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Analysis

Moral concerns on tradable pollution permits in international environmental agreements

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ABSTRACT

We investigate how moral concerns about permit trading affect an endogenous pollution permit trading equilibrium, where governments choose non-cooperatively the amount of permits they allocate to domestic industries. Politicians may feel reluctant to allow permit trading and/or may prefer that abatement is undertaken domestically because of moral concerns. This will have an effect on the initial permit allocations, and, therefore, on global emissions. The impact on global emissions depends on the precise formulation of the moral concerns, but under reasonable assumptions, we show that global emissions may increase. Thus, doing what is perceived as good does not always yield the desired outcome. However, this can be offset by restrictions on permit trading when governments have moral concerns about this trade.

1. Introduction

Economists typically prefer trade in pollution permits to conventional, non market-based environmental policy instruments, as both in theory (Montgomery, 1972) and in practice (Schmalensee et al., 1998), market-based policy instruments have been shown to foster cost-effectiveness. However, many non-economists such as environmental organisations and political parties have objected against permit trade. Some consider it a way of avoiding one's obligations, to pay others to clean up, or to pay indulgence, see Goodin (1994), or as Hansen (2009) put it: "[…] it actually perpetuates the pollution it is supposed to eliminate".[1]

Several existing multinational tradable permit schemes contain restrictions on permit trading. These may have been introduced as a consequence of signatories being reluctant to allow full trading.[2] In the Kyoto protocol on greenhouse gas emissions for instance, trade in pollution permits is allowed, but only as a supplement to national mitigation.[3] Also in the European Emission Trading Scheme (ETS), access to buying emission reductions in third party countries (JI—Joint Implementation for economies in transition and CDM—Clean Development Mechanism for developing countries) is limited.[4] Thus, the cost-effective volume of trade may not be within reach.

In this paper we will study the implications of moral considerations about permit trading in an international cap-and-trade market. These moral considerations are assumed to play a role only in the governments' decision making process; not in the profit maximization objective of the permit trading firms. In a first stage of the model, governments are assumed to negotiate on national emission targets at an international forum. The emission ceilings are allocated freely to the national industries, which can trade the permits in an international and competitive pollution permit market in the second stage of

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[1] Carsten Helm pointed out to us that "Luftverschmutzungsrechte"—tradable air pollution permits—was on place 3 in the 2004 voting for the "Unwort des Jahres" (ugliest word of the year) in Germany, see http://www.unwortdesjahres.org/.

[2] Competing explanations based on market power arguments have also been put forward, see Ellerman and Wing (2000).

[3] Article 6.1 of the original Kyoto Protocol text states "The acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3". However, later meetings of the Conference of the Parties (CoP) have not been able to find a consensus on a more precise or quantitative meaning of this supplementarity requirement.

[4] Under Phase II of the ETS (2008–2012), some EU member states have limited access to CDM credits for the installations on their territory. For Phase III (2013–2020), a stricter limitation is in place requiring that no more than 50% of the total EU reduction effort over the period 2008–2020 can be covered by credits generated by project based mechanisms in third countries. More details can be found at http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/796.

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the model. The set-up is similar to the one of Helm (2003) and implies that the overall emissions, and hence the total number of pollution permits, is determined endogenously and not given exogenously as is the case in most of the existing literature on tradable permit markets. Our model is particularly suited to describe the ongoing negotiation process to forge a follow up agreement to the Kyoto Protocol and the Copenhagen Accord. Most likely, a new agreement will combine national emissions targets with provisions for emissions trading.

Moral considerations are captured in our model by means of identity effects (Akerlof and Kranton, 2000, 2005; Brekke, et al., 2003). Governments are assumed to care about the identity of their nation as this reflects the views of their voters. There may be different reasons for moral concerns as discussed below, and we focus on two ways to specify identity effects that we think capture many arguments that have been raised. First, we assume that a nation's identity is negatively affected by its net permit trade volume. This reflects the idea that some do not like trading pollution permits simply because they believe one should not trade an essentially non-desirable item like licences to pollute. But, at the same time, we assume that countries are willing to trade off the better identity against benefits from exchanging permits.

In our second formulation of moral considerations, we assume countries' identities depend on their actual abatement effort at home. Thus, they benefit in identity terms from abating at home instead of buying emission reductions elsewhere. This is specified as the identity depending negatively on the gap between countries' actual and ideal emission levels, the latter reflecting what they think they ideally should do. This formulation captures concern for the state of the global environment and one's own responsibility for it.

We study how moral considerations may affect global emissions in an endogenous permit trading equilibrium, and we find that the effect on global emissions depends on how these concerns are specified. With distaste for permit trading, moral considerations will most likely lead to higher, instead of lower, global emissions in an international climate agreement with permit trading. The reason is that on average, permit importing countries have a stronger incentive to overallocate their domestic industries to reduce permit purchases compared to the incentive of permit exporting countries to underallocate theirs. However, if the concern of countries is based on a preference for domestic abatement and global responsibility, global emissions will go down. This conclusion is based on an equal concern in all countries, which will probably not be the case. If only a few countries share this concern, the beneficial environmental effect may be rather small. Both these results show that good intentions do not always yield the desired results.

While restrictions on permit trading as introduced in the Kyoto Protocol and the ETS, may increase the costs of reaching an emissions target, we show that such restrictions may actually reduce global emissions when governments are morally concerned about trading permits. The reason is that the incentive of permit importers to overallocate domestic industries to limit permit purchases has been reduced. Thus, if the restrictions result from reluctance to trade, they may actually be good for the environment.

The paper is organised in the following way. We first discuss possible reasons behind the reluctance to trade pollution permits. In Section 3, we present the model, while Section 4 derives conclusions on how moral concerns about emission permit trading change governments' behaviour in the permit trading market and, therefore, global emissions. Section 5 studies the impacts on global emissions from restrictions on buying permits, and the final section concludes.

2. Ethical reasoning, norms and identity

Markets for pollution permits have been recognised by several authors as a case in which there may exist some reluctance or even repugnance against transactions, see, e.g., Goodin (1994), Bénabou and Tirole (2007) and Roth (2007). But why may there be reluctance against trade in pollution permits? We can identify several possible reasons for this, some of which are based on arguments rooted in a more procedural view of justice, and others in a more consequentialist ethics framework.

Based on a procedural justice approach, one can argue that industrialised countries have created the global warming problem, and that it is their *duty* to reduce the consequences of it, even if this does not minimise overall costs of taking action. This can be used as an argument against developing countries selling permits to industrialised countries because the permit trade would not lead to abatement in the countries responsible for the problem. Another argument is based on *unfair background conditions* (see Kverndokk, 1995, and Eyckmans and Schokkaert, 2004). Even if two parties agree to trade permits, the trade may not be justified on ethical grounds. A voluntary agreement between two parties is not necessary fair if is entered into conditions that are not fair (Pogge, 1989). Background justice is not preserved when some participant's basic rights, opportunities or economic positions are grossly inferior.[5] Under the Kyoto Protocol, for instance, some may argue that this is the case for some CDM contracts, as this is a trade between poor and rich countries.[6]

Another line of arguments hinges on consequentialist ethics. Standard economic analysis is basically about consequences and if the consequences of a particular policy are positive (i.e., increased welfare), economists will recommend it. This is the case with emission permits. The basic argument in favour of permit trade is that it is cost-effective (Montgomery, 1972). Parties involved in permit trade would get lower abatement costs than if they had to mitigate the emissions within their geographical boundaries. Thus, cost-savings will be welfare improving, everything else equal. One possible explanation of the resistance to permit trade is, therefore, that welfare improvements following from permit trade have not been communicated well enough, i.e., this point of view is based on *lack of information*.

However, explanations based on allegedly negative side effects of a permit market, may also be plausible. Buying CDM quotas, i.e., greenhouse gasses pollution permits in countries that did not subscribe to binding emission limits in the Kyoto Protocol, may have *adverse effects* based on lack of an emission baseline, lack of incentives to undertake emissions reductions by the developing countries, transaction costs and carbon leakages. As a result, CDM projects may not fully offset emissions, see Rosendahl and Strand (2009). Related to this is *cheating* or non-compliance in the permit market that also has negative environmental impacts, see van Egteren and Weber (1996). Further, *hot air*, meaning that some countries receive an initial emission quota allocation that exceeds their actual emissions, has also been mentioned as a reason to avoid emission trading as trading hot air will not reduce emissions.

Some papers argue that if the permit allocation is set in a non-cooperative equilibrium, permit trading may actually *lead to higher emissions*, see Helm (2003) and Holsmark and Sommervoll (2008) This can particularly be the case for sellers of permits that may allocate more permits than in the non-cooperative case without permit trade. One example is “hot air” as mentioned above, when several countries got allowances higher than their business-as-usual emissions. The idea is that if the permit price is not very sensitive to increases in permits and if the marginal damage of the country is relatively low, the benefits from overallocation is higher than the costs.

[5] Some examples can be kidney trade or an agreement between a prostitute and her/his customer.

[6] Some argue that it is not fair that the developed countries take all the “low hanging fruits” and the developing countries are left with the more expensive mitigation options in a possible future agreement. An economic treatment of this long hanging fruit argument can be found in Narain and van 't Veld (2008).

Countries may also be opposed to permit trade because of *inequality aversion*. If for instance they are concerned about income inequality and if inequality increases in a trade regime, they may prefer not to trade. Further, permit trade may reduce incentives to behave "green". As Hansen (2009) points out, individual actions to reduce the carbon footprint will not have any impacts, as all you do is to free up emission permits for someone else as the total amount of emissions is given the society. Thus, there may be some *crowding out of moral motivation*.

Abating at home instead of buying emission permits may also be perceived as a better policy based on consequences. Arguments that have been raised in this debate are the positive *spillover effects* of technology development by national abatement as well as the *ancillary benefits* (reduction in local emissions, traffic accidents, congestion etc.) of abating at home.[7] It is further argued that unilateral abatement may lead to *similar behaviour* by other countries, it may *affect* positively *the negotiation climate in the international policy arena*, and it may *reduce the conflict of interest* within a country as it actually shows the true costs of abatement, a cost that economic agents have an incentive to exaggerate; see Hoel (1991) and Golombek and Hoel (2004).

The discussion above provides arguments, based on both procedural fairness and consequentialist ethics, against permit trading. We summarize this discussion by reducing it to two basic statements that we will use to formalize moral concerns:

1) People might dislike permit trading, and
2) People might prefer to do abatement at home.

The first statement is weaker than the second as reluctance to trade permits does not necessary mean that countries care about the environment. However, reasons to avoid trading are often based on a preference for environmental values, and in the second claim, the major motivation is to save the environment, independent of international agreements and quota trade. We do not claim that these statements are true, nor that there are good ethical arguments against permit trading. Instead, we take an agnostic stand by taking these arguments as given as we think they describe some of the reluctance observed in the political debate on permit trading. Also note that in the following, we assume that governments perform the moral reasoning on behalf of their voters, so that moral concerns by the people of a nation are reflected in government's policies. If a substantial share of voters has moral concerns about permit trading, it may be reflected in the government's decision, for instance because in democratic regimes politicians care about their re-election chances.

The statements above may constitute a norm against trading pollution permits. A norm is defined as a standard of right or wrong, and norms are closely related to the preservation of identity. Thus, by modelling a norm against permit trade, we build on the theory of identity and moral motivation (Akerlof and Kranton, 2000, 2005; Brekke, et al., 2003). In this way we can model both the reluctance to trade with pollution permits, and given that the agent does not follow the norm, the wish to reduce the trade even if it is economically profitable. As the reasons for reluctance to trade may be based on both procedural fairness as well as consequences, we do not try to endogenise the norm in the model, meaning that we do not determine why a society chooses a certain norm against pollution permit trading.

3. The endogenous permit market allocation model

Our framework is based on Helm (2003) who presents a model of international emissions trading in which countries choose the amount of permits they allocate to their domestic industry in an endogenous and non-cooperative way.[8] We expand Helm's model by introducing moral concerns (identity considerations). Countries are assumed to be reluctant to trade emissions permits and/or may dislike the fact that they emit more than what they think they ideally should do.

The basic building blocks of the model are as follows. There are n countries or governments engaged in negotiating a future international environmental agreement including provisions for pollution permit trading. The governments represent the view of their voters who are, to some extent, reluctant to trade permits. However, they are also willing to trade if the benefits from trade are large enough. As in Helm (2003), we make the assumption that the permit trading regime is established only by unanimous approval of all countries.[9]

In the first stage, governments choose non-cooperatively their initial emissions allocation. This set-up resembles closely the reality of international climate negotiations, in particular the process leading to the 1997 Kyoto Protocol, the 2009 Copenhagen Accord, and presumably also future international climate policy negotiation rounds. Another example is the ETS where EU member states had to draft National Allocation Plans (NAPs) suggesting a permit allocation for all installation covered by the ETS directive on their territory for Phase 1 (2005–2007) and Phase 2 (2008–2012). In contrast to most of the literature on national emission permit schemes, the overall number of permits cannot be assumed to be exogenous in an international context.

In the second stage of the game, individual firms trade emissions in a competitive permit market. We assume that they obey the emission ceiling and that they maximize their private profit only. Thus, firms do not have moral concerns about trading.[10]

This game is solved by backward induction, i.e., we start be solving the second stage.

3.1. Stage 2: Firms trading emissions

In every country $i \in N=\{1,2,\ldots,n\}$ there is a large number of identical firms that maximizes profits due to emissions, π, taking as given the emissions trading scheme:

$$\max_{e_i} \quad \pi_i(e_i; p, \omega_i) = B_i(e_i) + p[\omega_i - e_i] \tag{1}$$

Let $\omega_i \geq 0$ be the initial allocation of permits to the representative firm in country i and assume that permits are allocated for free. For simplicity, we set the emissions of one country equal to the emissions of its representative firm, $e_i \in [0, \overline{e}_i]$, where $\overline{e}_i$ is business as usual (BAU) emissions, i.e., emissions in absence of an international treaty and any moral considerations. This is the maximum emissions that a country will emit.[11] Emissions can be traded at a given market price p. Firms choose emissions in order to maximize profits, i.e., the sum of benefits and net permit trade revenues. The benefits of emissions, B_i, can be interpreted as a production function. Production requires input of carbon emissions, and is assumed increasing and strictly concave in emissions: $B_i^e \geq 0$ and $B_i^{ee} < 0$. In the Appendix, the formal properties of

[7] Related to this is the *environmental justice* argument, that minority groups suffer from permit trading because they live close to polluting facilities and will, therefore, not benefit from the ancillary benefits of abating at home (see, e.g., Kverndokk and Rose, 2008, for a survey).

[8] For other applications of the model, see Holsmark and Sommervoll (2008) and Carbone et al. (2009).

[9] Allowing for endogenous coalition formation would substantially complicate the analysis, as the countries are not symmetric in our analysis. Symmetric or homogeneous countries are a common assumption in studies of coalition formation, see, e.g., Barrett (2005), but would be inappropriate in our case since the difference between countries is essential in the analysis of pollution permit trading.

[10] This is consistent with Siebert (1992, p. 130) and Rauscher (2006) who argue that a firm spending resources on social activities not rewarded by the market will not remain competitive and will be driven out of the market. However, if firms have market power, non-profit motives can survive. In contrast to this, Brekke and Nyborg (2008) argue that corporate social responsibility can lead to recruitment of highly motivated workers and, therefore, be profitable.

[11] Note that with moral concerns on abatement at home, emissions will be less than $\overline{e}_i$ even in the absence of a climate treaty, see Section 4.2.

the benefit function are derived from the standard properties of an emission abatement cost function.

From the first-order condition for profit maximization, we can derive the demand for emissions:

$$B_i^e(e_i) = p \Rightarrow e_i = E_i(p) = \left(B_i^e\right)^{-1}(p) \tag{2}$$

Profit maximizing behaviour by firms leads to *cost-effectiveness*; marginal benefits of emissions are equalised across firms. Thus, this condition is valid even if countries have moral arguments against permit trading as such considerations are not taken into account by the competitive firms.

Comparative statics of this expressions shows that emissions are decreasing in the permit price:

$$B_i^{ee}de_i = dp \Rightarrow \frac{\partial e_i}{\partial p} = E_i^p = \frac{1}{B_i^{ee}} < 0 \tag{3}$$

Using first-order condition (2), we can define a "net supply of permits" function that is increasing in the price of permits:

$$S_i(p) = \omega_i - E_i(p) \text{ with } \frac{\partial S_i}{\partial p} = S_i^p = -E_i^p > 0 \tag{4}$$

A permit market equilibrium defines a price level such that total net supply of permits is nonnegative:

$$p^o \text{ such that } \sum_{j\in N} S_j(p^o) = \sum_{j\in N}\left[\omega_j - E_j(p^o)\right] \geq 0 \tag{5}$$

This market equilibrium condition implicitly defines a price function mapping a vector of emission allocations $\boldsymbol{\omega}$ into the market clearing price level: $p^o = \rho(\boldsymbol{\omega})$. We assume that the marginal benefit functions are such that for every vector of emission allocations, there exists a unique equilibrium permit price.[12] The permit price function can be shown to be decreasing in the initial allocations of permits to a country.

$$\rho^{\omega_i}(\boldsymbol{\omega}) = \frac{\partial \rho}{\partial \omega_i} = \frac{dp^*}{d\omega_i} = \frac{1}{\sum_{j\in N} E_j^p} < 0 \tag{6}$$

Hence, in accordance with standard economic intuition, higher allocations of permits lead to a decrease in the equilibrium permit price.

3.2. Stage 1: Governments choosing initial permit allocations

Given the smoothly working permit market in stage two, governments negotiate in stage one on the initial allocation of permits, and we assume that they choose the number of permits ω_i as to maximize the following national welfare function:

$$W_i(e_i, \omega_i; \overline{\omega}_{-i}) = B_i(e_i) + p[\omega_i - e_i] - D_i(\omega_i + \overline{\omega}_{-i}) + I_i\left(e_i, e_i^S, \omega_i\right) \tag{7}$$

The function D_i denotes pollution damages incurred in country i. These damages are convex in global emissions, defined by the total amount of permits distributed (country i's permits are ω_i, while all other countries' emission permits are denoted by ω_{-i}). Thus, the environmental problem is caused by a uniformly mixing pollutant as in the case of global warming. We assume that country i maximizes its welfare, taking as given the permit allocations by all other countries ($\omega_{-i} = \overline{\omega}_{-i}$). Hence, we are looking for a Nash equilibrium in permit allocations among national governments.

Our set-up is similar to the model introduced by Helm (2003). However, in addition to the approach by Helm, we assume that countries have moral concerns about permit trading defined as an *identity*, I_i, which adds positively to their welfare function. Identity is usually defined as a person's self image—as an individual or as a part of a group (Akerlof and Kranton, 2005). Identity has been recognised as important for individual behaviour in fields as social psychology and sociology, but has only recently been adopted in formal economic models. In this paper we define a country's moral concerns in the same way as the identity of an individual as governments perform the moral reasoning on behalf of their voters.

The model also bears some resemblance to the literature on voluntary provision of public goods, see Bergstrom et al. (1986), and in particular to the strand of literature on the so-called "warm glow of giving", see Andreoni (1990). In this literature, economic agents care about the overall level of the public good and feel good about contributing a positive amount to its provision. One can interpret this warm glow effect as a positive identity effect (see Brekke et al., 2003). However, in our model, private contributions, in the sense of low allocation of pollution permits to one's domestic industry, may lead to a cold feeling instead of a warm glow as this increases the incentives for firms to enter the permit trading market and buy large amounts of permits.

Based on the statements made in Section 2, the moral concern (identity) of a country is a function of its actual emissions, e_i, its permit allowances ω_i as well as its ideal emissions, e_i^S. The latter is defined as the emission level that the country would like to aim for based on ethical reasoning. This ideal is considered exogenous. We return to this in Section 4.

Using the notation introduced before, we can write the welfare function of country i, taking into account the competitive permit trading in stage two, as:

$$\begin{aligned} W_i(\omega_i, \omega_{-i}) = {} & B_i(E_i(\rho(\boldsymbol{\omega}))) + \rho(\boldsymbol{\omega})[\omega_i - E_i(\rho(\boldsymbol{\omega}))] \\ & - D_i(\omega_i + \omega_{-i}) + I_i\left(E_i(\rho(\boldsymbol{\omega})), e_i^S, \omega_i\right) \end{aligned} \tag{8}$$

Each country wants to set its initial permit allocation, $\omega_i > 0$, in order to maximize its welfare defined by Eq. (8). Let ΔI_i be the change in identity for a change in ω_i. The first-order condition for an interior solution is, therefore:[13]

$$B_i^e E_i^p \rho^\omega + \rho^\omega[\omega_i - e_i] + \rho\left[1 - E_i^p \rho^\omega\right] - D_i^\omega + \Delta I_i = 0 \tag{9}$$

Using the first-order condition $B_i^e = \rho$ of competitive permit trading among firms in stage 2 (Eq. (2)), the following condition should be satisfied for all countries $i \in N$:

$$\rho^\omega[\omega_i - e_i] + \rho - D_i^\omega + \Delta I_i = 0 \tag{10}$$

The first term on the left hand side (LHS) is the effect of additional permit allocations on the emission trading revenue through the effect on the permit price. A more generous permit allocation is beneficial for permit importers (the market price goes down), while a more restricted permit allocation is beneficial for permit exporters (the market price goes up). We label this effect the *strategic permit trading effect*.[14]

The second term is the *direct price effect* of a more generous permit allocation. Every additional permit is worth the prevailing market price ρ. The third term stands for the additional *pollution damage effect*

[12] If more permits would be allocated than the net demand for emissions, we assume that the equilibrium price is zero: $\sum_{j\in N}\omega_j > \sum_{j\in N} E_j(0) \Rightarrow p^o = 0$.

[13] All variables and functions are evaluated in the Nash equilibrium of permit allocations, i.e., the permit allocations of other countries are taken as exogenous.

[14] Note that this effect cancels out in the aggregate and will not have any effect on global emissions, see Helm (2003), p. 2741, or Eq. (14) below.

caused by a more generous permit allocation. More permits lead, ceteris paribus, to higher global emissions and hence higher pollution damages. This effect is therefore negative. Finally, the last term captures the *change in the moral concerns* of extra permits. This effect can be positive or negative depending on the precise specification of the identity function.

Rearranging Eq. (10) and using again the firms' profit maximizing first-order condition $B_i^e = \rho$, we obtain:

$$B_i^e = D_i^{\omega} - \rho^{\omega}[\omega_i - e_i] - \Delta I_i \tag{11}$$

Hence, every country chooses an initial permit allocation such that its marginal benefit from the last ton of emissions equals individual marginal damages, corrected for a strategic permit trade effect and an identity effect.

4. Different formulations of nations' moral concerns

In this section we present the main results for different formulations of countries' identity concerns. We start in Section 4.1 with the identity function based on reluctance to trade permits. Both the symmetric (Sections 4.1.1 and 4.1.3) and asymmetric formulation (Section 4.1.2) are explored. Section 4.2 focuses on identity considerations based on preference for abatement at home. Finally, Section 4.3 combines both formulations of the identity function.

4.1. Identity as reluctance to trade

4.1.1. Symmetric reluctance to trade

So far we have not specified the identity function. Let us consider the two statements on moral concerns from Section 2: Countries might dislike permit trading, and countries might prefer to do all the abatement at home. However, for ease of exposition, we study the two statements separately before combining them.

We first focus on the statement that countries dislike permit trading. Assume a *symmetric* formulation of reluctance to trade, i.e., countries dislike both selling and buying permits:

$$I_i(e_i, \omega_i) = \begin{cases} -F_i - \delta[\omega_i - E_i(\rho(\boldsymbol{\omega}))]^2 & \text{if} \quad \omega_i \neq E_i(\rho(\boldsymbol{\omega})) \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

Involvement in permit trading represents a cost, both for buyers and sellers, due to the fact that one does not act in accordance with one's moral conviction. This loss in identity consists of a fixed cost independent of the amount of permits traded, and a variable cost. The fixed cost, $F_i > 0$, is the loss of going from one regime to another, here represented by going from a non-trade regime to a trading regime. However, the volume of trade also matters. If a country decides to trade, it feels less comfortable the higher the volume of permit trading is when $\delta > 0$.[15] An example can be the supplementary condition in the Kyoto Protocol as well as political discussions in Norway on setting a limit on how much one can reduce abatement abroad. Finally, note that this identity function has a maximum at zero without emissions trading.

The specification of the moral concerns, both the fixed and the variable term represent costs of trading. This shares similarities with a permit trade system with transaction costs as in Stavins (1995). With transaction costs, the volume of trade is lower and welfare is lower compared to a system without such costs. Also the initial allocation of permits may affect the outcome of trading. However, moral considerations affect permit trading differently than transaction costs in several respects. First, the fixed identity term affects the decision whether the country wants to take part in the permit trading market, and second, the endogenous part of the identity function affects the allocation of initial allowances as countries do not want the allocations to be very different from actual emissions. However, for a given level of aggregated allowances (global emissions target), the outcome of trading is not affected by the initial allowance allocation. In our model, firms face no transaction costs in trade so they trade cost-effectively, i.e., marginal abatement costs among sources are equal. This is not the case in models with transaction costs as these costs are usually modelled as a function of the volume of trade.

Using this explicit identity function, we can derive the following lemma:

Lemma 1. *If countries are reluctant to trade permits, and if identity is symmetric, then:*

- *if country i is a permit seller ($\omega_i > e_i$) it follows that $B_i^e > D_i^e$;*
- *if country i is a permit buyer ($\omega_i < e_i$) it follows that $B_i^e < D_i^e$.*

This means that sellers underallocate and buyers overallocate emissions compared to a situation without permit trading and without moral concerns.

Proof. Note first that if there were no permit trading and no moral concerns, maximizing welfare in Eq. (7) would imply $B_i^e = D_i^e$. Now introducing permit trade and moral concerns, the change in identity from a marginal increase in ω_i is given by: $\Delta I_i = -2\delta[1 - E_i^p \rho^{\omega}][\omega_i - e_i]$. This change is positive for permit buyers and negative for permit sellers for the symmetric identity function because $0 \leq E_i^p \rho^{\omega} = E_i^p / \sum_{j \in N} E_j^p \leq 1$. It follows from Eq. (11) that:

$$\begin{aligned} B_i^e - D_i^e &= -\rho^{\omega}[\omega_i - e_i] + 2\delta[1 - E_i^p \rho^{\omega}][\omega_i - e_i] \\ &= [\omega_i - e_i] \underbrace{\left[-\rho^{\omega} + 2\delta[1 - E_i^p \rho^{\omega}]\right]}_{+} \end{aligned}$$

and therefore $B_i^e \lesseqgtr D_i^e$ if $\omega_i \lesseqgtr e_i$. □

The lemma says that permit sellers allocate permits so that the marginal benefit from emissions is higher than the marginal damage, while it is the other way around for permit buyers. The intuition is as follows. Net permit selling countries tend to underallocate their domestic firms, yielding marginal benefit from emissions in excess of marginal costs, as this makes permits scarce and drives up the equilibrium market price. In addition, the underallocation has positive identity effects as the volume of trade goes down and the gap between permit allocation and actual emissions shrinks. On the other hand, net permit buying countries tend to overallocate their domestic firms because this makes permits more abundant and lowers the market price. Further, the same identity mechanism as described for sellers is also valid for buyers; overallocating permits has positive identity effects as the volume of trade goes down. Summarizing, the moral concerns, if they only stem from reluctance to trade, reinforce the strategic trade incentives for both sellers and buyers of permits. This proves to be a useful result for the remainder of the paper.

4.1.2. Asymmetric reluctance to trade

How does the introduction of moral concerns affect the global amount of permits issued into the market? We start with a simple case based on the fact that the discussion on the acceptability of permit trading is mainly a topic in countries that are potential permit buyers. This means that the identity function is *asymmetric*, where countries only suffer an identity loss if they buy permits:

$$I_i(e_i, \omega_i; \beta) = \begin{cases} -F_i - \delta[\omega_i - E_i(\rho(\boldsymbol{\omega}))]^2 & \text{if} \quad \omega_i < E_i(\rho(\boldsymbol{\omega})) \\ 0 & \text{otherwise} \end{cases} \tag{13}$$

[15] In the case where $\delta = 0$, i.e., there is an identity cost of not following the norm, which is independent on the volume of trade as long as the volume is positive, we will actually get the same first -order conditions as when identity does not matter, i.e., $\Delta I_i = 0$.

Proposition 1. *If only buyers are reluctant to trade (asymmetric identity function), then every individual country will emit more and global emission will be higher than in the endogenous permit allocation equilibrium without moral concerns.*

Proof. The first-order conditions for governments issuing permits are different for permit importers ($\omega_i<e_i$) and exporters ($\omega_i\geq e_i$), see Eqs. (11) and (13):

$$\begin{cases} B_i^e - D_i^e + \rho^\omega[\omega_i - e_i] - 2\delta\left[1 - E_i^p\rho^\omega\right][\omega_i - e_i] = 0 & \text{if} \quad \omega_i<e_i \\ B_i^e - D_i^e + \rho^\omega[\omega_i - e_i] = 0 & \text{if} \quad \omega_i\geq e_i \end{cases}$$

Summing over both types of countries and using the market clearing condition from Eq. (5), it follows that:

$$\sum_{j\in N} B_j^e - \sum_{j\in N} D_j^e - 2\delta \sum_{j\in N} \min\left\{0, \omega_j - e_j\right\}\left[1 - E_j^p\rho^\omega\right] = 0$$

Let ω_N be global emissions and top scripts I and O refers to the equilibrium with moral concerns and without such concerns respectively. Then assuming, in contrast to the claim in the proposition, that $\omega_N^I<\omega_N^o$, and using the convexity of the damage functions, it follows that: $\sum_{j\in N} D_j^e(\omega_N^I)<\sum_{j\in N} D_j^e(\omega_N^o)$. Summing over the appropriate first-order conditions for both equilibria, see Eq. (10), it can be shown that (recall that $0\leq[1-E_j^p\rho^\omega]\leq 1$):

$$\rho^I - \rho^o < \frac{2\delta}{n}\sum_{j\in N} \min\left\{0, \omega_j - e_j\right\}\left[1 - \rho^\omega E_j^p\right] < 0$$

Hence, the equilibrium permit price would be lower with asymmetric moral concerns than without. Given that the equilibrium price function is decreasing in the global permit allocation, we get $\omega_N^I>\omega_N^o$, which contradicts the initial assumption. Therefore, $\omega_N^I\geq\omega_N^o$, and moral concerns will lead to higher global emissions than without such concerns.

As we have shown that the equilibrium permit price will be lower with asymmetric moral concerns than without, every country's representative firm will emit more: $B_i^e(e_i^I) = \rho^I < \rho^o = B_i^e(e_i^o) \Rightarrow e_i^I > e_i^o$ due to concavity of the benefit functions. □

The proposition is intuitively clear. From Lemma 1 we know that permit buyers have an incentive to overallocate their domestic industries because of 1) strategic trade considerations (driving down the equilibrium permit price), and 2) moral concerns (over-allocating domestic firms reduces the amount of permits that has to be imported). Since only buyers' moral concerns are taken into account in the asymmetric identity function, global emissions[16] in the international Nash equilibrium will be higher than in the scenario without such considerations.

4.1.3. Symmetric reluctance to trade revisited

We now turn back to the more complicated case where both permit importers and exporters dislike permit trading, i.e., the symmetric identity function. In order to find the global effect, we summarise all countries first-order conditions based on Eq. (10) and $\Delta I_i = -2\delta[1 - E_i^p\rho^\omega][\omega_i - e_i]$, to obtain:

$$\begin{aligned} &\sum_{j\in N}\left\{\rho^\omega\left[\omega_j - e_j\right] + \rho - D_j^e - 2\delta\left[\omega_j - e_j\right]\left[1 - E_j^p\rho^\omega\right]\right\} = 0 \\ &\Rightarrow \rho^\omega \sum_{j\in N}\left[\omega_j - e_j\right] + n\rho - \sum_{j\in N} D_j^e - 2\delta\sum_{j\in N}\left[\omega_j - e_j\right] \\ &\quad + 2\delta\rho^\omega \sum_{j\in N}\left\{\left[\omega_j - e_j\right]E_j^p\right\} = 0 \\ &\Rightarrow n\rho - \sum_{j\in N} D_j^e + 2\delta\rho^\omega\sum_{j\in N}\left[\omega_j - e_j\right]E_j^p = 0 \end{aligned}$$

Hence,

$$n\rho = \sum_{j\in N} D_j^e - 2\delta\rho^\omega \sum_{j\in N}\left[\omega_j - e_j\right]E_j^p \tag{14}$$

As the following result shows, the outcome depends on the "balance of power" between permit exporters and importers.[17]

Proposition 2. *If countries are reluctant to trade permits, identity is symmetric, and* $\sum_{j\in N}[\omega_j - e_j]E_j^p>(<)0$*, global emissions will be lower (higher) and every country will emit less (more) than without moral concerns.*

Proof. Assume the claim is false, i.e., $\sum_{j\in N}[\omega_j - e_j]E_j^p>0$ and $\omega_N^I>\omega_N^o$. Because of convexity of the damage functions if follows that: $\sum_{j\in N} D_j^e(\omega_N^I) > \sum_{j\in N} D_j^e(\omega_N^o)$. Using Eq. (14) and the appropriate condition when there is no identity function (i.e., the second term of the right hand side of Eq. (14) is equal to zero), it is easily shown that:

$$\begin{aligned} &n\rho^I + 2\delta\rho^\omega\sum_{j\in N}\left[\omega_j - e_j\right]E_j^p > n\rho^o \\ &\Downarrow \\ &\rho^I - \rho^o > \left[\frac{-2\delta\rho^\omega}{n}\right]\sum_{j\in N}\left[\omega_j - e_j\right]E_j^p > 0 \end{aligned}$$

Hence, the equilibrium permit price with moral concerns would be higher than the price without such concerns. Given that the equilibrium price is decreasing in the global permit allocation, $\omega_N^I<\omega_N^o$, which contradicts the initial assumption.

Finally, as we have just shown that if $\sum_{j\in N}[\omega_j - e_j]E_j^p>0$, global emissions will be lower and, hence, the equilibrium price of permits will be higher in case of moral concerns and, therefore, every country's representative firm will emit less: $B_i^e(e_i^I) = \rho^I > \rho^o = B_i^e(e_i^o) \Rightarrow e_i^I < e_i^o$ due to concavity of the benefit functions. □

Hence, if $\sum_{j\in N}[\omega_j - e_j]E_j^p>0$, reluctance to trade leads to lower overall emission allocations, and hence lower emissions, than in the absence of moral considerations. But how should we interpret the condition $\sum_{j\in N}[\omega_j - e_j]E_j^p>0$? It can be interpreted as a weighted average of all permit trades, where permits exporters have $[\omega_j - e_j]E_j^p<0$ and importers $[\omega_j - e_j]E_j^p>0$, and where the weights, E_j^p, are given by the inverse of the slope of the marginal benefit of emissions function (recall that $E_j^p = 1/B_j^{ee}<0$). Thus, in order for $\sum_{j\in N}[\omega_j - e_j]E_j^p$ to be positive, permit exporters should, on average, have smaller absolute values of E_i^p than permit importers. Note that high absolute values of B_i^{ee} (i.e., steep marginal emission abatement cost functions) imply small absolute values of E_i^p. Therefore, the term is positive if permit sellers are predominantly countries with steep marginal abatement cost functions (see the Appendix).

This is not very likely in the Kyoto permit market. Most empirical models predict the contrary, i.e., that low abatement cost countries (i.e., countries with flat marginal benefit functions, B_i^e) will export carbon emissions permits, see Böhringer (2002), Den Elzen and de Moor (2002) or Eyckmans and Hagem (2008). Therefore, it is more likely that moral concerns would lead to a higher number of permits issued. This means that the solution with moral concerns is likely to result in higher global emissions than in the absence of those considerations. The result is again due to the overallocation of permits in permit importing countries that follows from Lemma 1.

[16] We want to remind the reader that global emissions refer to actual emission. At the global level, the net trades of permits cancel out in a permit market equilibrium, see Eq. (5).

[17] Note that in the following propositions we do not do comparisons to a first-best social optimum as in general the first-best solution with and without moral concerns would differ. One exception is the first-best solution in Section 4.2 where the two solutions coincide.

4.2. Identity as a preference for abatement at home

Reluctance to trade is one aspect of a country's moral concerns, but the country could also have preferences for doing the abatement at home. To model this, we assume that identity depends on the relationship between actual emissions and the morally ideal emissions, e_i^S, i.e., the amount of emissions the country thinks it ideally should aim for. This can be specified in the following way:

$$I_i\left(e_i, e_i^S\right) = -\gamma\left[e_i - e_i^S\right]^2 \tag{15}$$

As the countries are concerned about the global environment, it is reasonable to assume that the ideal requires substantial abatement. One way to specify this is to follow Brekke et al. (2003) and assume that countries share an ethical view that global social welfare should be maximized. Thus, "ideal" emissions are found by maximizing a utilitarian global welfare function where everybody follows the same general rule, namely to emit the amount that maximizes global welfare:

$$\max_{(e_1,e_2,\ldots,e_n)} \sum_{j\in N}\left[B_j\left(e_j\right) - D_j\left(\sum_{k\in N} e_k\right) - \gamma\left[e_j - e_j^S\right]^2\right]$$

This gives rise to the following first-order conditions:

$$B_i^e(e_i^*) - 2\gamma\left[e_i^* - e_i^S\right] = \sum_{j\in N} D_j^e\left(\sum_{k\in N} e_k^*\right) \forall i \in N$$

We see that the global welfare function is maximized for $e_i^S = e_i^*$. Thus, in this case the identity terms disappear, and the first-order conditions equal the well known Samuelson rule (after Samuelson, 1954) that defines the first-best allocation of emissions without moral concerns:

$$B_i^e(e_i^*) = \sum_{j\in N} D_j^e\left(\sum_{k\in N} e_k^*\right) \forall i \in N \tag{16}$$

Having defined the ideal reference level of emissions, we can now write the identity function in the following way, where e_i^* is considered exogenous:

$$I_i(e_i, e_i^*) = -\gamma\left[E_i(\rho(\boldsymbol{\omega})) - e_i^*\right]^2 \tag{17}$$

Using this function in the maximisation problem defined by Eq. (7), we can show that every country will emit more than the "ideal" emissions level.

Lemma 2. *Even if countries care about their ideal emissions, every individual country will emit more than its ideal: $e_i \geq e_i^*$ and, therefore, total amount of permits allocated will exceed the socially optimal level: $\omega_N \geq e_N^*$.*

Proof. Assume, on the contrary, that $\exists i \in N: e_i < e_i^*$. From the strict concavity of the emissions benefit function, it follows that $B_i^e(e_i) > B_i^e(e_i^*)$. Using Eqs. (2) and (17) implies:

$$\rho(\omega_N) = B_i^e(e_i) > B_i^e(e_i^*) = \sum_{j\in N} D_j^e(e_N^*) = \rho(e_N^*) \Rightarrow \omega_N < e_N^*$$

At the same time, we can derive:

$$D_i^e(\omega_N) + 2\gamma\left[e_i - e_i^*\right]E_i^p\rho^{\omega} = B_i^e(e_i) > B_i^e(e_i^*) = \sum_{j\in N} D_j^e(e_N^*)$$

$$\Downarrow$$

$$\sum_{j\in N} D_j^e(\omega_N) - \sum_{j\in N} D_j^e(e_N^*) \geq D_i^e(\omega_N) - \sum_{j\in N} D_j^e(e_N^*) > -2\gamma\left[e_i - e_i^*\right]E_i^p\rho^{\omega} \geq 0$$

$$\Downarrow$$

$$\omega_N > e_N^*$$

This contradicts the previously established inequality. Thus, for $\forall i \in N: e_i \geq e_i^*$.

Given that every country emits more than the ideal level, the total emissions in the endogenous permit allocation equilibrium will exceed the first-best level: $\omega_N > e_N^*$. □

As every country always emits more than its ideal, we can easily sign the derivative of the identity function with respect to ω_i:

$$\Delta I_i = -2\gamma\rho^{\omega}\left[e_i - e_i^*\right]E_i^p < 0 \tag{18}$$

Based on this, we find that when all countries care about their ideal effort, the endogenous permit allocation equilibrium shifts towards the Pareto efficient first-best allocation of emissions, and they will emit less than without moral concerns.

Proposition 3. *If countries care about their ideal effort, every individual country will emit less without moral concerns and global emissions will be lower.*

Proof. Assume, in contrast, that $\omega_N^I > \omega_N^o$. Using convexity of the damage functions, it follows that: $\sum_{j\in N} D_j^e(\omega_N^I) > \sum_{j\in N} D_j^e(\omega_N^o)$. As before, using the appropriate first-order conditions for both equilibria, we find:

$$\rho^I - \rho^o > \frac{2\gamma\rho^{\omega}}{n}\sum_{j\in N}\left[e_j - e_j^*\right]E_j^p > 0$$

Hence, the equilibrium permit price would be higher with moral concerns than without. As the equilibrium price is decreasing in the global permit allocation, we find that $\omega_N^I < \omega_N^o$ which contradicts the initial assumption. Therefore, we get $\omega_N^I \leq \omega_N^o$.

Also, as the equilibrium price of permits will be higher with moral concerns, every country's representative firm will emit less: $B_i^e(e_i^I) = \rho^I > \rho^o = B_i^e(e_i^o) \Rightarrow e_i^I < e_i^o$ due to concavity of the benefit functions. □

This result is in contrast to the previous conclusion when countries cared about their level of emissions trading and moral concerns could lead to higher global emissions. The reason is that, when countries care about their ideal level of emissions, they feel a warm glow when doing more than what a strictly private cost benefit analysis would prescribe. This shows that it matters what people's concerns are about. If the main concern is distaste against trading emission permits, the environment may be harmed, while if the desire is to reduce emissions at home, the environment will benefit. Note, that in this latter conclusion we have assumed that all countries share the same moral standpoint. This will not necessary be the case. If only a few countries have this view, the additional abatement would share similarities to unilateral actions taken by one single country, and it is known from the literature that unilateral actions from one country can actually increase global emissions (Hoel, 1991).

4.3. Combining both identity effects

One may argue that people's moral concerns follow both from distaste against trading permits as well as the desire to reduce emissions at home. Thus, it seems appropriate to combine the identity functions from the previous sections. Taken together, the full identity function can be written as:[18]

$$I_i(e_i, e_i^*, \omega_i) = \begin{cases} -F - \delta[\omega_i - E_i(\rho(\boldsymbol{\omega}))]^2 - \gamma[E_i(\rho(\boldsymbol{\omega})) - e_i^*]^2 & \text{if} \quad \omega_i \neq E_i(\rho(\boldsymbol{\omega})) \\ -\gamma[E_i(\rho(\boldsymbol{\omega})) - e_i^*]^2 & \text{otherwise} \end{cases} \tag{19}$$

[18] Here we chose the symmetric version of the reluctance to trade identity function.

The new identity function describes an internal conflict; we can have $e_i = e_i^*$, but still $\omega_i \neq e_i$, thus doing what is best according to one moral ideal may not fulfill the other.

We can now characterize the full impacts of the moral concerns.

Proposition 4. *If countries are reluctant to trade permits and if they care about abatement at home, global emissions will be lower if either:*

- $\sum_{j \in N}[\omega_j - e_j]E_j^p > 0$, *or*
- *the concerns about abatement at home are strong enough to compensate the reluctance to trade.*

Proof. The proof is trivial by combining Proposition 2 and Proposition 3. □

At first sight, one might think it is obvious that moral concerns would lead to lower global emissions. However, Proposition 4 shows that this depends crucially on both the form of the identity function and the balance of power between permit importers and exporters.

As we have argued above, in the case of global climate change, $\sum_{j \in N}[\omega_j - e_j]E_j^p$ is likely to be negative. We can, therefore, conclude that the overall emission level resulting from the international climate negotiations outcome will be lower if there is a relatively strong concern about actual emission levels in all countries. If this concern is weak, or if few countries share this concern, and in addition there is a strong distaste against permit trading, emissions may actually be higher than without any concerns about permit trading. Thus, aiming for the good does not always bring the desired outcomes.

5. Restrictions on permit trading

As mentioned in the introduction, restrictions of permit trading as found in the Kyoto Protocol and in the ETS, may have been introduced due to reluctance of trading permits. From economic theory we know that restrictions on permit trading are likely to increase the costs of a treaty for a given number of total allowances; while there is no impact on the environment the, cost-effective allocation of emission reduction may not be reached. Thus, restrictions are considered to be bad from an economic point of view. However, this result follows from standard economic assumptions where the permit allocation is assumed exogenous to each country, and where countries are assumed to have no moral concerns about permit trading. If these assumptions do not hold, will the standard result still prevail?

Overallocation of permits by buyers was the reason for higher emissions under moral concerns about permit trading. Thus, we focus on the case with symmetric identity function and where buyers are restricted from buying permits,[19] i.e.,

$$-(\omega_i - e_i) \leq a(\bar{e}_i - \omega_i) \tag{20}$$

This means that the amount of permit a country can buy should be less or equal to a certain share, a, of the necessary abatement. Assume now that this restriction is binding for some countries, i.e., these countries would like to buy a larger share. In this case we find:

Proposition 5. *If countries are reluctant to trade permits, identity is symmetric, and the restriction on buying permits is binding for at least one country, global emissions will be lower than in the case without such restrictions.*

Proof. The proof follows the same line as the proof of Lemma 1. As the first-order condition from Eq. (11) gives

$$B_i^e - D_i^e = \underbrace{[\omega_i - e_i]\left[-\rho^{\omega} + 2\delta\left[1 - E_i^p \rho^{\omega}\right]\right]}_{+},$$

we see that an effective restriction on buying permits makes the term on the right side less negative. Thus, the marginal benefit will be closer to the marginal damage and there will be less of an over allocation. □

As there is a restriction on trade, the permit importing countries are restricted and cannot overallocate emissions to the same amount as in the situation without the restriction. This has a beneficial effect on the environment. Thus, when allowances are set in a non-cooperative setting, and when countries have moral concerns on permit trading, restrictions on trading have a positive effect on the environment, i.e. global emissions are lower. Note that this conclusion also holds for the asymmetric identity function.[20]

Finally, in the case with moral preferences for abating at home, a restriction on permit trading will not affect the identity function. Thus, the effect on total emissions will be the same as without moral concerns.[21]

6. Discussion and conclusions

In this paper we have analysed how moral concerns about permit trading affect an endogenous pollution permit trading equilibrium, in which governments choose non-cooperatively their national permit allocations, and therefore also the overall global environmental objective. Without moral concerns, such an equilibrium typically leads to a cost-effective allocation of emission reduction efforts (because of the permit market), but the global environmental objective falls short of the ideal (i.e., the global welfare maximizing) environmental ambition level, see Helm (2003). This modelling set-up resembles closely the reality of international climate policy negotiations in the aftermath of the Copenhagen Accord.

However, there may be different reasons why people, and therefore also their governments, have moral concerns about permit trading. For instance, countries may be reluctant to trade permits because they think it is a way to escape their moral responsibility, or because of the assumed negative consequences the trade may have in developing countries. Hence, both consequentialist and procedural ethics arguments are used to justify calls for limits on the access to flexible mechanisms like CDM in the framework of the Kyoto Protocol or the European Emission Trading Scheme.

Given an internationally negotiated permit trading system, we find that moral concerns may increase or reduce global emissions depending on the precise formulation of these concerns. This is

[19] Note that this restriction is always satisfied for sellers as long as there is no "hot air".

[20] With standard economic assumptions and no moral reasoning, we know that restrictions increase the costs of a treaty, and the incentives to join the treaty for individual countries will be lower. As a result, the treaty may fail or it may consist of fewer countries. The consequence may be higher global emissions. In our setting we find that while total emissions go down with restrictions, welfare will also go down, otherwise the restrictions would not have been binding. Thus, also in this case the costs of joining the treaty will be higher, which may give a negative incentive to join. However, it is not obvious that this has negative impacts on total emissions in this model, see footnote 21 below.

[21] Restrictions on permit trading may have an effect on emissions when allowances are set in a non-cooperative equilibrium. As mentioned in Section 2, Helm (2003) and Holsmark and Sommervoll (2008) found that emissions may be higher in a permit trade system compared to business-as-usual when allowances are set non-cooperatively as in our model. Thus, restrictions on permit trading may also lead to lower total emissions even without moral concerns. This is, however, outside the scope of this paper.

based on two different ways to specify the moral considerations. The first captures the idea that countries might be reluctant to trade. They may have some distaste about trading and would like to avoid it; they consider trading pollution permits not a good thing in itself. If this view is held by permit importers only, global emissions will be higher than in an equilibrium without moral concerns. The reason is that permit importers tend to overallocate their domestic industries in order to reduce the amount of permits they have to import. This further depresses the international price of permits (and hence permit acquisition costs) and limits the negative identity effect because their permit trade volume is lower. However, if both permit sellers and buyers dislike permit trading, this result is not necessary true as permit exporters would like to reduce their export. By doing so, permit exporters can drive up the international permit price (and hence increase their permit sales revenue) by making permits scarcer and, in addition, they can limit the negative identity effect because their permit trade volume is lower. The overall effect on global emissions will depend on the balance of power (more precisely, on the slope of the marginal abatement cost functions in equilibrium) between permit importers and exporters. But under reasonable assumption, we conjecture that global emissions are likely to increase also in this case.

The second formulation of moral concerns takes into account that countries would like to avoid permit trading as they feel it is their obligation to reduce emissions at home. This is implemented by introducing an identity effect that depends negatively on the gap between actual and ideal emission levels. These ideal effort levels are chosen to be the global welfare maximizing emission reduction levels and require substantial additional emission reductions compared to the endogenous permit trading equilibrium without moral concerns. We show that in this case global emissions will always be lower with this type of moral considerations if all countries follow this rule, as they all have an additional incentive to reduce emissions. However, note that this conclusion depends on all countries having similar moral concerns. If this is not the case, and only a few countries share this view, moral concerns about permit trading based on the desire to reduce national emissions to what is deemed morally right, does not necessary have a significant or beneficial impact on global emissions.

Another interesting result from this study relates to restrictions on permit trading as has been introduced in the Kyoto Protocol and the EU ETS. While standard economic theory suggests that such restrictions are bad as they tend to increase the cost for a given environmental target, we show that such restrictions may actually reduce global emissions when governments have moral concerns about trading permits. The reason is that the incentive of permit importers to overallocate their domestic industries is dampened. If permit trading restrictions have been introduced out of moral considerations, global emissions will actually be lower. Thus, counterintuitive compared to standard economic theory, permit trade restrictions may actually be good for environmental quality.

There are several ways to follow up this study. First, different formulations of the moral concerns than the ones we considered in this paper are of course possible. However, we believe that we covered two simple, though realistic and interesting, cases: one that leads to a higher level of environmental quality and one that leads to a lower level of environmental quality. Secondly, a tempting task is to relate the first practical experiences with international emission allocations by governments, such as the first two phases of the EU ETS and the Kyoto agreement, to our theoretical results. In particular, it would be interesting to disentangle moral motivations for imposing limits on access to permit trading from strategic price manipulation motives. Our theoretical results might provide a reference framework to do empirical tests comparing actual negotiation outcomes with results from simulations models of permit trading markets for distinguishing between the different motivations.

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Appendix A. The benefit function

A general abatement cost function frequently used in the literature is:

$$C(a)$$

Abatement, a, is defined as the difference between the business-as-usual emissions $\overline{e}$ and actual emissions e, i.e., $a=\overline{e}-e$. Where business as usual (BAU) emissions are defined as emissions in absence of environmental regulations.

It is usually assumed that this cost function has the following properties (see, e.g., Golombek and Hoel, 2005):

$$C^a \equiv \frac{\partial C}{\partial a} > 0; \quad C^{aa} \equiv \frac{\partial^2 C}{\partial a^2} > 0$$

Abatement costs are defined as the difference in benefits between the business-as-usual and actual emission level

$$C(a) = C(\overline{e}-e) = B(\overline{e})-B(e)$$

which defines a benefit function:

$$B(e) = B(\overline{e})-C(a)$$

We assume that benefits of emissions are such that an interior solution to the firm's maximization problem always exists. Thus,

$$B^e \equiv \frac{\partial B(e)}{\partial e} = C^a > 0$$

$$B^{ee} \equiv \frac{\partial^2 B(e)}{\partial e^2} = -C^{aa} < 0$$

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