be monitored and controlled as well, so that not all cost on the government's side can be avoided.

Nonetheless, evidence shows that voluntary approaches in environmental policy do exist, but what are the exact benefits aligned with them as opposed to

11 See e.g. Baumol and Oates (1988).

other environmental policy options such as Pigouvian taxation? Two lines of thought explore this question: First, enforcement and monitoring cost accompanying voluntary agreements might be lower than these costs connected with a tax. How can this be? Government regulation is often justified by some kind of market failure due to the problem of externalities. Given these externalities, each member of a group has an incentive to freeride. In our case, each firm has an incentive to emit above the efficient level. With a tax this problem is overcome by allocating the property rights to the public and pricing the externality according to (3). In the case of a voluntary agreement, this problem is overcome by allocating the property rights to the public as well - but allowing the member firms of a business association to emit a specific amount according to (3)[12]. In this case, the regulator only needs to observe total emissions but not the emissons of each firm, since this is done by the business association. The free-rider problem is now shifted to the business association, which provides a club good for its member firms, i.e. the absence of government regulation. However, this allocation provides an incentive to free-ride for each participating firm as well. Any member firm would then sign the agreement but would not reduce emissions according to the business association's standards. To control its member firms, the association needs to employ monitoring and enforcement (the exclusion from the association) schemes as well. But, as opposed to the tax solution, the size of the group that benefits from the public good is smaller (i.e. many interest groups with individual abatement obligations). The sum of the individual interest group's monitoring and enforcement cost will be lower than the government's cost of controlling total abatement levels alone or, put another way, there are diseconomies of scale in monitoring and enforcement activities. This is due to different factors: On the one hand, the free rider problem is easier to overcome in small and homogenous groups. On the other hand, in small groups the 'moral' obligation to act according to the group's goals is higher. Absence of government controls becomes a club good, whereas pollution abatement is a pure public good. Assuming, additionally, that the business association's member firms act according to the moral principle of reciprocity[13], there is a chance that the club good 'absence of government controls' is Pareto-optimally provided and the efforts of each member (i.e. abatement obligations) are efficiently allocated. The more homogenous such groups are, the higher the probability that the amount of public good provision is Pareto-optimal. Given this and the fact that industry interest groups consist of homogenous firms with similar production functions, they have a comparative monitoring and enforcement advantage. Therefore, their costs are lower than the

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12 A problem similar to the one analyzed by Weitzmann (1974).

13 Suppose each member of a group is making a given effort towards the supply of the public good. Under this principle, each member of a group is obliged to make a contribution to this good if the level of effort he would most prefer that every member of the group should make is not less than the effort each member already makes. Sugden (1984).

government's cost. Thus, by voluntary agreement it is possible that emission obligations are Pareto-optimally allocated and monitoring and control cost shrink at the same time. This cost advantage shrinks as the number of member firms adhered to the business association shrinks. With only one firm there is no net advantage of monitoring and enforcing!

Second, even if we assume that the tax revenue stays constant (i.e. the government cuts taxes on other activities), environmental protection cost and the burden imposed by a tax have an effect on the industry's investment decisions. In the short run, this might lead to a lack of international competitiveness and the growth of unemployment, especially in environmentally sensitive branches of the industry[14]. This trade-off between environmental protection and other economic policy objectives is difficult to overcome, especially in times of recession, and places some kind of political cost on the government's decision to introduce a tax. Note that there might not be any trade-off between economic growth and environmental protection, there might as well be a harmony or a 'double dividend' from environmental taxation. This is not important for the political cost the government faces. These cost stem from the voters *perception* on the existence of such a cost, and in fact most people believe that there is a trade off between those goals. However, with a voluntary agreement as the outcome of cooperation between industry and the government, a political cost can be partially avoided.

Therefore, consider b(e) as the government's cost to monitor and control pollution abatement levels as well as the political cost of introducing a Pigouvian tax. The higher the total amount of pollution abatement, the higher the cost b(e) will be.

(4a) $b = b(e)$ the government's disadvantage in monitoring and enforcing plus the political cost of introducing a tax

(4b) $b_e < 0, b_{ee} > 0$

Setting the corresponding cost for the business association to zero, the problem for the government changes to

(5) $$\max_e \quad a(e) - b(e) - c(e) \qquad \text{s.t. } e \quad [0, \hat{e}],$$

when the restriction is non-binding the optimal level e' is the solution of the f.o.c. $a_e - b_e = c_e$ and the optimal emission level is given by e' in Figure 1 and Figure 2. Figure 2 also allows us to illustrate the changes in the welfare function with different emission levels and a tax versus a voluntary agreement policy. $u^{vol}(e) = a(e) - c(e)$ gives the course of the welfare function with a voluntary agreement, whereas $u^{tax}(e) = a(e') - b(e') - c(e')$ illustrates the course of the welfare function with a tax. Given the convexity of the firm's and the government's (enforcement) cost function, c(e) and

[14] For a short discussion see e.g. Cropper and Oates (1992), p. 694.

b(e), and the concavity of the benefit function a(e), e' will always be higher than e* given that b(e) > 0.

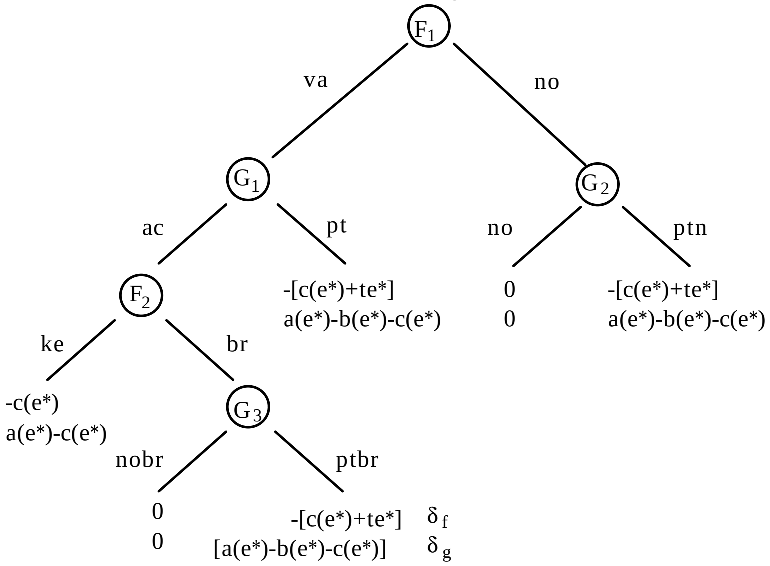
Before turning to the theoretical analysis of voluntary agreements, let's once again resume the 'heroic' assumptions made: The free-rider problem on the business associations side will be overcome and reduction obligations will be Pareto-optimally allocated. However, whether voluntary agreements are superior to Pigouvian-taxation and then lead to a socially optimal emission level depends on the outcome of negotiations between the government and the firm (or association). The focus in the following analysis will be on these negotiations. For a critique on voluntary agreements on general see {Kreuzberg, 1994 #26}

The voluntary agreement with a single technology

Now assume that there is a single technology which is either installed and immediately reduces emissions to e* or not installed and emissions stay at ê.

Figure 4a gives an extensive form representation of the game played between the government and the firm and the corresponding payoffs which will be described below. F indicates a move of the firm and G a move of the government. The outcome vector describes the payoff (cost) of the firm (above) and that of the government (below).

Figure 4a: The extensive form of the game



The strategy profiles available to the company in the reduced strategic form are:

A_f = {(α_1, α_2), α_1= decision in F_1, α_2= decision in F_2}
= {(va, ke), (va, br), (no, •)}[15]

The firm can either propose a voluntary agreement and keep it, propose an agreement and break it or do nothing. The government, on the other hand has a much larger variety of strategies to choose from.

A_g = {(β_1, β_2, β_3), β_1= decision in S_1, β_2= decision in S_2, β_3= decision in S_3}
= {(ac, ptn, ptbr), (ac, ptn, nobr), (ac,no, ptbr), (ac, no, nobr), (pt, ptn, •), (pt, no, •)}

First, the government can decide to accept a voluntary agreement, or to introduce a Pigouvian tax if no agreement is proposed. Then, if a voluntary agreement is accepted, the government can either retaliate if it is broken or simply do nothing. Following the second strategy profile, the government would do nothing if the agreement is broken. The interpretation of the other strategy profiles is left to the reader.

Although moves are made at 3 stages it is a two-period game. In the first period, the government and the firm negotiate whether an agreement will be installed or not. If those negotiations fail, a Pigouvian tax will be installed immediately; if both come to an agreement and the firm decides to keep it, it will start to reduce emissions in the same period. If the firm decides to break it, the government will only in the next period be able to introduce its threat startegy. Therefore, δ_g and δ_f represent the government's and the firm's discount factors.

Figure 4a gives a strategic form representation of the game, all information sets are singletons, thus the game played is one of perfect information.

Proposition 1: For the game as described above, equilibria depend crucially on the distribution of the firm's discount factor. When discounting is high, the equilibrium outcome will be a Pigouvian tax, when discounting is low, the outcome will be a voluntary agreement.

Proof

Case 1: δ_f [c(e*)/(c+te*), 1]; δ_g (0,1]: In the reduced strategic form of the game, there are seven Nash-equilibria in pure strategies. The best response for the government -given that the firm plays (va, ke)- is to accept at node S_1 (see Figure 4a) and given the strategy (ac, ptn, ptbr) the firm's best response is (va, ke). So {(va, ke); (ac, ptn, ptbr)} is a Nash-equilibrium. If the firm plays (va, br) the government's best

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[15] Note that a dot indicates a move after a nonterminal history where the player, given his preceding moves, will not have to decide on the following moves.

response requires (pt) at node S_1 or (ptn) at node S_3 and if the firm plays (no, •) the government's best response requires (ptn) at node S_2. If the government plays (pt, ptn, •) all strategies are best responses of the firm. Thus, the two strategy pairs {(va,br), (pt,ptn,•)} and the four strategy pairs {(no, •), (pt,ptn,•)} are Nash-equilibria. However, the regulator's strategy (pt,ptn,•) is weakly dominated by (ac, ptn, ptbr). This coincides with the fact that only the first equilibrium is perfect. Working back up the tree, we see that (ptbr) in S_3 is strictly preferred by the government. Thus, the firm will never play (br) in F_2, but it will keep the agreement. Knowing this, the government will accept the agreement (ac) in S_1 which in turn leads the firm to propose a voluntary agreement in the first period, ensuring an outcome of c(e*) which is strictly preferred to c(e*)+te*, the outcome if no agreement is proposed. Thus {(va, ke); (ac, ptn, ptbr)} is a subgame perfect equilibrium.

Case 2: δ_f [c(e*)/(c+te*), 1]; δ_g =0: At the subgame starting at point F_2 of the game tree in Figure 4a there are 2 Nash-Equilibria in pure strategies, {(br, nobr), (ke, ptbr)} and an infinite number of equilibria in mixed strategies. Since δ_g =0, the government's threat to introduce a tax if the agreement is broken is not credible anymore. However, this credibility is necessary to chose {(va, ke); (ac, ptn, ptbr)} as the only subgame perfect equilibrium. Now, the government knows that the firm might chose (br) if it can not credibly commit itself to introduce a tax after the agreement is broken. Therefore, it might chose (pt, •) as one of the two NE {(ke), (ac, ptbr); (br, pt,•)} of the subgame starting at point S_1 of the game. On the other hand, it prefers the outcome of the equilibrium {(ke), (ac, ptbr)} and therefore sends (ac) as a message to the firm that it will react with (ptbr) following (br). Using forward induction this equilibrium becomes unique.

Case 3: δ_f [0, c(e*)/(c+te*)); δ_g [0,1]: In the reduced strategic form of the game, there are six Nash-equilibria in pure strategies. If the firm plays (va, br), the government's best response requires (pt) at node S_1 or (ptn) at node S_3 and if the firm plays (no, •) the government's best response requires (ptn) at node S_2. Given the government plays (pt, ptn, •), all strategies are best responses of the firm. Thus, the two strategy pairs {(va,br), (pt,ptn,•)} and the four strategy pairs {(no, •), (pt,ptn,•)} are Nash-equilibria. However, iterated elimination of weakly dominated strategies allows us to reduce the number of equilibria. First, the firms strategy (va,ke) is weakly dominated by (va, br). This also makes the governments strategy pairs (ac, ptn,•) dominated by (pt,ptn,•), wich in turn allows us to eliminate the firms strategy (va, br). This leaves strategy pairs {(no, •), (pt, ptn,•)} as equilibrium candidates. However, all those pairs lead to the same outcome, i.e. (c(e')+te'; a(e')-b(e')-c(e')). This outcome is in turn subgame perfect→

If the firm's dicount factor is not too small, there is a unique SPE implying a voluntary agreement. This equilibrium relies on the threat of the government to introduce a Pigouvian tax if the agreement is broken or no voluntary agreement is proposed. The result is not very surprising, but one should note that it depends crucially on the technical assumptions of the game. The government's discount factor has no influence on the outcome, whereas the firm's discount factor decides whether the game ends with a tax or with a voluntary agreemement. All threats that lie far in the future will be discounted high by the firm whereas immediate threats will be discounted low. This in turn implies immediate monitoring activities to be the crucial point in voluntary negotiations. For the following we will therefore assume that:

(6) $$\delta_f \geq \frac{c(e')}{c(e') + te'}$$

Variations of the game

Up to this point, the game has a fairly simple structure and comes to an intuitive solution. In this section, some of the assumptions are changed and it is analyzed how these variations affect the solution presented above.

First, the one technology assumption is dropped and continuous abatement levels are introduced. Now the firm and the government have an incentive to negotiate the total amount of emission reduction. The amount of emission reduction will be the outcome of a bargaining game between the two players.

Negotiating the amount of emission reduction: one period

In the above game, the question of how to divide the surplus, i.e. the fruits of "cooperation" between the two is not addressed. The firm gets away without a tax and the government saves the cost of regulation. This is due to the fact that there are only two levels of emission, either the optimal level or the current level. Now we will go further and assume that there is a continuous level of emissions anywhere in the interval [0, _). The amount of emissions relevant to us in the following can, without loss of generality, be limited to e [0, ê]. This means that there is no incentive for the firm to pollute more after a negotiation on emission levels fails than before.

The amount of emission reduction is part of the negotiating procedure. Firm and regulator will start to bargain not only on the installation of an agreement, but also on the total amount of emission reduction related to this agreement. This is indicated by the dotted line in Figure 4b. Depending on the amount of emission reduction negotiated, each of the parties gets a different payoff from cooperation. But -if we assume continuous abatement levels- what exactly are the benefits both parties can achieve from cooperation via a voluntary agreement? The relevant cost for both, government and firm, were given above and shown in Figure 2. Figure 2 also shows these costs and the cost of introducing a tax combined with the different utility levels for the government, where $u^{tax}(e)$ relates to the tax solution and $u^{vol}(e)$ relates to the solution with a voluntary agreement according to the maximization problems (3) and (5). Now it is obvious from Figure 2 that every emission level e relates to a different utility level $u^{tax}(e)$ or $u^{vol}(e)$ for the government and a different cost level for the firm c(e). Figure 3 gives the combinations of cost and benefits to the firm and the government respectively. On line (va), the combinations (c(e), $u^{vol}(e)$) with a voluntary agreement are given and line (tax) gives the combinations (c(e') + te', $u^{tax}(e')$) with a tax. Curve (tax) is shifted to the left because the firm's costs are given by the cost of emission reduction as well as the burden of paying the tax t per emission unit. However, this burden is not part of the government's maximization problem. Point 0 in Figure 3 gives the 'payoffs' to both if a tax is introduced. This is the 'conflict payoff' and therefore the starting point of the payoff region which is to the right and above 0. Any agreement saves the firm cost te' and therefore the firm always has an incentive to propose an agreement. The higher the corresponding emission level, the higher the abatement cost c(e) the firm can save. At emission level e^{max} the firm saves a maximum amount of abatement cost, whereas the government has no gains. The firm has cost $c(e^{max})$ and the government's payoff is $u^{vol}(e^{max})=u^{tax}(e') = a(e^{max})-c(e^{max}) = a(e')-b(e')-c(e'))$. The lower the corresponding emission level, the higher the firm's cost and the government's payoff. At emission level e^{min} the government's payoff is given by $u^{vol}= a(e^{min}) - c(e^{min}) > u^{tax}(e')$, whereas the firm's costs are $c^{vol}(e^{min}) = c^{tax}(e') = c(e')+te'$.

Now, if we introduce continuous emission levels, the parties are able to divide the surplus in a different way. Different rules of the game will lead to different equilibria. Therefore, distinct bargaining models either describe a concession mechanism or axioms a solution should satisfy[16]. We will first analyze the game according to Nash's cooperative bargaining solution and then change to a non-cooperative setting.

Given the fact that no player is able to introduce a voluntary agreement without consent of the other player, an agreement is individually and jointly rational and it can be contracted and enforced, Nash's axiomatic solution for the bargaining problem can be applied.

Proposition 2: Nash's axiomatic[17] bargaining solution, with the conflict payoffs stemming from the introduction of a tax implies an emission level described by

$$\text{(7a)}\quad a_e = c_e \frac{a(e) - 2c(e) - a + b + 2c + te'}{c + te' - c(e)}$$

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16 Osborne and Rubinstein (1990) ; Sutton (1986).

17 Scale invariance, independence of irrelevant alternatives, symmetry and Pareto-optimality.

which is higher than the socially optimal level described by (3).

Proof: Given Nash's axioms and treating the conflict payoffs (tax) constant, the Nash bargaining solution selects the emission level e which maximizes

(7b) $[(a(e) - c(e))-(a-b-c))] [c + te' - c(e)]$
with a,b,c being the constant payoffs with tax.

The region of emission levels proposed can be limited to the interval $[e^*, e^{max}]$. First, any emission level below e^{min} will not be accepted by the firm because $c(e^{min})$ _ $c(e')+te'$. However, any emission level between e^{min} and e^* can be excluded as an equilibrium because, in this region there are no conflicting interests and because of the game's structure coordination problems will not occur. Second, any emission level higher than e^{max} leads to a lower payoff for the government than the tax-payoff and therefore will not be accepted by the government.

Deriving the f.o.c to (7b) and rearranging it, we arrive at (7a).
For every utility/cost combination with e _ e*, a_e _ c_e holds. The efficient abatement level e* is reached if $a_e = c_e$. For the negotiated amount of emissions to be efficient the multiplier of c_e in equation (7b) would have to be equal to 1. This would also mean that

(7c) a(e) - c(e) - a + b + c _ 0

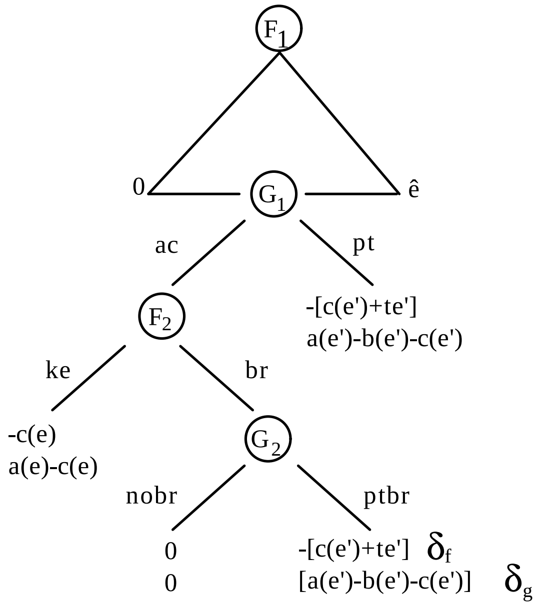
holds as an equality. This equality is fulfilled only in point A in Figure 3 and related to emission level e^{max}, a contradiction, because at $a_e(e^{max})>c_e(e^{max})$. Therefore (6d) holds as a strict inequality and the negotiated emission level is larger than e*→

Nash's solution to the above described problem falls short of one serious problem: the enforcement of the contract. Since most voluntary agreements are unilateral declarations of a firm (a business association), the game can be more realistically analyzed in a non-cooperative bargaining setting. But note, that even under these 'ideal' (Nash's) circumstances,, abatement will be less than in a Pigouvian world.

The size of the payoff region is given by the cost disadvantage b(e) of introducing, monitoring and enforcing the tax t. The lower b(e), the closer (tax) gets to (va) and the smaller the region of possible improvements for both parties.

Figure 4b illustrates the changes in the game's structure. Instead of simply proposing an agreement, the firm now proposes an emission level e   [0, ê] that the government either rejects or accepts. The agreement will be installed if both parties have agreed on an emission level. Negotiations last for one period and payoffs are realized in the same/the following period respectively.

Figure 4b: Continuous abatement levels



As opposed to the first game illustrated above, the strategy profiles available to the company in the reduced strategic form now are:

$A_f = [0, \hat{e}] \infty \{ke, br\}$ and for the government we get

$A_g = H \infty \{nobr, ptbr\}$ with H being the set of all mappings
$h(va): [0, \hat{e}] \varnothing \{ac, pt\}$

Corollary: Given the above assumptions and $\delta_g = 1$, the non-cooperative game as described in Figure 4b has a unique SPE where the firm proposes a voluntary agreement which is immediately accepted by the government and kept by the firm. The corresponding emission level will be e^{max}.i

The above corollary is introduced to show one crucial point. The firm has a strategic advantage insofar as it controlls the emission level. This enables the firm to propose an emission level e^{max} higher than the outcome with a tax and achieve the whole surplus from cooperation.

Proposition 3: If we assume that $0 < \delta_g < 1$, the firms surplus rises as the government's discount factor gets closer to zero ($\delta_g \varnothing 0$).

Proof: Consider the non-cooperative ultimatum bargaining equilibrium described in the corollary and assume that $0 < \delta_g < 1$. Since the emission level e^{max} is not implementable[18] insofar as it does not constitute a SPE in the game starting at stage F_2 of the game, it is not renegotiation-proof. At stage F_2, the firm always has an

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18 see Rubinstein and Wolinsky (1992), Definition 1

incentive to renegotiate the agreement as soon as monitoring starts. At this stage of the game, the government would accept any agreement that ensures him an outcome $u(e_r^{max})$ _ δ_g (a(e')-b(e')-c(e')). Since $\delta_g < 1$, it follows that $u(e_r^{max}) < u(e^{max})$. Given (1d), (2c) and (4b) it follows directly that $e_r^{max} > e^{max}$ and $c(e_r^{max}) < c(e^{max})$ as δ_g ∅ 0→

From an institutional point of view, the settings described above seem to be an optimal environment for voluntary agreements. Abatement levels are negotiated, installed and monitored immediately and threats are credible and enforce the outcome agreed upon.

The static analysis in the preceeding section has therefore shown a few crucial points. In all cases, whether we have only one abatement technology or a continuum of technologies, equilibria are on the Pareto frontier and voluntary agreements are superior to Pigouvian taxation. However, the Pareto frontier in Figure 3 is different from the one we obtain in the classical Coasean negotiations between the damaging and the harmed party. Recall that the Pareto-frontier limits the payoff region in the negotiations between the government and the firm. It is convex, whereas in most environmental conflict cases with strictly opposing interests it is concave. The firm has strictly opposing interests towards the government whilst the government is interested in maximizing total surplus according to (3) and (5). In the absence of b(e) a welfare maximizing government would chose e*, the outcome of the ideal Coasean negotiation.

In the context of only one abatement technology the governments discount factor did not influence the SPE outcome It was only necessary to introduce immediate monitoring to ensure (6). Whereas, in the context of continuous abatement levels the government's discount factor is very important, since it influences the amount of emission reduction directly through negotiations.

Negotiating the amount of emission reduction: T>1 periods

Typically, negotiations on voluntary agreements take more than one period and can, in extreme cases take a few years. Consider for example the negotiations on the voluntary agreement of the German industry on the reduction of carbon-dioxide emissions. In march 1995, the holding organization of the German industry (*Bundesverband der Deutschen Industrie*) came up with an agreement proposal to cut its *specific* carbon-dioxide emissions by *up to 20%* until 2005 related to the *base year 1987*. This proposal was appreciated by the government, yet it could not guarantee that it would postpone the proposed energy / carbon-dioxide tax. About a year later, in april 1996, the industry decided to renew its proposal and committed itself to reduce (*absolute*) carbon-dioxide emissions by *20%* related to the *base year 1990*. The German minister of the environment Ms. Angela Merkel therefore guaranteed, that all sectors of the German industry that signed this agreement would be exempted from an energy / carbon-dioxide tax. This example shows two crucial points:

- As long as no agreement is made and no threat (tax) implemented, the industry achieves its most preferred outcome, it needs not invest in emission abatement nor has to carry any tax-burden.
- For the one period delay that occurs after a proposal was rejected the industry risks the introduction of a tax.

However, this risk might not be controlled by the government. As was pointed out earlier, the government has cost of implementing its threat strategy. Now due to actions the government cannot control, it might be forced to introduce a tax at a certain time period. On one hand, this might stem from an environmental catastrophe that makes voters force the government to act, e.g. Bhopal or Chernobyl, or environmental interest groups that suddenly become more powerful as in the Brent-Spar case. On the other hand, a superordinate authority, e.g. the EU, might force the government to introduce a tax[19]. For the following analysis let p be the probability that a new proposal might be accepted, whereas (1-p) captures the risk of exogenuous tax introduction. Figure 5 illustrates this game.

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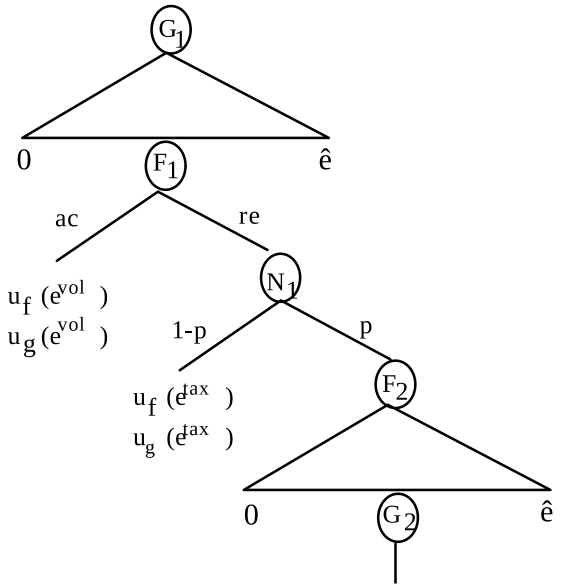
19 One argument that the risk of introducing a tax might not be controlled by the government is the six-month turnover in the EU council of ministers. Consider e.g. the situation in 1993 / 94. During the first half of the year the Danes held the presidency and just like Belgium who held it for the second half, they vigourously sought an approval of the EU carbon dioxide / energy tax. However. for the first half of 1994 the Greek presidency as vigourously opposed the tax. see: 'Clintons Energy Tax Staggers into Senate', in: Energy Economics and Climate Change, May 1993.

Figure 5: Negotiating the amount of emission reduction over T>1 periods with the exogenuous risk of a tax



In the first section, we deduced the payoff/cost functions for the government and the firm respectively. Both vary inversely with the amount of total emissions. The higher the emission level, the lower the government's utility and the firm's cost. Looking at the firms payoff as avoided cost, its payoff function runs parallel to the amount of emissions. Given the risk of an exogenuous tax introduction and both parties strictly opposing interests, the game can be analyzed according to Rubinsteins non-cooperative bargaining solution[20]. Additionally, during each period of negotiations, the government has a 'cost of delay' while -on the other hand- the firm derives utility from negotiating. Since each period with no agreement and no tax allows the firm to emit ê, let the firms utility of delay in each period be ζ_f while the governments cost of delay will be captured by ζ_g.

Proposition 4: Given that both parties, firm and government, bargain over the amount of emission reduction for T>1 periods before an agreement is installed, given additionally that the firm makes an offer in every even while the government makes an offer in every odd period and, finally, given the risk that following a rejection negotiations last for one more period only with probability p, the government's payoff gets smaller.

Proof: Let U_g be the maximum payoff the government can achieve at any time during the negotiations. If 1 is the maximum gain one of both parties can achieve via negotiations, the firm will receive $1\text{-}U_g$ if the governement gets U_g . Then, the firm will have to offer the expected value pU_g less the cost of waiting one more period

20 Rubinstein (1982), Sutton (1986) and Bolle (1996). Assuming linear transformation curves reduces complexity but not the quality of the findings.

$p\zeta_g$ to make the government indifferent towards accepting now or waiting one more period to achive U_g . The same holds for the preceeding period and the government's offer. Thus, we have two expressions for the maximum gain the government can achieve which we can set equal to each other.

Table 1: Deriving the unique SPE for negotiations over T ∅ periods

	payoff		who offers
period	government	firm	
T-2	$1-p\delta_f(1-p\delta_g(U_g-\zeta_g)+\zeta_f)$	$p\delta_f(1-p\delta_g(U_g-\zeta_g)+\zeta_f)$	government
T-1	$p\,\delta_g(U_g-\zeta_g)$	$1-p\,\delta_g(U_g-\zeta_g)$	firm
T	U_g	$1-U_g$	government

(8) $$U_g = \frac{1-p\delta_f - p^2\delta_g\delta_f\zeta_g - p\delta_f\zeta_f}{1-p^2\delta_f\delta_g}$$

Let u_g be the minimum payoff the firm can achieve through negotiations. The procedure leads to the same outcome, thus the equilibrium is unique.

Deriving the first derivative of U_g with respect to p one can see that

(9a) $$U_{g_p} = \frac{(1+\zeta_f)p^2\delta_f^2\delta_g - (1+\zeta_f)\delta_f + (1-\zeta_g)2p\delta_f\delta_g - (1+\zeta_f)2p^2\delta_f^2\delta_g}{(1-p^2\delta_f\delta_g)^2}$$ where

(9b) $$U_{g_p} < 0 \quad \forall \quad \{\zeta_f,\zeta_g,\delta_f,\delta_g,p \mid 0<\delta_f,\delta_g,p<1\}$$

Thus, the higher p, the probability that a rejection of an agreement leads to a new proposal, the lower the government's maximum payoff. For the firm, on the other hand, the opposite holds. The higher p, the higher its payoff from negotiations. This is intuitively clear since the firms payoff varies inversely with the governements payoff. Since the payoff functions are inversely related, or, put another way, what the firm gets the government loses and vice versa. The same holds for the cost and benefit of delay. Therefore, one can set $\zeta_f = \zeta_g$ and, with $\delta_g = \delta_f = 1$, (8) changes to

(10) $$U_g = \frac{1}{1+p} - \frac{pZ}{1-p}.$$

As p ∅ 0 the government achieves the whole surplus while as p ∅ 1 the government's payoff U_g ∅ 0→

As the risk of an exogenuous tax-introduction influences the governments payoff, so do the discount factors. Where, the higher the governments discount factor, the higher its payoff where for the firm's discount factor the opposite holds. Equation (11) gives the first derivative of U_g with respect to δ_g.

(11a) $U_{g_{\delta_g}} = \dfrac{(1-\zeta_g)p^2\delta_f - (1+\zeta_f)p^3\delta_f^2}{(1-p^2\delta_f\delta_g)^2}$ where

(11b) $U_{g_{\delta_g}} > 0 \quad \forall \quad \{\zeta_f, \zeta_g, \delta_f, \delta_g, p \mid \zeta_g \leq 1-(1+\zeta_f)p\delta_f\}$

(11b) backs up proposition 3 for the case of multiperiod bargaining and cost/benefit of delay. The higher the governments ability to wait, the higher its payoff. It is important to note, that the governments cost of delay has to be smaller than the firms benefit of delay. Setting $\delta_f = p = 1$ the well known outcome, that the party with cost of delay gets zero payoff, can be seen from the condition in (11b). Here, once again, the government profits from a high probability of breakdown and a high discount rate of the firm. The last result can equally well be seen from (12a):

(12a) $U_{g_{\delta_f}} = \dfrac{(1-\zeta_g)p^2\delta_g - (1+\zeta_f)p}{(1-p^2\delta_f\delta_g)^2}$ where

(12b) $U_{g_{\delta_f}} \leq 0 \quad \forall \quad \{\zeta_f, \zeta_g, \delta_f, \delta_g, p\}$

Conclusion

Voluntary agreements are becoming more and more popular as one way of doing environmental policy. The above analysis has shown, using a simple game theoretic model, that through voluntary agreements an abatement level similar to one with a Pigouvian tax can be reached only in a very limited number of cases. In the presence of only one abatement technology, enforceable contracts, one period, credible threats, and perfect information, the government is able to shift monitoring and enforcement cost to the business association and voluntary agreements are superior to standard command and control policies. If we consider continuous abatement levels, the firm always has an incentive to reduce the level of total emissions to a level lower than the efficient emission level e*. This holds even for cases where enforceable contracts are existent as the (cooperative) Nash solution to the bargaining problem has shown. However, the analysis of the cooperative vs. the non-cooperative bargaining result has also shown, that in the latter discounting matters, whereas in the former discounting has no influence on the agreed upon outcome. This is due to the fact, that with enforceable contract as opposed to unilateral declarations the emission level is implementable. However, in all settings the solution lies on the transformation curve. So, in the presence of diseconomies of scale in control and enforcement, voluntary agreements can be superior to

Pigouvian-taxation, insofar as efficiency losses in emission reduction are traded against efficiency gains in control- and enforcement cost.

Literature

Arora, Seema, and Shubhashis Gangopadhyay (1995b): "Toward a Theoretical Model of Voluntary Overcompliance", in: *Journal of Economic Behaviour and Organization* , 28, p. 289-309.

Baumol, William J., and Wallace Oates (1988): "The Theory of Environmental Policy", 2 ed. Cambridge, Cambridge University Press.

Bolle, Friedel (1996): "Verhandlungen brauchen Zeit: Bemerkungen zur siebzehnten der masurischen Geschichten von Siegfried Lenz", in: *Zeitschrift für Wirtschafts und Sozialwissenschaften* , to appear.

Cropper, M.L., and W.E. Oates (1992): "Environmental Economics: A Survey", in: *Journal of Economic Literature* , 30, p. 675-740.

Glachant, Matthieu (1994): "The Setting of Voluntary Agreements Between Industry and Government: Bargaining and Efficiency", in: *Business Strategy and the Environment* , p. 43-49.

Kreuzberg, Peter (1994): "Zur ökonomischen Rationalität freiwilliger Kooperationslösungen für das Klimaproblem", in: *Zeitschrift für Energiewirtschaft* , 3 / 1994.

Osborne, Martin J., and Ariel Rubinstein (1990): "Bargaining and Markets", London, New York, Harcourt Brace Jovanovich.

Rubinstein, Ariel (1982): "Perfect Equlibrium in a Bargaining Model", in: *Econometrica* , 50, (1982), p. 97-109.

Rubinstein, A., and A. Wolinsky (1992): "Renegotiation-proof Implementation and Time Preferences", in: *American Economic Review* , 82, p. 600-614.

Salop, S.C., and D.T. Scheffmann (1983): "Raising Rivals Cost", in: *American Economic Association, Papers and Proceedings* , 73, 2, p. 267-271.

Smart, B., ed. (1992): "Beyond Compliance: A New Industry View of the Environment", Washington DC, World Resources Institute, 1992.

Sugden, Robert (1984): "Reciprocity: The Supply of Public Goods through Voluntary Contributions", in: *Economic Journal* , 94, p. 772-787.

Sutton, John (1986): "Non Cooperative Bargaining Theory: An Introduction", in: *Review of Economic Studies* , 53, p. 709-724.

Weitzmann, Martin L. (1974): "Prices vs. Quantities", in: *Review of Economic Studies* , 41, p. 477 - 491.