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Abstract

This article discusses domestic climate policy design in a country that has made a binding commitment to the Kyoto Protocol but at the same time want to limit the number of industry shutdowns that follows from the policy. It is furthermore considered how public budget constraints might affect climate policies.

The similarities between an optimally-designed taxation regime and a domestic tradable permit regime that is integrated into the international permit market are brought into focus. The similarities presuppose a greenhouse gas tax that fluctuates in accordance with the international permit price. It is argued that climate policy can generate double dividends, but that the allocation of free permits reduces these dividends.

It is concluded that some organisations promotion of systems tradable permits, with distribution of permits free of charge, as an alternative to carbon taxes must be understood from their effect on income distribution. [*]

[*] The paper is to a large extent based on an article, Holtsmark (1999), written in Norwegian and prepared for presentation at a seminar held by the Norwegian Ministry of Finance in November 1998. I gratefully acknowledge Lynn P. Nygaard's translation to English. Valuable comments on the Norwegian article from Cathrine Hagem, Michael Hoel and Jon Vislie were also appreciated.

Contents

Chapter 1
BACKGROUND AND RESEARCH QUESTIONS

The Kyoto Protocol sets quotas for the emission of greenhouse gases in 38 industrialized countries for the period of 2008 – 2012. The agreement, however, is flexible in that it opens for emissions trading. A joint implementation mechanism and the Clean Development Mechanism will supplement the "ordinary" market for permits.*

The topic of this paper is climate policy design in the 38 industrialized countries with set quotas. The analysis assumes that the Kyoto Protocol is ratified by a sufficient number of states to enter into force. The two main cost–effective climate policy options are a regime based only on greenhouse gas taxes or domestic markets for emission permits. The paper compares and evaluates these two options, taking into account that the public sector has budgetary constraints and that there are costs related to the generation of public funds that are higher than unity, cf. Ballard and Fullerton (1992). The analysis emphasizes the importance of accommodating the public sector's budget limitations in the design of climate policy.

If domestic permit markets are established, they can be integrated into each other and thereby constitute an international permit market. If permits are freely tradable across national boundaries, the permit prices would have to be the same in the different domestic markets. This would also be a cost–effective solution because it ensures that the marginal costs are the same in all countries, and also between different enterprises within each country. This article compares this type of international system with a cost–effective domestic tax systems. The systems' abilities to generate double dividends are compared, and the concept of double dividend itself is re–examined. Finally, the paper discusses under what conditions the allocation of free permits can hinder firm closure.

This article does not attempt to enter into a general discussion of instruments for mitigating environmental problems, such as that we find in Hoel (1998). Rather, it compares certain aspects of tradable permit and taxation regimes as instruments in the compliance with the requirements of the Kyoto Protocol. The article further dis-

*The Kyoto Protocol states that industrialized countries with an emissions quota may acquire additional permits from other industrialized countries by financing specific emissions-reducing measures in these countries. This is called joint implementation. The protocol also established the Clean Development Mechanism, which is designed to be a tool for allowing industrialized countries to also acquire permits by financing specific emissions-reducing measures in developing countries.

cusses how these instruments should be designed in a situation with a well–behaving international permit market.

The article is structured as follows: Chapter 2 presents a model of a country with only a domestic greenhouse gas tax and no domestic permit market. An international permit market is nevertheless assumed to exist, and the country's government is assumed to be trading in this market. Chapter 3 introduces the notion of behavior into the model and suggests an optimal tax rule on greenhouse gas emissions given the requirements of the Kyoto Protocol and the existence of an international permit market. Chapter 4 adapts the model to a scenario with a domestic permit market that is integrated into the international permit market. Chapter 5 re–examines the notion of double dividends. Chapter 6 looks at the relationship between free permits and firm closure. Finally, chapter 7 provides some concluding remarks.

Chapter 2
THE BASIC MODEL

The model presented in this and the next chapter presupposes that we are studying a state with both a private and a public sector, but where only the private sector acts as the source of greenhouse gas emissions. In the first scenario presented, only the government acts in the international permit market, while the private sector is cut off from such trading and instead pays a greenhouse gas tax to the state. This is called the "taxation regime." In contrast, chapter 4 looks at a scenario in which private firms may also participate directly in the international permit market and where the greenhouse gas tax is replaced by an obligation to acquire permits on the market in order to have the right to emit gases. This is called the "permit regime".

The models aim to incorporate, in a simple way, the costs of generating public funds into the model. This is achieved by letting the value added generated by production in the private sector be affected negatively by the amount of revenue the public sector takes out of the private sector on top of the revenue generated from the greenhouse gas tax.

Leaving aside for the moment the issue of behavior, which will be discussed in the next chapter, the model of the taxation regime is as follows:

$$V = \pi_p + \pi_o \tag{2.1}$$
$$\pi_p = v(e) - \lambda R - te - R, \; v'(e) > 0, \; v''(e) < 0, \; \lambda > 0 \tag{2.2}$$
$$\pi_o = te + R - pq \tag{2.3}$$
$$\pi_o \geq G \tag{2.4}$$
$$q = e - q_K \tag{2.5}$$

The following variables are defined:

V	National welfare indicator
π_p	Private sector profit
π_o	Public sector net income
p	Permit prices on the international market
q	Amount of imported greenhouse gas permits
e	Domestic greenhouse gas emissions
q_K	National quota of greenhouse gas emissions in the Kyoto Protocol
t	Tax rate for greenhouse gas emissions, including the fiscal tax, t_F
t_F	Fiscal tax on greenhouse gas emissions
R	Other revenue from the private sector
λ	Marginal excess burden of taxation
G	Required public sector net income

Equation (2.1) provides the total income in the economy from both private and public sources, that is, the sum of profit/net income in the private and public sectors. Equation (2.2) calculates the profit in the private sector. The two first terms, $v(e) - \lambda R$, together represent the value added in the private sector. The sector's product is the numéraire. The value added is expected to increase with increasing emissions; the more that is produced, the more gases that are emitted. With this simple modeling, emissions cannot be reduced in any other way than through changes in the amount produced. The model has nevertheless not eliminated the possibility of abatement through cleaning technology, transition to renewable energy sources, etc. Such measures would also incur a cost in the form of resource use, that is, less final production overall.

A central aspect of the model is the stipulation that $\lambda > 0$, that is, the assumption that if the public sector takes out additional revenue from the private sector on top of the revenue from the greenhouse gas tax, there will be less final production. Behind this formulation lies an assumption that the public income generated by the private sector must come from taxes, which then causes a loss of efficiency. Equation (2.2) thus incorporates the loss of efficiency through taxation. The term λ represents the increased loss of efficiency through increased revenues, i.e. the marginal excess burdens of taxation. The expression $(1 + \lambda)$ thereby represents the marginal costs of public funds. The loss of efficiency through taxation is incorporated in a highly simplified way. The model should therefore be applied with caution. Hoel (1997) describes a more general version of a comparable model. Ringius et al. (1998) apply a numerical model based on the same concept.

It is important to emphasize that the formulation of the model does not obscure the fact that taxation of greenhouse gases, just like other similar taxes, can create losses of efficiency. In fact, efficiency loss from taxation of greenhouse gas emissions is included explicitly in this model. This theme will be discussed further in the next chapter.

The last two terms in equation (2.2), $-te - R$, reflect that public revenue generated in the private sector must be subtracted from the value added in the private sector to calculate the sector's profit after tax.

Equation (2.3) represents the total public sector income and expenses, which are the sum of the greenhouse gas taxes and other revenue from the private sector, less expenses incurred through governmental purchase of permits abroad. Equation (2.4) represents the public budget constraint, where G is an exogenous variable. Equation (2.5) represents the Kyoto Protocol's emission constraint, given the possibility of unrestricted trade in permits.

Chapter 3

THE NOTION OF BEHAVIOR, AND DESIGNING AN OPTIMAL TAXATION REGIME

The model is based on two assumptions about behavior. The first is that the private sector maximizes its profit through changes in e without taking into consideration how this behavior affects the behavior of the public sector. Thus in concrete terms, $\pi_p = v(e) - te - (1+\lambda)R$ is maximized with respect to e without taking into account that the changes in e can affect R or t through the public budget constraints. This behavioral assumption is built on an "invisible hand" reasoning, since the private sector actually comprises a large number of actors. Since each of these actors on its own represents only a small part of the whole, the assumption is that they will behave as if their individual behavior will have little or no effect on the behavior of the public sector.

The private sector's optimization problem gives the first order condition $v'(e) = t$, an equation that results in the decision rule:

$$e = e(t), \quad e'(t) < 0 \tag{3.1}$$

with the accompanying maximum profit of $\pi_p(t, R) = v(e(t)) - te(t) - (1+\lambda)R$. As described above, the loss of efficiency through taxation of greenhouse gas emissions is made explicit in the model. The first order condition above reflects this. To what extent a domestic tax on greenhouse gases actually results in a loss of efficiency or corrects for market failure will not be discussed here. The issue is addressed in Bohm (1997).

The second behavioral assumption applies to the government, which maximizes the national welfare indicator V with respect to the policy tools t and R, subject to the behavior of the private sector, the public budgetary constraint, and the requirements of the Kyoto Protocol as defined by equation (2.5). The government thus maximizes the function $V^*(t, R) = v(e(t)) - \lambda R - p(e(t) - q_K)$. It is nevertheless simpler to solve the optimization problem if we here recall that:

$$R = \pi_o - te(t) + p(e(t) - q_K) \tag{3.2}$$

cf. equations (2.3) and (2.5). The optimization problem can then be formulated as follows:

$$\begin{aligned}\max_{t,\pi_o} V(t,\pi_o) &= v(e(t)) - \lambda te(t) - \lambda\pi_o - (1+\lambda)p(e(t) - q_K) \\ s.t.\ \pi_o &\geq G\end{aligned}$$

Let the shadow price associated with the constraint be μ. The Lagrange function can then be defined as follows:

$$L(t,\pi_o) = v(e(t)) - \lambda te(t) - \lambda\pi_o - (1+\lambda)p(e(t) - q_K) + \mu(\pi_o - G)$$

This then results in the following first order conditions:

$$\frac{\partial L(t,\pi_o)}{\partial \pi_o} = -\lambda + \mu = 0 \tag{3.3}$$

$$\frac{\partial L(t,\pi_o)}{\partial t} = v'(e(t))e'(t) + \lambda(e(t) + te'(t)) - (1+\lambda)pe'(t) = 0 \tag{3.4}$$

>From equation (3.3), we see that $\mu = \lambda$. Since there is a positive excess burden of taxation, that is $\lambda > 0$, as described in (2.2), the shadow price of the budget constraint is thus positive, and therefore binding, in other words, $\pi_o = G$.

Rewriting (3.4) gives:

$$v'(e)e'(t) + \lambda(e(t) + te'(t)) = (1+\lambda)pe'(t) \tag{3.5}$$

Equation (3.5) is well suited to illustrate what happens when the greenhouse gas tax is increased. The equation could perhaps, however, be easier to understand if we first imagine for a moment that there is no excess burden of taxation, that is, that $\lambda = 0$. Equation (3.5) then leads to:

$$v'(e)e'(t) = pe'(t) \tag{3.6}$$

The left–hand side of equation (3.6) expresses the reduced value added in the private sector as a result of increased greenhouse gas taxes. The right–hand side of the equation represents the reduced costs of permit buying as a result of the increase in the greenhouse gas tax, since an increase in the tax results in reduced domestic emissions and thereby allows room for reducing the purchase of permits. The simplified first order condition states that the greenhouse gas tax must be set so that the marginal cost in the form of reduced value added in the private sector must be equal to the marginal dividend in the form of reduced costs of purchasing permits abroad.

It is, however, more realistic to continue to assume that $\lambda > 0$, and therefore return to equation (3.5). This first order condition reflects that domestic emissions not only provide foundation for value added but also public revenue, and takes into account that this revenue can be recycled into the economy and thereby generating efficiency gains. On the other hand, increased domestic emissions must be answered by purchases of emissions permits abroad, and costs associated with this purchase must be incorporated in the public sector budgets. We thus see that the right hand side is multiplied by the marginal costs of public funds $(1 + \lambda)$. We must remember here that the regime in question is one where the state undertakes the purchase of permits on the international market. Purchasing of permits must thus be financed by public budgets, which must therefore absorb the extra costs in addition to the direct nominal costs. The left–hand side of the equation also includes a term that does not appear in equation (3.6). This term reflects that an increase in greenhouse gas taxes changes the revenue inflow and therefore necessitates the increase or reduction in other distortionary taxes. In theory it is uncertain whether increased greenhouse gas taxes provide increased or reduced revenue. A change in the revenue inflow must in any case be multiplied by the marginal costs of public funds regardless of whether the term is positive or negative.

Formulas (3.5) and (3.1) comprise two equations that determine t and e as functions of p. Without further simplification, it is not possible to find an explicit expression for e and t as functions of p. With some reformulation, we can nevertheless derive the following implicit expression for the correct emissions tax, t^*:

$$t^* = p + t_F \tag{3.7}$$

$$\text{where } t_F = -\frac{\lambda}{1+\lambda}\frac{e(t_F+p)}{e'(t_F+p)} > 0. \tag{3.8}$$

These implicit expressions are useful for illustrative purposes, but do not provide an explicit solution since we see that $e'(t)$ and $e(t)$ are included on the right side. We can nevertheless see from equation (3.7) that the tax should be equal to the international permit price plus a surcharge, t_F. We furthermore see that if we solve the optimization problem again, but without the Kyoto restriction, the tax will be exactly t_F, which we can call the fiscal greenhouse gas tax. (Without the Kyoto requirement, the right side of equation (3.5) must be zero.) Thus with the Kyoto requirement, the greenhouse gas tax must be equal to the international permit price plus a fiscally determined surcharge. This is analogous to the findings described in Sandmo (1975), which demonstrates that taxes on objects with negative environmental consequences essentially should have one fiscal element and one element reflecting the environmental damage. In the model described in this article, Sandmo's environmental problem is replaced by a national restriction on emissions. In principle, this difference is non–essential. Regardless, there is a shadow price stemming from an environmental problem.

The conclusion to be drawn from the above is not, however, that (3.7) and (3.8) demonstrate that the Kyoto Protocol should encourage a tax increase in an amount equal to the international permit price. As pointed out earlier, (3.7) and (3.8) are not explicit solutions. We see from (3.8) that the fiscal element of the tax must be changed when the Kyoto Protocol is implemented, unless coincidentally $e(t)/e'(t)$ is constant when t is changed. Furthermore, in reality the marginal costs of public funds may also change somewhat with changed tax revenue, but it is reasonable to assume that these changes are so small that we can ignore them here. The changes in $e(t)/e'(t)$ resulting from changes in the greenhouse gas tax can, however, be significant. How large these changes are and in what direction they pull will not be discussed here. The model used here is too simple to be able to be used for a quantitative assessment of the relationships between a Kyoto–based and a fiscally based tax on the same tax object.

Implicit in the discussion above is that the size of the national quota has no impact on domestic policy design. It is the international permit price that is influential. This is readily apparent from the rules of behavior developed above, where the Kyoto quota q_K does not appear in any of the behavioral expressions, cf. (3.1) and (3.5). If the greenhouse gas tax is set in accordance with the rule expressed in (3.7), it would be an improbable coincidence for domestic emissions to be equal to the Kyoto quota.

In the discussion above, it was ignored that the fluctuation in the international permit price is problematic for a taxation regime. Only when the domestic greenhouse gas tax fluctuates in accordance with this price will the domestic climate policy be cost–effective. In principle, there is probably nothing wrong with letting the tax fluctuate in this way, just as the central bank lets its different interest rates fluctuate to, among other things, reflect changes in the international financial markets. It would, however, be an innovation to let a tax fluctuate in this manner. It is possible that the establishment of a domestic permit market would imply a greater harmonization with the international permit market. Domestic permit trade will be discussed in the next chapter.

Chapter 4
ADJUSTING THE MODEL FOR DOMESTIC AND INTERNATIONAL PERMIT TRADE

As an alternative to taxation, the government in the country we are studying can establish a domestic market for trade in permits. Letting this domestic permit market become an integrated part of an international market would increase the chances of achieving a cost–effective distribution between domestic abatement and import of permits. At the same time, the danger of weakening the market's efficiency through market powers is reduced. The domestic government can create the market by establishing a law stating that all entities must acquire permits corresponding to their greenhouse gas emissions.*

The analysis below builds on the assumption that firms can freely buy and sell permits on the international market, but also that they are allocated a certain number of permits free of charge, q_g, from the national government. The government is allocated a quota q_K through the Kyoto Protocol.

In an isolated domestic permit market, the government must auction or sell off the permits that are not distributed free of charge. There is, however, no reason to hold national auctions if there is a well–behaving permit market at the international level. In this case, the government can simply sell the permits through a permit exchange, which is likely to be established eventually. If permits are not allocated free of charge to domestic actors, the government can then sell its entire allotment of permits on the exchange.

The following discussion looks at adapting the model from the two preceding chapters. First, the notion of behavior of the private sector is taken into account. As demonstrated above, even without a Kyoto Protocol it is fiscally prudent to tax greenhouse gas emissions, as seen in (3.8). Allowing free trade in permits would therefore result in the following profit function for the private sector:

$$\pi_p = v(e) - (1 + \lambda)R - t_F e - p(e - q_g) \tag{4.1}$$

Let (4.1) replace (2.2) and (2.5). Maximization of π_p with respect to e thus results in the first order condition $v'(e) = t_F + p$, which provides a new decision rule

*It would probably be far more practical to include distribution companies in the permit market instead of all of the individual emissions sources, households in particular. That it probably is impossible in practice to include all gases/sources will, for the sake of simplicity, be overlooked here.

to replace (3.1):

$$e = e(t_F + p) \tag{4.2}$$

Since the private sector must itself ensure that enough permits are acquired to correspond to its own emissions, the government, as mentioned above, can sell all of the permits it has been allotted in accordance with the Kyoto Protocol, with the exception of those that it has received free of charge. As a replacement for (2.3), the public sector's income is now calculated as follows:

$$\pi_o = t_F e + R + p(q_K - q_g) \tag{4.3}$$

The first two terms on the right-hand side of (4.3) do not require further explanation. The third term is public sector income through the sale of emissions permits.

The model for the permit regime thus far comprises (2.1), (4.1), (4.3), (2.4), and (4.2). The behavior of the public sector must also be determined: The government maximizes the welfare indicator $V = \pi_p + \pi_o$ with respect to the policy tools t_F, q_g, and R. We can easily see from (4.3) that:

$$R = \pi_o - t_F e(t_F + p) - p(q_K - q_g). \tag{4.4}$$

It is reasonable to presuppose that the number of free permits must not be negative. The optimization problem for the public sector can thus be formulated as follows:

$$\begin{aligned} \max_{t_F, \pi_o, q_g} V(t_F, \pi_o) &= v(e(\cdot)) - \lambda(\pi_o - t_F e(\cdot) + pq_g) + (1+\lambda)pq_K - pe(\cdot) \\ s.t.\ \pi_o &\geq G \\ q_g &\geq 0 \end{aligned}$$

Again, let the shadow price associated with the budgetary constraints be μ and the shadow price associated with the free permits be ω. The Lagrange function can then be defined as follows:

$$L(t_F, \pi_o, q_g) = v(e(\cdot)) - \lambda(\pi_o - t_F e(\cdot) + pq_g) + (1+\lambda)pq_K - pe(\cdot) + \mu(\pi_o - G) + \omega q_g$$

This results in the following first order conditions:

$$\frac{\partial L(t_F, \pi_o, q_g)}{\partial \pi_o} = -\lambda + \mu = 0 \tag{4.5}$$

$$\frac{\partial L(t_F, \pi_o, q_g)}{\partial t_F} = v'(e)e'(\cdot) + \lambda(e(\cdot) + t_F e'(\cdot)) - pe'(\cdot) = 0 \tag{4.6}$$

$$\frac{\partial L(t_F, \pi_o, q_g)}{\partial q_g} = -\lambda p + \omega = 0 \tag{4.7}$$

As in the taxation regime, it follows from (4.5) that the public budgetary constraint is binding, that is, that $\pi_o = G$. From (4.7) we see that $\omega = \lambda p$, and because $\lambda > 0$ the other constraint is also binding, that is, we see that no permits should be allocated free of charge, provided that is a positive extra cost from the taxation.

Without any significant changes in (4.6), we get:

$$v'(e(\cdot))e'(\cdot) + \lambda(e(\cdot) + t_F e'(\cdot)) = pe'(\cdot) \tag{4.8}$$

This first order condition resembles (3.5). On the right-hand side we can see that the costs associated with permit purchases are no longer multiplied by the marginal costs of public funds $(1 + \lambda)$. This corresponds to the fact that the import of permits is now financed by the private sector, so that the extra costs of public financing are eliminated. On the other hand, we see that the negative term in the parentheses on the left-hand side is now $t_F e'(\cdot)$, while the comparable term in (3.5) is $te'(\cdot) = (t_F + p)e'(\cdot)$. A term equal to the extra tax cost associated with permit import, which disappeared on the right–hand side, is thus also removed from the left. Thus in a permit regime, increased taxation, with reduced permit import as a result, would likely provide a less effective dividend because import expenses would no longer be financed by public budgets. But at the same time, increasing the taxrate would result in a smaller revenue effect domestically because the taxrate now is smaller than in the taxation regime.

Equation (4.8) can be reformulated to get:

$$t_F = -\frac{\lambda}{1+\lambda}\frac{e(t_F + p)}{e'(t_F + p)} > 0 \tag{4.9}$$

This equation is identical with equation (3.8) from the taxation regime. When we then establish that the extra cost of taxes λ and the international permit price p are the same in the two regimes, we can conclude that the size of the fiscal tax t_F is the same in the permit regime and the taxation regime. Thus we can also establish that both regimes result in the same behavior both in the public and private sectors, as seen in (3.1), (3.7), and (4.2). The introduction of a domestic permit market that is linked to the international market will, in other words, result in exactly the same behavior in the private sector as was the case in the taxation regime. It is also easy to demonstrate that the need for any other revenue, that is, the size of R, becomes the same as in the taxation case. Insertion of the expression $t = t_F + p$ in equation (3.2), and insertion of $q_g = 0$ in (4.4) results in R being the same size in both cases.

It might seem counterintuitive that the degree of domestic abatement, and thereby the net permit import, is identical in the taxation and permit cases. In the taxation case, purchasing of permits is financed through public budgets, and the real cost of the permits is thus the permit price plus the excess burden of tax funding. If the permits are purchased by the private sector, as in the permit case, the excess costs related to public funding are eliminated. The reason why the degree of abatement is the same in the two cases is that, as pointed out in the discussion of (4.8), the revenue effect of adjusting the domestic tax at the margin is reduced comparably.

Let us now summarize the conclusions drawn from this and the preceding chapters. The previous chapter analyzed the design of climate policy in a regime using domestic taxation, but no trading of permits within national boundaries. The government, however, would be free to buy and sell permits on the international market. I have called this the "taxation regime". Optimization in the taxation regime resulted in, in addition to a fiscally based greenhouse gas tax, the existence of an extra levy equivalent to the international permit price.

This chapter has addressed an analogous case where the fiscal greenhouse gas tax is retained, but with the addition of a commitment to acquire permits corresponding to the actual emissions being imposed on all actors emitting greenhouse gases. These actors must acquire emissions permits through trading, although governments may distribute a number of permits free of charge. In this "permit regime," governments put all of their allocated permits up for sale on the international permit market, although reserving the option to distribute some of them to domestic actors at no cost. The optimization in the permit regime resulted in the retaining of the fiscal tax and setting it at the same level as that derived in the taxation case. Thus the private sector's marginal abatement cost in these two regimes is the same, suggesting that likewise the behavior of the private sector in both regimes will be the same. It was also demonstrated that these two regimes would generate the same amount of public revenue, given that no permits are distributed free of charge. The greater the number of free permits, the lesser the public income. Dividends from the recycling of revenue, or "double dividends," which will be discussed in the following chapter, are consequently reduced by the distribution of free permits. Thus in theory, the economic cost of complying with the Kyoto Protocol is the same in the two regimes, under the condition that no permits are allocated free of charge. Distribution of free permits increases the costs of being in compliance with the Kyoto Protocol.

Chapter 5
CAN CLIMATE POLICY RESULT IN DOUBLE DIVIDENDS?

The concept of double dividends in association with environmental policy has been a frequent topic of discussion in the economic literature, a discussion that seems to generate more confusion than it alleviates. A clarifying and thorough summary of the debate is provided in Bohm (1997). Part of the reason for the confusion is perhaps that the term "double dividend" suggests that there are no socioeconomic costs associated with achieving environmental policy goals, such as the Kyoto Protocol. I will return to this shortly, but first I will examine the term more closely.

As far as I have been able to establish, Pearce (1991) can be credited with the first usage of the term "double dividend" in relation to environmental taxes. David Pearce's article should therefore form a central focus for the debate. His main point was actually quite simple. He compared characteristics of a carbon tax with direct regulation, which until that point had been the traditional environmental policy approach, and he pointed out that a carbon tax has the significant advantage of generating public income. Pearce reminded us that this income could be used to reduce existing distortionary taxes and levies, which would in turn increase economic effectiveness. Thus according to Pearce (1991), environmental taxes provide two dividends: one environmental and one in the form of public revenue that can be used to reduce existing fiscal taxes that impair inefficiency — a "double dividend".* By this definition, the existence of double dividends should not be any more controversial than the existence of a marginal excess burden of taxation. The actual size of the additional costs of taxes is, as is well known, difficult to estimate, but there is a good foundation for assuming that it is significantly positive, as described in, for example, Jorgenson and Yun (1993).

In the years after 1991, there has been considerable debate about the existence of double dividends. What seems to have been partially forgotten in this discussion is that Pearce used the term in a comparison of a carbon tax with direct regulation to achieve the same level of abatement. Pearce's point was that direct regulation

*Ligthart and van der Ploeg (1999) point towards the fact that several European authors define the second dividend in terms of increase in employment and/or reduced unemployment. Ligthart et al. (1999) also give the impression that Pearce (1991) used the 'term double dividend' "in the sense that both environmental quality and employment rise." Pearce (1991) did however not claim that revenue recycling should have any effects on employment or unemployment.

would result in at least the same level of costs to achieve the same abatement as a carbon tax regime, but that unlike carbon taxes, it would not generate any public revenue. Pearce's definition thus suggests that a carbon tax could provide a double dividend only in a relative sense, i.e., in comparison to direct regulation, but not in an absolute sense. Because many appeared to overlook these nuances, we have had a long discussion about whether emissions reductions could provide an economic dividend in an absolute sense, even when the environmental dividends are not taken into account. This is what Goulder (1995) calls "strong double dividends", but what Pearce (1991) never claimed existed.[†] When one sticks to Pearce's definition of the term it is actually quite obvious that double dividends exist and are of great importance in environmental policy.

Naturally, however, many have concluded that "strong double dividends" generally do not exist. This is also a kind of contradiction. If a carbon tax were to provide an economic dividend, without even taking into account reduced global warming, then one can conclude that the tax system must have been poorly designed to begin with. That is to say, a tax reform should have been implemented irrespective of the greenhouse problem. When we say that strong double dividends exist, we thus take into account the benefits derived from two reforms: one fiscal reform and one environmental reform. A recent analysis of fiscal and environmental tax reforms and various types of "dividends" is found in Bovenberg and van der Ploeg (1998).

One of the reasons that such a comprehensive debate about double dividends arose in the first place was perhaps that Pearce (1991) made a point of saying that carbon taxes could generate a great deal of public revenue in absolute terms. This has been questioned by several authors, including Bovenberg and de Mooij (1994) and Parry (1994). The reason for the doubt is that carbon taxes could potentially weaken other sources of revenue, particularly because carbon taxes would result in higher prices for consumers and thus result in reduced return on labor. Thus, reduced supply of labor could be the result, with the accompanying weakening of the public budget. As Bohm (1997, 1998) points out, abatement through direct regulation would also reasonably be expected to weaken existing revenue sources if a carbon tax would do so. Bohm (1997) as well as Bovenberg and van der Ploeg (1998) casts doubt on whether a carbon tax would end up weakening other revenue sources. Regardless of whether Pearce (1991) actually overrated the absolute revenue dividend of a carbon tax, he did not overrate the revenue dividend relative to direct regulation.

The reason why the concept of "double dividend" seems to have created so much confusion is probably because it gives a false impression of environmental policy being costless. It is important to acknowledge that there are also costs associated with achieving environmental goals. Pearce's point was that these costs could be reduced considerably if instruments that generate public income were employed, and

[†]A "strong double dividends" is an impossibility in the model used in this paper. In such a case, the fiscal tax t_F that maximized the welfare indicator V could not have been set optimally in the first place.

if this income were used to reduce existing fiscal taxes and levies. If this is included in the calculation of the costs of climate policy, the cost estimates would be adjusted downward, but they would not be eliminated, as for example described in Ekins (1995). Instead of using the term "double dividends," it might be more useful here to use the more intuitive concept of "benefits from revenue recycling," as described in Goulder (1995).

Chapter 6
FREE PERMITS: EFFECT ON FIRM CLOSURE

This chapter addresses the correlation between free permits and firm closure. Let us look at a single firm in the private sector that has the profit:*

$$\pi_i(e_i, t_F, p, q_{gi}) = v_i(e_i) - t_F e_i - p(e_i - q_{gi}) \tag{6.1}$$

For the permits that are not free of charge, the firm pays the international permit price p. Profit maximization gives $v_i^{'}(e_i) = t_F + p$. We see that the number of free permits does not affect behavior. Emissions are determined only by the fiscal tax and the international permit price. Let e_i^* be the level of emissions that satisfies this first order condition. In other words, e_i^* is the optimal level of emissions for firm i also from a social point of view.

The aspect of time must be mentioned here. All of the variables are seen as flow variables. This means that, for example, e_i represents emissions per unit of time, q_{gi} represents free permits per unit of time, π_p profit per unit of time, etc. Strictly speaking, all of the variables should have had a subscript depicting the period of time. For the sake of simplicity, that has not been done here. No other changes apart from the ones discussed here are expected to take place over time. The issues of discounting and uncertainty, etc., thus become irrelevant.

Assume that the criteria for a firm to receive free permits remain unchanged over time and are known — for example, based on 1990 emissions. It can similarly be assumed that the number of free permits allocated in every subsequent period is based on a fixed percentage of a firm's emissions in 1990, and that such permits are allocated irrespective of production development or possible closure. The firm can thus close down and thereby sell all of its permits for all future periods, which would result in a constant income flow equivalent to pq_{gi} from the point of closure.

Assume that we are at the point in time when the permit market is established. The firm thus receives new operating conditions and closes down if:

$$\pi_i(e_i^*, t_F, p, q_{gi}) \leq pq_{gi}$$

*We look at the profit as a flow, that is, profit per unit of time. The permits have a lifetime of one unit of time. For the sake of simplicity, we will ignore the effects of taxes and levies other than greenhouse gas taxes.

which is equivalent to

$$v_i(e_i^*) - t_F e_i^* - pe_i^* + pq_{gi} \leq pq_{gi}$$

We can nevertheless see that pq_{gi} appears on both sides of the inequality sign. The term can thus be eliminated from both sides and we get a criterion for closure that is independent of the extent to which free permits are distributed. Free permits, in other words, do not have any effect on the extent of firm closures.[†]

Meeting these closure criteria is in line with a cost-effective climate policy. If one attempts to hinder such closures, a cost-effective allocation of abatement measures is not achieved. The closures that do occur should be considered cost-effective climate measures.

In its mandate to the Norwegian Commission on a domestic market for greenhouse gas emission permits, the Norwegian parliament, *Stortinget*, has stated that it will limit the sales of free permits after firm closure. To observe the effects of such a system within the model used here, let us assume that the free permits are allocated as long as production is maintained. From the time that production is stopped, no more free permits will be issued. In that case, the criterion for closure is as follows:

$$v_i(e_i^*) - t_F e_i^* - pe_i^* + pq_{gi} \leq 0$$

Here we see that free permits appear only on the left-hand side and thus make a difference. Such a criterion for closure would hinder firm closure. However, this also hinders firm closures that, at least within the framework of this model, should have taken place from a social point of view. The point is that the permit price represents the shadow price of greenhouse gas emissions in a country that has agreed to comply with the Kyoto Protocol. If a firm cannot operate profitably given a well-behaving permit market, it is unlikely that it can be beneficial in social terms.

There can, of course, be other circumstances that would mean that private profitability and a social surplus in the case of an unrestricted permit market may not always correspond. There are a number of conditions that are not incorporated in the simple model applied here and that can in fact lie behind the reason that *Stortinget* in fact wishes to place restrictions on the sale of free permits. One such condition, to give an example, might be a desire to maintain special cornerstone industries because they are considered to play an important role in population settlement patterns, etc. The model used in this article is not designed to take into account such political reasons for limiting the number of firm closures in relation to what an unrestricted permit market would lead to. If cost-effectiveness is the main concern, it should

[†]See also Koustaal (1997), who also discusses to what extent the allocation of free permits to existing firms can constitute a hindrance to the establishment of new firms.

nevertheless be pointed out that a system allowing the distribution of free permits that cannot be sold upon closure has two downsides:

First, there would no longer be a cost-effective distribution of abatement. In practice, the system would be no different than a kind of production subsidy with the downsides that such support implies. This element is made clear in the model used above.

A second problem, one that can't be clarified by the model, is that the concept of firm closure is not all that straightforward. No employees and no production is hardly a practical criterion for achieving the desired objective. In that case, firms would be able to maintain their permits with only one employee and minimal production. Nevertheless, the term "closure" has to be defined in one way or another. It can be difficult to avoid these definitions becoming an invitation to industries to undertake adaptations that may be irrational for society as a whole. This would imply social costs.

Stortinget's desire to prohibit further sale of the free permits after closure would have worked well if the firms in question had only two options: either maintain production and employment at current levels or close down. Because most firms in practice can choose from a wide range of middle-ground options, this type of restriction on trade can have unfortunate consequences.

It has also been proposed that permits could be allocated for a limited period of time, thus avoiding the allocation of new free permits to firms that have closed down by the beginning of the next period. This would allow the use of free permits to limit the number of closures without putting restrictions on the permit market. This is a readily apparent solution, but it does not, however, avoid the problems of reduced cost-effectiveness, adaptation to the definition of closure, etc., as described above. The longer the time period the permits are allocated for, the smaller these problems will be. But also the weaker the desired effect will be, namely fewer closures. In addition, the commitment is long, and the value of the free permits that are allocated would be great. Thus public budgets are weakened for a comparable period of time.[‡]

Finally, it must be pointed out that a system of free permits contingent upon continued production is clearly distorting in terms of competition and thus perhaps would be seen as illegal within the EEA area, as discussed by Koutstaal (1997). If free permits are to be compatible with the intentions of EEA regulations, they must be distributed unconditionally, that is, not contingent upon future production — but then they would no longer have, as described above, any effect on the number of closures.

[‡]The market for tradable sulfur permits in the USA is mainly based on free permits. They were allocated on the basis of past emissions for a period of 35 years, without restrictions on the right to re-sell after closure.

Chapter 7
CONCLUSION

The first part of this article presented a simple theoretical model to study the optimal tax on greenhouse gas emissions in a country that has agreed to comply with the Kyoto Protocol, but that continues to use taxes to regulate domestic emissions. Given the existence of a well-behaving international permit market, it was demonstrated that the government should place an environmental tax on greenhouse gas emissions, on top of a fiscal tax, and that the environmental tax should be equal to the permit price on the international market. In addition, it was demonstrated that the introduction of the Kyoto-based environmental tax should encourage the government to adjust the level of the fiscally based tax. The environmental tax must fluctuate in accordance with the international permit price to ensure cost-effectiveness. However, it is debatable whether such a system is practical and suitable.

The fourth chapter of this article looked at the establishment of a domestic market for tradable permits that would be integrated in the international permit market and compared this to a taxation regime. It was argued that the public sector should provide just as strong incentives to undertake abatement in a permit regime as in the taxation regime. If this is indeed the case, then a regime with tradable permits would result in the same behavior in the private sector as would the taxation regime. It was further maintained that given cost-effectiveness considerations, free permits should not be allocated because they allow less room for tax relief and thereby would reduce double dividends. Free permits allocated on the basis of past emissions would not change the behavior of the private sector as long as the free permits were also freely tradable and distributed without restrictions contingent upon, for example, firm closure.

The notion of double dividends was also discussed, and it was shown that double dividends, as the term was originally defined, would undoubtedly be generated by a cost-effective climate policy. This suggests that a greenhouse gas tax, as well as tradable permits, would reduce the economic costs of complying with the Kyoto Protocol's requirements compared to direct regulation, which does not provide public revenue. The point is that the public revenue generated by a greenhouse gas tax, or tradable permits, could be used to reduce other existing, distortionary taxes, and thus provide better resource utilization in the economy. However, it was also argued that, regardless of policy design, there is a significant overall cost associated with meeting climate objectives. If this were not the case, then the policy should have been implemented regardless of the Kyoto Protocol. In that case, the fiscal taxes cannot have been correctly set in the first place and a fiscal tax reform should be called for.

Free permits were originally proposed to hinder closure of vulnerable industrial firms with large greenhouse gas emissions. It was nevertheless argued that such a system does not hinder closures as long as the permits are freely tradable and the allocation criteria are stable and based on, for example, past emissions. In this case, the lifetime of the permit also has no effect on decisions to close down. Finally, it was discussed whether making allocation of free permits contingent upon continued production would help hinder closure, but it was argued that this would lead to the prevention of closures that would have actually been socioeconomically sound. A number of problems that would occur if allocation of free permits were used as a tool for hindering closure were also discussed. Such a scenario would risk the development of, in economic terms, an unsound industrial structure adapted to regulations for allocation of free permits.

We have concluded that as far as economic efficiency is concerned domestic emissions trading and emissions taxes are very similar tools in national climate policy. Both these tools could give rise to a costefficient allocation of abatement efforts. Nevertheless, tradable emissions permits are promoted by private enterprises in several countries. This preference for tradable permits can't therefore be explained from efficiency reasons. It is consequently natural to understand the preferences in light of the policytool's distributional aspects. The key element here is the possibility for distribution of permits free of charge: While emissions taxes have to be paid by all emitters, the distribution of permits free of charge could turn out be an important element in tradable permit regimes. Distribution of permits free of charge would mean a redistribution of income *from* taxpayers in general, for example the households depending on how the free permits are funded, *to* private enterprises. This distributional aspect of the two policy tools that have been analyzed in this paper might be important in order to understand the manufacturing industries promotion of tradable permits and their resistance against corresponding taxes.

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