Joint Meetings of Tax and Environment Experts

THE TAX TREATMENT OF EMISSION TRADING TRANSACTIONS - A Graphical and Illustrative Analysis

Meeting: 1 June 2012

This document is submitted to Delegates to the Joint Meetings of Tax and Environment Experts FOR DISCUSSION under item 7 of the Draft Agenda for their meeting to be held on 1 June 2012.

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NOTE FROM THE SECRETARIAT

This paper builds on the literature review of the tax treatment of emission trading transactions presented at the Joint Meeting of Tax and Environment Experts in November 2011 (COM/ENV/EPOC/CTPA/CFA(2011)36). That paper noted there is very little literature that examines how tax treatment affects the ability of emission trading schemes to achieve a given emission reduction at least cost. Some of the tax issues identified in that earlier paper are investigated in this paper using a graphical analysis and illustrative case examples.

This paper begins with a theoretical analysis of the functioning of emission trading markets. After having briefly reviewed the main potential sources of inefficiency, the tax treatment of emission trading transactions is introduced. For analytic purposes, the income tax treatment of permit transactions and of abatement costs is first analysed separately, and then combined. A graphical and illustrative case analysis examines tax treatment in various settings: static and dynamic, price-taker and price-maker firms, and harmonised and non-harmonised rates.

It is planned to eventually combine the analysis developed in this paper with the critical literature review presented in the earlier paper and to publish the final product in the OECD’s Tax Policy Working Paper series.

FOR THE MEETING, Delegates are invited to provide comments on the paper, its conclusions, the potential areas of future work outlined, and the plan for eventual publication.
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THE TAX TREATMENT OF EMISSION TRADING TRANSACTIONS - A GRAPHICAL AND ILLUSTRATIVE ANALYSIS

1. Introduction

1. Alongside environmental taxes, one of the main market-based instruments for limiting harmful emissions is systems of tradable emission permits. A number of cap-and-trade systems are currently in operation, such as the European Union Emission Trading Scheme, the US Sulphur Dioxide Emission Allowance Trading Program, and the New Zealand Emission Trading Scheme. Cap-and-trade systems are also being piloted, planned or considered in a number of other jurisdictions including Australia, California, China, and Korea.

2. An important literature discusses the economics of emission trading systems – see recent contributions by Tietenberg (2006), Smith (2007) and Kaplow (2010). By contrast, the level of attention devoted to the taxation of such markets has to date been relatively thin. This paper attempts to address this gap by providing a graphical analysis and some illustrative cases showing how the income tax treatment of emission trading transactions affects the efficiency of emission markets in reducing emissions at least cost. The analysis finds the potential for a tax-induced abatement displacement effect.

3. The paper is divided in two parts. The first describes how emission trading works from a microeconomic point of view. It explains how an emission trading system is aimed to achieve a fixed emission reduction objective by exploiting the lowest-cost opportunities for abatement. At the market equilibrium point, where permits supply equals the demand, the marginal cost of abatement is also equalised among all emission sources involved in the trading scheme. There is a brief review, however, of issues that in practice can impair the efficiency of an emission trading system. Then, in the second part, income taxation is introduced, so that its impact on the functioning of an emissions market can be identified by means of graphical and illustrative case analyses. For analytic purposes, the income tax treatment of permit transactions and of abatement costs is first analysed separately, and then combined. A graphical and illustrative case analysis examines how different tax treatments can impact firm behaviour and abatement choices and, ultimately, the allocative efficiency of the system. Tax treatment is considered in various settings: static and dynamic, price-taker and price-maker firms, and harmonised and non-harmonised rates.

4. In general, the analysis concludes that if income from sale of permits is taxable and costs of emission abatement and of buying permits are deductible, all at the same tax rate, and this treatment (including the rates) is symmetric across participants in the trading system, taxation would not be expected to impact the efficiency of the emission trading market in promoting abatement at least cost. It explores, however, how various asymmetries (e.g. in tax recognition of costs and revenues, or in rates) could impair market efficiency. The analysis points out several types of asymmetries that merit future study and notes various factors that could influence the scale of efficiency impacts.

2. The implications of emission trading at micro-economic level

5. In this first section, the basic functioning of an emission trading scheme is explained. A theoretical emission trading system is first examined in a static setting (Section 2.1). Then, the changes in its working principles in a dynamic setting are introduced (Section 2.2). A tree diagram is used to summarise the decisional margins and situations faced by a firm operating in a cap-and-trade system.
2.1 Firm behaviour in a static context

6. In this section the functioning of an emission trading system is explained using a framework which illustrates its cost-effectiveness property. The situation of a single firm is analysed, then the abatement choices of two firms facing different marginal abatement costs (MACs) are investigated.

7. In a cap-and-trade scheme the regulator makes a number of pollution permits available to polluters. Each permit provides the participants in the scheme with the legal right to release one unit of pollution. This initial allocation reflects the policy objective of keeping pollution, e.g. CO$_2$ emissions, below a certain threshold level – the cap. The government can auction the permits or allocate them for free. Each polluter is allowed to produce emissions equal to the amount of permits owned, and has to abate the remaining emissions, namely the amount corresponding to its business-as-usual emissions less allocated permits. If the polluter abates more than the required, it will be left with unused emission permits, which it can sell (or save for use in the future). Vice versa, if the polluter abates less than the required abatement level, it will have to buy permits from other participants in the scheme to cover its emissions. Depending on the decisional margin we are looking at, the firm may face either an explicit cost (if it is considering to buy a permit) or an opportunity cost of polluting (if it is considering to sell a permit).

8. At the level of the emission trading system, two preliminary steps are required. First, the regulator must set the optimal level of pollution – the cap. The overall required abatement level ($RA_{tot}$) for the regulated sectors is the difference between business-as-usual emissions (the amount that would be emitted in the absence of a cap) and the cap, the total number of allocated permits. Second, a number of permits corresponding to the emission cap must be allocated to the polluters, who will later trade them.

9. These two steps are strictly connected. Stringency of the cap is needed in order to create both a market and a positive price. In other words, the number of permits allocated must be smaller than the projected level of emissions, in order to avoid over-supply and dramatic price collapse. An emission trading system works in a way which enables it to reach any given cap at the least cost, whether or not the cap is efficient from an environmental point of view.

10. Once the regulatory authority has established a cap and allocated permits, firm decisions can be analysed as an exercise of either cost minimisation or profit maximisation; both approaches ultimately give the same result. In the following analysis, the functioning is described by looking at cost minimisation.

11. The required abatement level ($RA_j$) for firm $j$ is given by $E_j - AP_j$, the difference between its business-as-usual emissions level ($E_j$) and its allocated permits ($AP_j$). The firm chooses the optimal (actual) abatement level $A_j$ by minimising the abatement total cost (ATC), solving a problem structured in this way:

$$\min_{A_j} ATC_j = \sigma \times (E_j - AP_j - A_j) + C(A_j)$$

with

$$RA_{tot} = \sum_j (E_j - AP_j) = \sum_j RA_j \quad (1)$$

12. We can hypothesise that a firm’s cost of abatement has the following functional form $^2$

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$^1$ The required abatement level is equal to the emission reduction objective: both refer to the same emission quantity, which according to the allocation of the overall cap needs to be abated by the firm.

$^2$ Since the MAC function is the first derivative of the abatement cost (AC) function, such functional form is equivalent to assume MAC=$\alpha A$. An AC function having the form $\alpha A^a$ would instead have been consistent with MAC=$\alpha A^{a-1}$. Adopting a similar functional form would have created computational difficulties in the numerical examples, and for this reason the linear functional form was adopted.
13. The firm will buy or sell permits if there is a positive or negative difference between the required abatement level and its actual abatement level. The abatement total cost (ATC) is represented by the sum of the amount paid to buy permits on the market at the price $\sigma$ (or received on permits sold) and of abatement cost $C(A_j)$.

14. In order to solve this optimisation problem, the first derivative of the abatement total cost ATC with respect to the abatement variable A has to be computed. This derivative is equal to zero at the minimum, and then the optimal abatement is the level satisfying this condition

$$\frac{\partial ATC}{\partial A_j} = -\sigma + C'(A_j) = 0$$

where the first derivative of the abatement cost function shown in (2) is equal to

$$C'(A_j) = \alpha_j A_j$$

15. The equation in (4) shows the marginal abatement cost, that is to say the cost associated with abating an additional emission unit, for example the $n+1$ unit after the first $n$ units abated. This functional form reflects the hypothesis of linear marginal abatement costs, according to which the cost is increasing with abatement in a linear way ($\alpha$ coefficient), so that the first emissions abated are cheaper than the last ones. The coefficient $\alpha_j$ is a representation of how expensive abating emissions is for firm $j$. Substituting the functional form (4) in the optimisation solution we obtain

$$\alpha_j A_j^* = \sigma \rightarrow A_j^* = \frac{\sigma}{\alpha_j}$$

16. The condition in (3) – calculated in (5) for a specific functional form – means that the firm will abate up to the point where its marginal abatement cost equals the permit price. If the marginal abatement cost is lower than the permit price, it will be cheaper for the firm to abate than to buy permits. On the contrary, if the marginal abatement cost is higher than the permit price, the firm will find it cheaper to buy permits than to abate.

17. The term in the round brackets in the cost minimisation equation (1) represents the market demand for permits by firm $j$, $PD_j$ (Permit Demand). In the least cost solution, permit demand can be obtained by substituting the optimal abatement level shown in (5).

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3 For the sake of simplicity, in this analysis separability is assumed between the maximisation of firms’ profit related to choosing the optimal production level (and corresponding emissions) and the cost minimisation associated with abating emissions. In particular, initial emissions are assumed to be the result of firm profit maximisation before the introduction of emission trading. It is not taken into account how abating emissions affects the production costs and the output level.
\[ PD_j = E_j - AP_j - A_j(\sigma) = E_j - AP_j - \frac{\sigma}{\alpha_j} \]  

(6)

18. The firm \( j \) may be a seller or buyer, depending on the value of the parameters in equation (6). In particular, a firm will buy permits if \( PD_j > 0 \), which corresponds to

\[ (E_j - AP_j) > \frac{\sigma}{\alpha_j} \]  

(7)

whereas it will sell the permits it was allocated (by auction or grandfathering) if the opposite condition holds \( (PD_j < 0) \). In this framework there is a price \( \sigma_{AP} \) at which the firm has a permit demand equal to zero: in equation (7) it is equal to \( \alpha_j(E_j-AP_j) \). This means that at the price \( \sigma_{AP} \) the firm based on its MAC will find it convenient to abate exactly the required abatement level, and it will use only the allocated permits. This price is the dividing line for the firms between assuming a selling or a buying behaviour. It will be different for each firm, and be greater i) the greater is the \( \alpha \) coefficient (i.e., the firm-specific abatement cost), ii) the greater are initial emissions, and iii) the smaller is the initial permit allocation.

19. The effect of different price levels on the market behaviour of a firm is shown in Figure 1. On the x-axis the amount of abatement \( A \) is shown (corresponding emissions \( E \) can be read in the opposite direction). Abatement is measured starting from business-as-usual emissions \( E_j \), corresponding to an abatement level equal to zero. On the contrary, the abatement level \( A_0 \) represents full abatement of business-as-usual emissions produced by the firm, corresponding to emission level \( E_0=0 \). The allocated permits \( AP_j \) will cover the emission quantity corresponding to the distance \( E_0AP_j \). The required abatement level is given by the distance \( 0AP_j \). The sum of the required abatement levels for each firm \( j \) is equal to the total required abatement level \( RA_{tot} \), and the regulator sets the total number of permits to be allocated in order to ensure the achievement of this abatement level. The firm may abate an amount exactly equal to the required abatement level, or it may continue to emit more emissions than allocated permits and buy permits. In this case another firm would have to abate more than its required abatement level, and sell permits. In this way \( RA_{tot} \) will be achieved. At price level \( \sigma_{AP} \) the firm will use only allocated permits and not buy or sell. In fact, its MAC is lower than the permit price \( \sigma_{AP} \) up to the point \( AP_j \), implying that it will abate up to that point in order to meet the required abatement level. When the price is \( \sigma_j \) (lower than \( \sigma_{AP} \)), then the firm will decide to abate up to where its MAC equals the price, corresponding to the quantity \( OA_1 \), and it will need to buy permits of quantity \( A_1AP_j \) in order to cover residual emissions (required abatement not realised). On the contrary, when the price is \( \sigma_2 \) (greater than \( \sigma_{AP} \)), the firm will have a permit surplus equal to \( AP_jA_2 \) which it can sell.
20. As shown by the result of the minimisation problem and by Figure 1, firms choose the demand for permits by abating any emissions for which the marginal abatement cost is less than the permit price level, and then buying permits if there is a shortfall and selling them if there is a residual. Given the assumption that abatement gets progressively more expensive, the first emission reductions exploit the cheaper abatement options, whereas for further emission reductions the firm may be willing to pay the permit price since their abatement cost is higher.

21. The equilibrium in the emission trading market will now be analysed, explaining how the solution of each cost minimisation problem at firm level allows the emission trading system to reach the least cost solution for achieving a given abatement target. Figure 2 illustrates how, according to the cost-effectiveness criterion, the marginal abatement costs is equalised among all the installations covered in an emission trading system (Montgomery, 1972). This result is achieved whether permits are allocated for free or auctioned. Further details about this issue will be provided in section 3.1.

22. Figure 2 shows that polluters with high marginal abatement costs participating in an emission trading system will purchase permits from those with low marginal abatement costs. The simplified illustrative case depicted in the figure shows a cap-and-trade system composed of only two firms. The total of their individual abatement levels (measured in opposite directions on the x-axis) equals the total required abatement level \( A_{\text{tot}} \) satisfying the cap established by the regulatory authority\(^4\). Abatement levels \( RA_1 \) and \( RA_2 \) represent the required abatement levels for firm 1 and 2, which have different MACs. The least cost solution is given by the intersection of MAC\(_1\) and MAC\(_2\), setting a market clearing price and optimal abatement levels \( A^*_1 \) and \( A^*_2 \). It can be verified from the figure that any other set of abatement decisions would lead to a greater total cost (area below the two MACs). Firm 1, having the higher MAC, will be a permit buyer, whereas firm 2, having a lower MAC, will be a permit seller. Each firm would

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\(^4\) The two marginal costs depicted in the figure might belong to different firms within the same group, firms owned by different companies in the same sector, or firms in completely different sectors.
compare its own abatement costs with the market price and determine whether it is profitable to abate more than the required abatement level and sell permits, or abate less and buy permits to cover the additional emissions.

**Figure 2. Optimal abatement allocation between two firms with different MAC**

23. Figure 2 represents the case in which the MACs of the two firms 1 and 2 determine the market clearing price. Such firms are called price-makers, for their ability to influence price with their abatement choices. Using equation (6) for permit demand, the market clearing permit price $\sigma^*$ is obtained when the net demand for permits is equal to zero (positive permit demand plus negative permit demand). The following equation sums up permit demands for firm 1 and 2 ($PD_1$ and $PD_2$) and equals the sum to zero, in order to derive the equilibrium price

$$E_1 - AP_1 - \frac{\sigma}{\alpha_1} + E_2 - AP_2 - \frac{\sigma}{\alpha_2} = 0 \quad \rightarrow \quad \sigma^* = (RA_1 + RA_2) \frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2} = \frac{A_{tot} \alpha_1 \alpha_2}{\alpha_1 + \alpha_2}$$

(8)

24. The permit demand of each firm ($PD_j$) can be computed substituting in equation (6) the equilibrium price $\sigma^*$

$$PD_j = E_j - AP_j - \frac{\sigma^*}{\alpha_j}$$

(9)

25. At the price $\sigma^*$ the permit demand of firm 1 (buyer firm) will be exactly equal to the negative permit demand (permit supply) of firm 2 (seller firm). A firm will be a price-maker in any case where the number of permits it buys or sells is sufficient to have an appreciable influence on the market price.
26. The case in which two firms are price-takers can also be analysed. A firm can be a price taker for two main reasons. First, the quantity that they trade is too low to influence the equilibrium price, which might be typical in a large market like the EU ETS. Second, permit price is fixed by the regulatory authority through a cap or floor mechanism set, for example, at the level of a carbon tax levied on other sectors not participating in the emission trading.

27. Two firms that are price-takers will still make their abatement decision by minimising total cost at the exogenously given price $\sigma^*$. According to equation (5) their optimal abatement level will be represented by $A_j = \frac{\sigma^*}{\alpha_j}$. Permit demand will then be set according to the equation (9). The main difference with the price-makers case is that the price $\sigma^*$ is not the one ensuring the equality of positive and negative permit demands of the two firms\(^5\).

2.2 Firm behaviour in a dynamic context

28. In the real world, emission trading systems are implemented in a multi-period (or dynamic) setting. This means that heterogeneous firms have to achieve the required abatement levels in different periods. Two different cases may be distinguished in the dynamic setting. In the first situation, in each period the emission cap has to be respected by firms, and permit trading is allowed only inside the period. In the second situation, emission permits are not limited in use to the period for which they are issued but can be traded through time. Specifically, firms can “bank” excess permits issued from one period and use or sell them in a subsequent period, and “borrow” permits from a future period allocation for use in the current period.

29. In the first case (dynamic setting without banking and borrowing), emission trading is implemented in different periods, but each period is stand-alone with respect to the achievement of the period-specific total abatement level. The total required abatement level can be set each period as an increasing percentage of initial emissions – i.e. the cap becomes tighter from one period to the next. In this case, the equilibrium price would increase from one period to the next. This would be likely to provide a strong long-term signal for investment in abatement, such as the adoption of low carbon production technologies.

30. In the first case, from a theoretical point of view, the cost minimisation problem described in equation (1) is solved in each period $t$. Given the tightening cap, the price level will increase in time, and additional abatement units will become profitable each period in the least cost solution for each firm assuming that MAC is constant.

31. In the second case (dynamic setting with banking and borrowing), each period in which emission trading is implemented is connected to the others, due to the possibility for firms to achieve the period-specific required abatement level using permits from previous or future periods. Again in this case, if the cap is tightened from year to year, the equilibrium price would rise from year to year. Various situations may make firms willing to bank permits for future use, such as expectations that the cap will be tightened (putting upward pressure on permit prices) or that marginal abatement costs will be higher in the future. On the contrary, firms may wish to borrow permits if marginal abatement cost are expected to be lower in the future, or output prices to be higher (so that the firm will have additional resources available to invest in abatement).

\(^5\) However, it could still be case that given the exogenously given price and their MACs, the two firms choose to trade permits exactly up to the point where the two permit demands are equalised. This case is examined in the illustrative case analysis in Section 5.
Banking and borrowing levels are strictly connected to the permits allocated to firms, as shown in Figure 3. In the dynamic case with banking and borrowing, a firm choosing to pollute less than its current permit allocation, will not only be able to sell the permits to a different firm. It will also have the possibility of banking the surplus permits for later use or sale. On the other hand, a firm polluting more than its permit allocation will not only be allowed to buy permits from another firm. It will also have the option of borrowing permits that it will be allocated in a later period. In this case, the cumulative deficit would have to be repaid by the last period of the emission trading system.

Figure 3. Illustration of banking functioning

33. The cost minimisation problem in equation (1) can still be used to derive the dynamically cost-effective solution when banking and borrowing are allowed. Nevertheless, relevant changes would be needed (Chevallier, 2012; Rosendhal, 2008; Stranlund et al., 2005). The banked and borrowed quantities should be included in the cost minimisation equation, and they would constitute a new optimisation variable. In particular, banked and borrowed quantities should depend on the current and projected equilibrium price, on the required abatement levels and on the relative slope of the MAC function (namely, the $\alpha_j$ coefficient). The final result would be an inter-temporal abatement solution which minimises total costs taking into account the optimally chosen banking and borrowing levels.

34. Stranlund et al. (2005) introduce a model of an emission trading system that lasts several periods. Assuming that $AP_{0j}$ is the number of emissions permits that firm $j$ holds at the beginning of the period (index 0, as opposed to the end of period, for which index 1 is used). The choice about how many permits to purchase ($PD_{ij}>0$) or sell ($PD_{ij}<0$) is linked to the firm marginal abatement cost function, $C'(A_{ij})$ as shown in equation (3). If the emissions at the end of the period ($E_{1j}$) exceed the number of permits allocated $AP_{0j}$, the firm will have a positive permit demand and will be a buyer, according to equation (7). If after having included this positive permit demand, emissions are still above the firm’s permits holding, then the firm is not buying enough permits on the market and it is rather borrowing permits ($BP_{ij}>0$). If instead the emissions at the end of the period ($E_{1j}$) are below the permit allocation $AP_{0j}$, the firm has a negative permit demand and is a seller. If after having subtracted the supply of permits (negative permit

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6 A variety of reasons may exist for which a firm does not buy on the market all the permits needed to cover the difference between its required abatement level and actual abatement. In particular, a firm may prefer borrowing permits from its future allocation due to current high prices which are projected to decrease, or to high transaction costs.
demand), emissions are still below permits holding, then the firm is not selling all permits on the market and it is banking some permits ($BP_{ij}<0$). In both cases, after the amount of permits borrowed or banked ($BP_{ij}$) is added to the actual abatement ($A_{ij}$) plus the permit demand ($PD_{ij}$, negative or positive), the required abatement level is obtained ($E_{0j} - AP_{0j}$). In the case of a borrowing firm, this is shown in the following equation

$$RA_j = E_{0j} - AP_{0j} = A_{ij} + BP_{ij} + PD_{ij}$$  \hspace{1cm} (10)

35. In the case of a banking firm, equation (10) is better interpreted as showing that the actual abatement exceeds the required abatement of a quantity equal to the permits made available for sale (negative permit demand) plus the permits banked.

36. The quantity banked and borrowed in the current period by firms may affect their required abatement levels in the next period ($RA_{t+1}$) relative to their value net of banking or borrowing ($RA_t$). In particular, for a banking firm, the required abatement level decreases by the banked amount of permits if it keeps banked permits for its own use and does not sell them. By contrast, the required abatement level increases by the borrowed amount for a borrowing firm. Both effects are summarised in equations (11)

If borrowing in period $t$ \rightarrow $RA_{B} = RA_{t+1} + BP_t$

If banking in period $t$ \rightarrow $RA_{B} = RA_{t+1} - BP_t$

37. Based on the functioning of the minimisation problem described above, the possibility to bank and borrow permits will affect the optimal abatement level and the equilibrium price in each period. This will happen both whether banked permits are banked for future own use or to be sold. For this reason, banking and borrowing can be considered a useful tool to deal with uncertainty in the future emission threshold – the cap – and consequently in the price level, but also a potential source of inefficiency, in particular with respect to the chosen abatement levels. The consequences of banking and borrowing are analysed in further detail in Section 3.2.

2.3 A graphical summary

38. Figure 4 shows a decisional tree illustrating the principal contexts which may face a firm involved in an emission trading system and the different options (decisional margins) available to it. Different decisional margins become relevant according to the context in which the firm operates, for example if emissions could increase in the future or emissions per unit of output could be reduced. Since under cap-and-trade systems abatement and permits are substitutes – namely, permits are the vehicle with which capped firms transfer among themselves abatement obligations – firms’ choices have a dual characterisation. In particular, a decision to abate on the margin can correspond to selling or not buying a permit. Likewise, a decision not to abate corresponds with not selling or buying a permit.

39. Building on a representation provided by the IEA (2001), the relevant decisional margins for a potential seller are shown in the left-hand side of the diagram

1) Sell or Surrender (i.e., not abate)
2) Sell or Bank
3) Bank or Surrender
40. As shown in equation (6), a firm will decide to sell permits or use them for compliance based on its MAC, the allocated permits and the price level. These three variables are key elements of the different decisional contexts shown in Figure 4. The choices of price-maker firms will influence the market clearing price. The decision on banking is taken according to the principles described in Section 2.2.

41. By contrast, the right-hand side of the diagram includes the relevant decisional margins for a potential buyer

1) Buy or Abate
2) Buy or Borrow
3) Abate or Borrow

Again, for the first decisional margin the choice is determined based on equation (6). The reasons why a firm may be interested in borrowing are explained in Section 2.2.

42. In contrast to price-makers, price-taker firms will choose among the relevant margins taking the price as given. Although the conditions are different, the decisional margins are the same for price-maker and price-taker firms.

43. In Figure 4 the different decisional contexts are identified with a letter, while the decisional margins are shown by reference to the numbers above. The decisional tree in Figure 4 is relevant to both the static and dynamic settings. In the static setting, only decisional margins 1 and 4 are relevant, whereas in the dynamic setting all decisional margins 1-6 are applicable.

**Figure 4. Decision tree for a firm participating in an emission trading system**

44. The decisional margins (3) and (6) may be relevant both in the first decisional context of the diagram (context A), and in the last one (context C). In fact, a firm can decide to bank or borrow permits even if it does not have an emission level below or above the level of allocated permits (context A). This decision of banking or borrowing permits instead of surrendering them or abating emissions may be aimed
at taking advantage of speculative opportunities. This choice may be created by expectations regarding the stringency of the cap in the future, future emission permits prices or future abatement costs. For example, assume that permits prices are currently low and projected to increase. Looking at the decisional context C on the left-hand side, the driver for a decision to bank instead of surrender may not be an abatement higher than the required level, and then a surplus of permits as a consequence of this choice. The firm can in fact choose to become a net buyer in the current period in order to set aside some permits to be sold in the future at a higher price, in order to make a profit. Similarly, looking at context C on the right hand side, a firm may prefer abating beyond the level to which abatement cost equals permit price in the current period instead of borrowing permits. This would happen if marginal abatement costs are projected to increase.

3 Inefficiencies

45. While the efficiency properties of an emission trading scheme can be demonstrated in a simple model like that developed above, even without taxation, there are a number of system features that can interfere with efficiency. This section analyses some sources of inefficiency in an emission trading scheme without taxation. It does not, however, provide an exhaustive description of all the potential sources of inefficiency. For example, the coverage of the scheme in terms of firms and sectors participating is another element affecting the overall efficiency that is not investigated here.

3.1 The allocation of permits

46. The regulatory authority has many options for setting the initial allocation of permits. For example, under an output based allocation rule, firms receive an amount of free permits proportional to some historic production level, perhaps that for a specified baseline year. It is also sometimes referred to as grandfathering. Output based allocation could soften the price signal provided by the market, since firms can be considered as receiving a form of subsidy protecting their historical emissions relative to new entrants or other firms whose production is growing.

47. On the other hand, under auctioning, participants in the emission trading system have to buy permits (either from the government or other participants) for the emission level associated with their actual production. This allocation method is very different from grandfathering with respect to the liability rules imposed on firms. While auctioning increase the financial burden on firms, with grandfathering only emissions exceeding the historical levels incur a financial liability in the form of payments for additional permits.

48. It is a general principle of emission trading systems that initial allocation does not affect the functioning of an emission trading system, and the cost minimisation process according to which the firm make the marginal decision to abate vs. to buy or sell permits. Tietenberg (2006), however, shows that whether permits are auctioned or freely distributed can affect the overall cost-effectiveness of the cap-and-trade system. This is due to several reasons. The opportunity to recycle revenue from permit auctioning can reduce welfare costs by reducing existing tax distortions or funding other socially beneficial policies. Entry barriers can also arise in sectors that received permits under a cap-and-trade systems based on historical emissions, since no permits will be available for new entrants. The criterion for free allocation may be favourable to large firms, providing them with market power and thus affecting the functioning of a competitive emission trading market. Finally, transaction costs in trading permits may have a relevant role, both in sharpening the distortions associated with free allocation and in impeding the auctioning mechanism from working efficiently.

49. Stavins (2008) also notes that another disadvantage of grandfathering is that high emission industries are provided with a higher share of permits compared with more efficient industries, and may have windfall gains when their production level changes. This is likely to be the reason why, for example,
in the EU ETS it has been decided that best practice benchmarking will be used in the Third Phase (2013-2020), according to which industries will receive free permits based on the best practice emission reference level for their sector rather than their historical emissions.

3.2 Banking and borrowing

50. The rules for banking and borrowing differ among existing cap-and-trade schemes. Briefly describing them in the major existing programs may be helpful to understand their functioning and the potential sources of inefficiency. For example, banking is allowed in the U.S. Sulphur Dioxide (SO2) Emission Allowance Trading Program. The two phase structure of the program created the incentive to bank since the marginal cost of abatement in Phase II was expected to be higher than that for Phase I. During Phase I (1995–1999) of the program over 30% of the total allocation of SO2 permits were banked.

51. In the EU ETS, banking and borrowing are permitted within each phase. Unsurrendered (banked) permits are valid for compliance only for the remaining years of the phase. According to Alberola and Chevallier (2009), the underlying reason could be that the European Commission did not want to transfer market imperfections from the “warm up” period (Phase I) to the period of commitment under the Kyoto Protocol (Phase II). This inflexibility is likely to increase price volatility, because since surplus permits will have zero value after the end of each phase, as the end of a phase approaches, some participants may be willing to sell permits at any price, causing sharp price declines. This is what happened at the end of Phase I.

52. Ellerman and Montero (2007) show that allowing banking in the early phases of a cap-and-trade program is likely to produce a sort of voluntary “early action” if there is an expectation of increases in the stringency of the cap. This may have positive implications also from the environmental point of view, since emissions are reduced when concentrations are high. Moreover, the flexibility introduced by banking and borrowing is important and may also favour market overall functioning, distributing abatement efforts in time and helping to prevent over-demand from making abatement capital excessively expensive (Tietenberg, 2006). The possibility of banking permits will also help avoid the necessity to use permits when relatively inexpensive abatement options remain available (IEA, 2010).

53. On the other hand, Rubin (1996) and Chevallier (2012) point out that borrowing may also produce negative effects, such as aggravating environmental damage by a concentration of the emissions over specific periods. In fact, when the cost of respecting the emission cap is particularly high, firms can use banked or borrowed permits instead of abating emissions in the current period. Tietenberg (2006) suggests using a threshold on borrowing to avoid this effect or introducing increasingly stringent emission reduction objectives.

3.3 The firm decision about the location of the producing activity

54. An emission trading system could create incentives for a firm to move its production to a location outside the area covered by the regime and thereby avoid the additional costs imposed by the regime. Various variables drive relocation decisions, as for example the presence of uncertainty in policy decisions, such as the stringency of the cap, and the availability of abatement technologies.

55. This issue may be related to the decisional problem both of a multinational firm deciding where to locate its production in order to maximise profits, and of two firms producing the same product in a competitive market, one operating in a jurisdiction where emission trading is implemented and the other not. A relocation of production as a result of such competitiveness pressures may be problematic in two senses: the increase of emissions from unregulated sources offsets the reductions under the sources covered by the emission trading program, and production location decisions are distorted, potentially reducing
overall economic output. To counteract such effects, among the potential solutions that have been proposed (IEA, 2010) are

- allocation of permits for free to more exposed sectors; and
- border adjustment measures which attempt to include imported products in the emission trading scheme and restore a level playing field with respect to domestic production.

3.4 Enforcement costs

56. Enforcement effort is a crucial variable for ensuring that an emission trading system effectively achieves its objective. Tietenberg (2006) notes that the enforceability of an emission trading program may affect its overall evaluation, in the sense that a less cost-effective program could become preferred on the basis of its smaller enforcement costs.

57. The enforcement of a cap-and-trade program establishes a marginal cost of non-compliance for firms. In particular, the cost is equal to the likelihood a violation is detected multiplied by the corresponding sanction. In order to achieve complete compliance, it is fundamental to ensure that both the sanction per unit of excess emissions and the expected cost of non-compliance (associated with the probability of being audited and found noncompliant) are higher than the permit price (marginal cost of compliance). Very often firms self-report their emission levels, and the regulatory authority supplements this information by cross-checks, usually monitoring the flows of fuels used by firms. Different kind of violations can occur (Stranlund et al., 2005). If a firm under-reports its emissions a reporting violation occurs. On the other hand, a permit violation occurs when a firm holds insufficient permits to cover its emissions, after having included borrowing (if allowed).

58. The possibility of banking and borrowing complicates the monitoring system needed to ensure that an emission trading system is enforced properly. In particular, the regulatory authority has to implement credible mechanisms to ensure that the use of borrowed permits is offset through future emission reductions (Stavins, 2008).

59. Non-compliance is likely to have a perverse effect on permit prices. When firms are non-compliant, permits demand is reduced, and the emission price decreases. In this way a less effective price signal is provided to other firms participating in the emission trading system.

4 The impact of taxation on allocative efficiency

60. The analysis developed in Section 3 described several design and implementation issues which may affect the cost-effectiveness of an emission trading market, such as the allocation method and the possibility of banking and borrowing. This Section examines how the tax treatment of emission trading transactions could induce firms to disregard cost-effective abatement options.

61. The first subsection covers the key taxation issues. For more details on these issues, the earlier literature review paper (COM/ENV/EPOC/CTPA/CFA(2011)36) may be consulted. In the second subsection taxation is included in the abatement cost minimisation problem developed in Section 2.1, referring to the three key issues identified in the paper above.

4.1 Key taxation issues

62. The earlier literature review (COM/ENV/EPOC/CTPA/CFA(2011)36) focused on the corporate income tax treatment of a variety of transactions involved in markets for tradable emission permits: permit
acquisition, surrender to the regulatory authority to meet compliance obligations, the sale of permits, and
the treatment of emissions abatement activities for which permits are a substitute.

63. An expansive notion of the relevant transactions was adopted in order to highlight that the tax
treatment of permits and abatement costs need to be analysed jointly in order to appropriately investigate
the impacts of direct taxation on allocative efficiency. This is the same approach followed in this paper,
which concentrates on three main issues: the taxation of income from permit sale; the deduction of permit
acquisition costs; and the deduction of abatement costs. This is consistent with the main issues identified
by Copenhagen Economics (2010) and the Joint Committee of Taxation (2009), and discussed in detail in
the earlier literature review.

64. A key issue is whether the tax treatment of permits and costs influences decisions on abating or
emitting, and selling or buying permits, implying a deviation from the minimum cost solution which
should be the output of a properly functioning cap and trade system. This effect could potentially occur
within a tax jurisdiction or between different tax jurisdictions. The tax-induced abatement displacement
may also be associated with capitalisation effects, so that the tax differentials are reflected in the permit
price (Kane, 2011).

65. The following analysis illustrates that when there is taxation of income earned (and deductibility
of costs incurred) in emission trading markets, under certain conditions, a wedge may be introduced
between the market clearing permit price and marginal abatement cost, affecting the cost of achieving the
fixed abatement target. Each firm will adjust its behaviour to reach the point where its marginal after-tax
cost of permits equals its marginal after-tax cost of abatement. Direct taxation differences between firms or
countries may affect the least-cost order of abatement, even when the pre-tax permit price is the same.

66. The graphical and numerical examples in Section 5 demonstrate that because of the possible
influence of the tax treatment, abatement opportunities with high resource costs may be chosen, while
relatively cheaper abatement opportunities may be disregarded. As a result, the usual emission trading
incentives for taking cost-effective abating and purchasing decisions may be reduced.

4.2 Taxation effects on cost minimisation

67. This subsection provides a stylised model for the incorporation of tax treatment into the
abatement total cost minimisation problem introduced in Section 2.1. Three cases are introduced, which are
later analysed in the graphs and illustrative cases.

68. The taxation of income from permit sale and the deduction of permit acquisition costs are
assumed to be at the same tax rate, \( \tau_T \). They can both be introduced in the framework set by equation (1),
since it potentially represents both a seller and a buyer firm. For the seller firm the perceived price will be
decreased by the tax rate on income from sale, whereas for the buyer firm it will be decreased by the rate
of the deduction for acquisition costs. For this initial case, it is assumed that unlike permit costs, abatement
costs are not deductible. As a consequence, the cost minimisation problem is set as follows

\[
\min_{A_j} ATC_j = \sigma \times (1 - \tau_T) \times (E_j - AP_j - A_j) + C(A_j)
\]

(12)

69. The first order condition for the abatement total cost minimisation is given by
According to the least cost solution, the firm will compare its MAC – given by the functional form in (4) – with the net-of-tax price in order to choose its optimal abatement. Since the price decreases with respect to the no-taxation case, the optimal abatement level will decrease as well. If the firm is a seller, it will reduce the abated quantity and the surplus of permits available for sale will decrease. If the firm is a buyer, it will also reduce the abated quantity and it will demand more permits.

The deduction of abatement costs can be included in equation (1) at a rate $\tau_D$. In this case, we assume for the moment that gains on permits are not taxable and that permit acquisition costs are not deductible. In this case, the cost minimisation in equation (1) changes in the following way

$$\min_{A_j} ATC_j = \sigma \times (E_j - AP_j - A_j) + C(A_j) \times (1 - \tau_D)$$

In this case, the first order condition is given by

$$\frac{\partial ATC_j}{\partial A_j} = -\sigma + C(A_j) \times (1 - \tau_D) = 0$$

$$C(A_j) \times (1 - \tau_D) = \sigma$$

In this case, the net-of-tax MAC will be compared with the price to choose the level of abatement. Since the marginal abatement cost is decreased by taxation, then a higher abatement level will be chosen at a given price. If the firm is a seller, the quantity of permits for sale will increase, whereas if it is a buyer, the permits purchased will decrease.

It seems more realistic, however, to assume that the abatement cost deduction is combined with the taxation of income from permit sale and the deduction of acquisition costs. Assume that $\tau_D = \tau_T$, namely the two rates are harmonised. The harmonised rate is equal to $\tau$ in the following equation, where both changes to equation (1) introduced in equations (12) and (14) apply

$$\min_{A_j} ATC_j = \sigma \times (1 - \tau) \times (E_j - AP_j - A_j) + C(A_j) \times (1 - \tau)$$

The first order condition is given as usual by the first derivative with respect to $A_j$

$$\frac{\partial ATC_j}{\partial A_j} = -\sigma \times (1 - \tau) + C(A_j) \times (1 - \tau) = 0$$

$$C(A_j^*) = \sigma$$
76. Equation (17) shows that if the tax rates are harmonised, no effect on the optimal abatement quantity is observed with respect to the no-taxation case. This result will be confirmed by the graphical and illustrative cases analysis.

77. The framework developed in equations (5)-(7) on the conditions determining a seller or buyer behaviour remains valuable in the taxation case, and it is also applied to compute the figures shown in the illustrative cases.

5 Illustrative cases

78. The following graphs and illustrative cases will show that the whole set of decisional margins for firms shown in Figure 4 is potentially affected by the tax treatment of emission permits and abatement costs. The aim of the following graphical and numerical analysis is also to provide a reference, complementary to the paper COM/ENV/EPOC/CTPA/CFA(2011)36, for a better understanding of the literature review included in it.

79. Many existing studies (Copenhagen Economics, 2010; Joint Committee on Taxation, 2009; Yoram, 2009) do not devote much attention to the fact that different tax characterisations of permits may affect a firm’s marginal decision to abate or emit, and its behaviour on the emission trading market. OECD (2009b) highlights that the tax treatment of tradable permits may have implications for abatement incentives. Even though the cases examined in Section 5 do not reflect the complexity of the real world tax and emission trading systems, they may still provide a useful framework for assessing the likelihood of tax-induced distortions.

80. The numerical examples developed in this section describe how the tax treatment of emission trading transactions affects the quantity purchased and sold by firms, the equilibrium price and the overall cost of reaching a given abatement target. The issues covered are:

1. The taxation of income from permit sale and acquisition cost deduction in the static case
2. The taxation of income from permit sale and acquisition cost deduction in the dynamic case
3. The abatement cost deduction in the static case
4. The abatement cost deduction in the dynamic case
5. The taxation of income from permit sale and acquisition cost deduction combined abatement cost deduction combined in static and dynamic cases

5.1 Taxation of income from permits sale and acquisition cost deduction: static case

81. The working hypotheses for the static illustrative cases are as follows:

| Initial emissions (ton of CO₂) | E₁=1200 | E₂=2800 |
| Marginal abatement cost | MAC₁=α₁A, MAC₂=α₂A, with α₁=0.85 and α₂=0.15⁷ |
| Emission reduction objective | -5% of initial emissions |
| Income tax rate | 25% |

82. Given the emission reduction objective of 5%, permit allocation would cover the 95% of initial emissions. The required abatement level can be obtained as the difference between the initial emissions and allocated permits. The required abatement levels for firm 1 and firm 2 are 60 and 140 tons of CO₂ respectively. According to their MAC and to the permit price level, the two firms would decide how to

⁷ These values are in line with the results of Costantini et al. (2011) related to MAC estimation for a sample of OECD and non-OECD countries with a Computable General Equilibrium model.
satisfy the required abatement level, namely abating or buying permits. A seller firm would abate more
than the required abatement, and in this way it would have a surplus of permits, which would be made
available for sale.

83. The first issue examined is represented by the taxation of income from permit sale and the
deduction of permit acquisition costs. It is initially assumed for analytic purposes that while permit
acquisition costs are deductible, the costs of abatement are not. The case in which firms are price takers is
examined first, and in particular the effect on the amount of permits purchased and sold. As previously
discussed, firms can be price-takers if their dimension implies that their choices do not influence
equilibrium price, or the regulatory authority exogenously set price. In the following graphs, price-taker
firms will be considered as representing a portion of the emission trading market, corresponding to the first
explanation (although the analysis is compatible even with the second explanation).

84. Given the exogenous price and their respective required abatement levels, the two firms find it
convenient to trade emission permits. In Figure 5a and 5b the total of the two abatement levels required for
firm 1 and 2 is shown on the x-axis. Firm 2 is characterised by lower abatement costs (MAC₂) relative to
firm 1. At the exogenous price level σ* it is convenient for firm 2 to abate more than the required
abatement level RA₂ and to sell permits to firm 1. Firm 2 will abate up to where its MAC equals the permit
price – in A*₂ – and sell permits corresponding to the abatement quantity RA₂A*₂. On the other hand, firm
1 will abate less than its required abatement level, only up to A*₁, and will have a positive permit demand
equal to RA₁A*₁ which corresponds to the distance A*₁RA₁. This exactly equals what firm 2 is willing to
sell (RA₂A*₂), showing that at that exogenously given price level cost-efficient abatement opportunities
which make the two price-taker firms trade partners. This analysis is similar to Figure 2 in Section 2.1.

85. Figures 5a and 5b shows how taxation of income from permit sale affects the marginal decision
of firm 2 on the level of permits to be sold. In both cases, the graph also shows how the deduction of
permit acquisition costs modifies the marginal decision of firm 1 on the level of permits to be purchased.
The two effects are shown together since in most tax system when income from an asset is taxed, the
associated acquisition costs are deductible.

---

8 On the x-axis the total abatement of the two firms can be measured, but this is different from the total
abatement level Aₜₐₒₜ shown in Figure 2 in Part I, which represents the total abatement of the emission trading
system.
Figure 5a – Price taker firms: taxation of income from permit sale and deduction of permit acquisition costs

86. The taxation of income from permit sale can be seen in two different ways. First, it may be considered as the perception of a price decrease (from $\sigma^*$ to $\sigma_T$, dashed line in Figure 5a) for the seller firm (firm 2), which reduces the return on sale for firm 2 given its existing MAC.

Figure 5b – Price-taker firms: taxation of income from permit sale and deduction of permits acquisition costs

87. From another point of view, the taxation of income from permit sale may be interpreted as having an effect equivalent to an increase in abatement costs for the selling firm, as $MAC_{2T}$ shows in Figure 5b.

9 All the shifts in MACs curves and in permit price are purely illustrative. Their extent is not meant to be related to the working hypothesis.
Abatement will become relatively more expensive for firm 2, since the seller firm will be taxed on the surplus abatement. As in Figure 5a, here it is assumed that the costs of abatement are not deductible.

88. The deduction of permit acquisition costs can also be represented in two different ways. First, it could be assumed as constituting a decrease in the permit price perceived by the buyer firm (from $\sigma^*$ to $\sigma_T$, dashed line in Figure 5a). From another point of view, the deduction of permit acquisition costs is equivalent to making abatement more expensive relative to permit purchase for firm 1, as $\text{MAC}_{1T}$ shows in Figure 5b. Firm 1 will in fact benefit from a deduction on permit acquisition cost, which will make abatement (which for the moment is assumed not to be deductible) more expensive relative to permit purchase in comparison to the no-taxation case. Both the shifts depicted in the figure are an illustrative representation of the way the deductible amount for the quantity purchased can be distributed to the marginal unit of abatement. In all the next numerical illustrative cases the taxation is modelled as affecting MACs.

89. Due to the taxation of income from permit sale, firm 2 will abate less than in the absence of taxation, since it will compare its existing MAC with the perceived price $\sigma_T$ (or, from another point of view, it will compare the shifted MAC with price $\sigma^*$). As a result, firm 1 will sell a lower quantity of permits. In particular, it will abate up to $A^*_2T$. At the same time, due to the deduction of permit acquisition costs, firm 1 will be willing to buy a larger quantity of permits than in the absence of taxation, as shown in Figure 5a and 5b by $A_{1T}$. Since Firm 1 will not find another firm willing to sell permits at that price, it will be obliged to abate at a higher than efficient marginal cost, reduce its output or borrow permits.

90. Table 1 includes a numerical illustrative case of the effects described graphically. Since the static case is examined, the relevant column is period 1, in which the two firms must achieve an emission reduction objective equal to 5%. The first part of the table shows that without taxation, given the MACs and the required abatement levels $RA_1$ and $RA_2$, actual abatements ($A_1$ and $A_2$) equal 30 for firm 1 and 170 for firm 2. Firm 1 has a positive permit demand equal to 30, and firm 2 provides a permits supply (negative permit demand) equal to 30. The quantity of permits sold by firm 2 is exactly equal to what firm 1 is willing to buy. Since the two firms are price-takers, permit demand is obtained according to equation (9) in Section 2.1, as it can be verified for firm 1 by substituting:

$$PD_j = E_j - AP_j - \frac{\sigma^*}{\alpha_j} = RA_j - \frac{\sigma^*}{\alpha_j} = RA_j - \frac{\sigma^*}{\alpha_i} = 60 - \frac{25.5}{0.85} = 30$$

(18)

91. In Table 1 the taxation of income from permit sale and deduction of permit acquisition costs is modelled in equation (18) as increasing firm 1 MAC$^{10}$

$$PD_1 = RA_1 - \frac{\sigma^*}{\alpha_{1BT}(1 + \tau_i)} = RA_1 - \frac{\sigma^*}{\alpha_i} = 60 - \frac{25.5}{1.063} = 36$$

(19)

---

10 In this formula, the tax-inclusive rate shown in the hypothesis (Paragraph 80) has been replaced with the corresponding tax-exclusive rate. The tax-exclusive rate $\tau_e$ (usually applied to indirect taxes) is related to the tax-inclusive rate $\tau_i$ (usually applied to direct taxes) by the following formula $\tau_e = \tau_i/(1 + \tau_i)$. In equation (22) the tax-inclusive rate $\tau_i$ is applied.
where $\alpha_{\text{BT}}$ is the MAC coefficient before taxation (BT), equal to 0.85 for firm 1 (and to 0.15 for firm 1), as shown in Table 1. In Table 1 and also in all the following ones the after-tax $\alpha$ coefficient is included, given by $\alpha_{\text{BT}} (1 + \tau)$.

92. The increase in $\text{PD}_1$ shown in equation (19) is a result consistent with equation (12) in Section 4.2 where the effect of taxation of permit income and deduction of acquisition cost is modelled on permit price.

<table>
<thead>
<tr>
<th>Table 1 – Income taxation for price-taker firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting point (without taxation)</td>
</tr>
<tr>
<td>Coefficient for MAC1 ($\alpha_1$)</td>
</tr>
<tr>
<td>Coefficient for MAC1 ($\alpha_2$)</td>
</tr>
<tr>
<td>Required abatement (RA1)</td>
</tr>
<tr>
<td>Required abatement (RA2)</td>
</tr>
<tr>
<td>Actual abatement (A1)</td>
</tr>
<tr>
<td>Actual abatement (A2)</td>
</tr>
<tr>
<td>Permit demand (PD1)</td>
</tr>
<tr>
<td>Permit demand (PD2)</td>
</tr>
<tr>
<td>Equilibrium price $\sigma$ (exogenous)</td>
</tr>
<tr>
<td>Tax rate firm 1 ($\tau_1$)</td>
</tr>
<tr>
<td>Tax rate firm 2 ($\tau_2$)</td>
</tr>
</tbody>
</table>

93. Taxation of income from permit sale and deduction of acquisition costs affect the actual abatement levels chosen by firms and then the quantity sold and purchased. Consistently with Figures 5a and 5b, the quantity sold decreases up to the point that firm 2 also has a positive permit demand (4), so it is not any more a seller firm. On the other hand, the quantity demanded for purchase increases (36), and firm 1 would have to find another seller to satisfy its permit demand. The effects just described increase as the tax rate increases.

94. Several observations can be derived. In an economy where more than two actors operate (i.e., in a real world emission trading system) the higher permit demand from firm 1 is likely to find another seller, and taxation will imply that efficient (low cost) abatement opportunities existing in firm 1 are disregarded as a consequence of the possibility of deducting acquisition costs. If only one of the two tax treatments is in applied – taxation of income from permits sale or deduction of permit acquisition cost – only the corresponding effect on quantity (respectively sold or purchased) described above will apply, though this situation is probably not common. The case in which the two tax rates are non-harmonised may be more likely, and it will be examined in Table 2. Other aspects of the tax treatment of emission are likely to have a relevant role, in particular the abatement cost deduction will counteract this effect as will be shown in the next subsections.

95. Table 2 shows the case in which the tax rate to be applied to income from permit sale and the one to be used for the deduction of acquisition cost are not the same for each given firm, and also differ between the two firms (the price-takers case is named PT in the table). In particular, if the tax rate is higher
on income from permit sale (PT1), a higher positive demand for firm 2 emerges (14), sharpening the decreasing effect on quantity (which was previously) sold. On the other hand, if the deduction of acquisition costs is allowed at a higher rate (PT2), a greater impact in terms of increase of quantity demanded for purchase occurs (38).

Table 2 Non-harmonised rates for price-taker and price-maker firms

<table>
<thead>
<tr>
<th></th>
<th>Starting point</th>
<th>Price Takers (PT)</th>
<th>Price Makers (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(without</td>
<td>Different taxation on income from</td>
<td>Different taxation on income from</td>
</tr>
<tr>
<td></td>
<td>taxation)</td>
<td>permit sale and deduction of permis</td>
<td>permit sale and deduction of permis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s acquisition costs</td>
<td>s acquisition costs</td>
</tr>
<tr>
<td>Coefficient for MAC1</td>
<td>0,85</td>
<td>1,06</td>
<td>1,06</td>
</tr>
<tr>
<td>(α1)</td>
<td>0,15</td>
<td>0,20</td>
<td>0,20</td>
</tr>
<tr>
<td>Coefficient for MAC1</td>
<td>0,85</td>
<td>1,06</td>
<td>1,06</td>
</tr>
<tr>
<td>(α2)</td>
<td>0,15</td>
<td>0,20</td>
<td>0,20</td>
</tr>
<tr>
<td>Required abatement</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>(RA1)</td>
<td>140</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>Required abatement</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>(RA2)</td>
<td>140</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>Actual abatement</td>
<td>30</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>(A1)</td>
<td>170</td>
<td>22</td>
<td>28</td>
</tr>
<tr>
<td>Actual abatement</td>
<td>30</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>(A2)</td>
<td>-30</td>
<td>4</td>
<td>-32</td>
</tr>
<tr>
<td>Permit demand</td>
<td>30</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td>(PD1)</td>
<td>-30</td>
<td>14</td>
<td>-28</td>
</tr>
<tr>
<td>Permit demand</td>
<td>30</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td>(PD2)</td>
<td>-30</td>
<td>14</td>
<td>-28</td>
</tr>
<tr>
<td>Equilibrium price σ</td>
<td>25,50</td>
<td>25,50</td>
<td>34,02</td>
</tr>
<tr>
<td>(exogenous for price-</td>
<td></td>
<td>25,50</td>
<td>32,23</td>
</tr>
<tr>
<td>takers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax rate firm 1 (τ1)</td>
<td>25%</td>
<td>35%</td>
<td>25%</td>
</tr>
<tr>
<td>Tax rate firm 2 (τ2)</td>
<td>35%</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Figure 6 shows the effects of the taxation of income from permit sale and the deduction of permit acquisition costs for price-maker firms. The two price-makers are considered as being representative of the whole emission trading market, consistent with the analysis in Figure 2.

Firm 2 has a lower MAC than firm 1, coherent with the working hypothesis. The equilibrium is found by the intersection of the two MACs, at the price $\sigma^\ast$. Based on the equilibrium price and on their required abatement levels $\text{RA}_1$ and $\text{RA}_2$, firm 1 and 2 will choose their market behaviour. Firm 2 will be a seller, abating more than the required abatement $\text{RA}_2$ ($A^\ast_2$ in the figure), and then having a surplus of permits corresponding to the quantity $\text{RA}_2A^\ast_2$ which it will sell. Firm 1 will be a buyer, abating less than the required abatement $\text{RA}_1$ ($A^\ast_1$ in the figure), and then having to buy permits corresponding to the abatement quantity $A^\ast_1\text{RA}_1$.

In this case, taxation is also modelled as affecting MACs, which are shifted upwards, as in Figure 5b. As a result, a new equilibrium is found at the price $\sigma^\ast_T$. The quantity traded will not change with respect to the initial equilibrium if the tax rate is the same for the taxation of income from permit sale and the deduction of permit acquisition costs. This is the case shown in Figure 6. If the tax rates are not the same, the quantity of permits traded will change with respect to the initial equilibrium (see Table 2 for a numerical example), but the changes in the quantities supplied and purchased will lead to a new equilibrium with a new market clearing price.
The effects described graphically are examined in the numerical example in Table 3. The relevant column is period 1, in which the two firms must achieve an emission reduction objective equal to 5%. Without taxation, actual abatements $A_1$ and $A_2$ are respectively equal to 30 and 170. The values of permit demands show that market is in equilibrium, and the clearing price is equal to 25.5 USD per ton of CO$_2$. Given that the two firms are price makers, the equilibrium price is obtained according to equation (8) in Section 2.1, as it can be verified by substituting:

$$\sigma^* = (R_A + R_A_2) \times \frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2} = (60 + 140) \times \frac{0.85 \times 0.15}{(0.85 + 0.15)} = 25.5$$

(20)

Permit demand is then obtained applying equation (9), as it has been shown in the numerical example in equation (18). In Table 3 the taxation of income from permit sale and deduction of permit acquisition costs is modelled as increasing MACs. Taxation is introduced as having an impact on MAC – under the same approach adopted in equation (19) – and in this case taxation produces an effect on the market equilibrium price.

$$\sigma^* = (R_A + R_A_2) \times \frac{\alpha_{1BT} (1 + \tau_1) \alpha_{2BT} (1 + \tau_2)}{\alpha_{1BT} (1 + \tau_1) + \alpha_{2BT} (1 + \tau_2)} = (60 + 140) \times \frac{1.063 \times 0.188}{1.063 + 0.188} = 31.87$$

(21)
Table 3 – Income taxation for price-maker firms

<table>
<thead>
<tr>
<th></th>
<th>No emission trading</th>
<th>Starting point (without taxation)</th>
<th>A. Taxation on income from permit sale and deduction of permits acquisition costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient for MAC1 ($\alpha_1$)</td>
<td>0.85 0.85 0.85</td>
<td>1.06 1.06 1.06</td>
<td>1.06 1.06 1.06</td>
</tr>
<tr>
<td>Coefficient for MAC1 ($\alpha_2$)</td>
<td>0,15 0,15 0,15</td>
<td>0,19 0,19 0,19</td>
<td>0,19 0,19 0,19</td>
</tr>
<tr>
<td>Required abatement (RA1)</td>
<td>60 66 72</td>
<td>60 66 72</td>
<td>60 66 72</td>
</tr>
<tr>
<td>Required abatement (RA2)</td>
<td>140 154 168</td>
<td>140 154 168</td>
<td>140 154 168</td>
</tr>
<tr>
<td>Actual abatement (A1)</td>
<td>30 33 36</td>
<td>30 33 36</td>
<td>30 33 36</td>
</tr>
<tr>
<td>Actual abatement (A2)</td>
<td>170 187 204</td>
<td>170 187 204</td>
<td>170 187 204</td>
</tr>
<tr>
<td>Permit demand (PD1)</td>
<td>30 33 36</td>
<td>30 33 36</td>
<td>30 33 36</td>
</tr>
<tr>
<td>Permit demand (PD2)</td>
<td>-30 -33 -36</td>
<td>-30 -33 -36</td>
<td>-30 -33 -36</td>
</tr>
<tr>
<td>Equilibrium price $\sigma$</td>
<td>25,50 28,05 30,60</td>
<td>31,88 35,06 38,25</td>
<td>31,88 35,06 38,25</td>
</tr>
<tr>
<td>Tax rate firm 1 ($\tau_1$)</td>
<td>25% 25% 25%</td>
<td>25% 25% 25%</td>
<td>25% 25% 25%</td>
</tr>
<tr>
<td>Tax rate firm 2 ($\tau_2$)</td>
<td>25% 25% 25%</td>
<td>25% 25% 25%</td>
<td>25% 25% 25%</td>
</tr>
<tr>
<td>Abatement cost firm 1 (AC1)</td>
<td>1530 383</td>
<td>478</td>
<td>478</td>
</tr>
<tr>
<td>Abatement cost firm 2 (AC2)</td>
<td>1470 2168</td>
<td>2709</td>
<td>2709</td>
</tr>
<tr>
<td>Total abatement cost</td>
<td>3000 2550</td>
<td>3188</td>
<td>3188</td>
</tr>
</tbody>
</table>

101. Table 3 shows that when the tax rate is the same for the two firms, the market clearing price increases relative to the no-taxation case (from 25 to 32 USD per ton of CO2), and quantity traded remains the same. In Table 3 for the static case is also shown the overall abatement costs in the different cases, computed in this way

$$AC_j = \frac{\alpha_j}{2} (RA_j - PD_j)^2$$

where $\alpha_j$ changes according to the case examined, and the term in brackets is actual abatement, and it also varies in every tax aspect examined. The numbers obtained – meant to be only illustrative – demonstrate how taxation applied on a non-symmetric basis, so that permit income is taxable and permit costs deductible, but abatement costs non-deductible, changes firm behaviour in a way that implies an increase in the overall cost to reach a given emission reduction target. It is worth noting that without emission trading the overall abatement cost to reach the target would have been higher, so even after having considered the increase induced by the tax treatment the emission trading remains a cost-effective policy.

102. If the tax rates differ, the quantity traded changes with respect of the starting point, as shown in Table 2 (where the price-makers case is named PM). The results of the non-harmonised price-makers case are consistent with the changes in quantities for firm 1 and 2 observed in the price-takers case. The quantity traded decreases if the seller is taxed more heavily (PM1), and increases if the buyer is allowed a higher deduction of acquisition costs (PM2). The increasing trend in the overall abatement cost (AC) with respect to the no-taxation case is maintained (in this case numbers are not shown in the table). The equilibrium price increases in both non-harmonised cases, and the increase is higher when the quantity of permits traded is lower.
5.2 Taxation of income from permit sale and acquisition cost deduction: dynamic case

103. The dynamic case is modelled with a tightening cap, equal to 5.5% of initial (first period) emissions in the second period and 6% in the third and last period. If banking and borrowing are not allowed, the dynamic case is constituted by three subsequent static cases, in which firms have to achieve the period-specific emissions reduction targets and permits cannot be traded inter-temporally.

104. In such a setting, the findings obtained in the static case are confirmed, as shown in Table 1 for price-taker firms. Quantity traded is increasing in time in the non-taxation case. When taxation is introduced, the quantity which firm 1 is willing to buy increases, whereas firm 2 is not willing to sell permits anymore, and instead becomes a buyer.

105. The findings obtained in the static case are also confirmed for price-maker firms, as shown in Table 3. Given the tightening emission reduction objective, there is an increasing equilibrium price in the three periods in the non taxation case. The introduction of taxation implies an increase in the market clearing price, whereas the quantity traded does not change with respect to the case without taxation.

106. Banking and borrowing are then introduced\(^\text{11}\). Firm 2, having a surplus of permits, is allowed to bank permits for later use, based on its expectation of an increasing price. Similarly, firm 1, having a positive permit demand, is allowed to borrow permits (instead of buying them) from its future permit allocation and to use them to cover its current emissions surplus. The decision about how much banking/borrowing is modelled as being linked (in a fixed percentage) to the previous period permit demand, and in this way it is indirectly responsive to the presence of taxation.

107. The aim of modelling banking and borrowing is answering two questions:

1. if and how taxation affects the quantity of permits banked or borrowed

2. how the presence of banking and borrowing influences the impacts of taxation on the market clearing price.

108. The first question will be investigated in the price-takers case, the second one in the price-makers case.

109. Starting from the no-taxation case, in period 2 – the one in which banking and borrowing effectively take place, based on period 1 abatement decisions – the quantity traded decreases with respect to the case without banking/borrowing. In period 3, which is the last one, the quantity traded increases. This is a consequence of the fact that at the end of the emission trading program the overall quantity of permits should respect the total required abatement level. For price-maker firms, an equilibrium price decrease is observed in period 2 with respect to the case without banking/borrowing, followed by an increase in period 3.

110. The taxation of income from permit sale and the deduction of permit acquisition costs has an impact on the quantity of permits banked and borrowed. If the two firms are price-takers and taxation is introduced, the quantity which firm 1 is willing to borrow will increase, whereas firm 2 will decrease the quantity banked up to the point where it will start to borrow a small amount of permits. These effects are in line with the impact of taxation on the quantity purchased and sold shown in Table 1.

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11 More details on banking and borrowing functioning can be found in Section 2.2.
The taxation of income from permit sale and the deduction of permit acquisition costs will also influence the impacts of taxation on market clearing price. When taxation is introduced for price-makers firm, it will have an increasing effect on market clearing price, which will increase from 28 to 35 USD per ton of CO₂ in period 2, and from 30 to 38 USD per ton of CO₂ in the last period.

In both the price-takers and price-makers cases, the possibility of banking and borrowing sharpens the impacts of taxation observed in the dynamic case without banking/borrowing.

### Table 4 – Income taxation with banking and borrowing for price-taker and price-maker firms

<table>
<thead>
<tr>
<th></th>
<th>Starting point (without taxation and banking/borrowing)</th>
<th>Starting point (without taxation and with banking/borrowing)</th>
<th>Price Takers (PT) Banking/borrowing with taxation on income from permits sale and deduction of permits acquisition costs</th>
<th>Price Makers (PM) Banking/borrowing with taxation on income from permits sale and deduction of permits acquisition costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient for MAC1 ($α_1$)</td>
<td>0.85, 0.85, 0.85</td>
<td>0.85, 0.85, 0.85</td>
<td>1.06, 1.06, 1.06</td>
<td>1.05, 1.05, 1.05</td>
</tr>
<tr>
<td>Coefficient for MAC2 ($α_2$)</td>
<td>0.15, 0.15, 0.15</td>
<td>0.15, 0.15, 0.15</td>
<td>0.19, 0.19, 0.19</td>
<td>0.19, 0.19, 0.19</td>
</tr>
<tr>
<td>Required abatement (RA1)</td>
<td>60, 66, 72</td>
<td>60, 66, 74</td>
<td>60, 66, 74</td>
<td>60, 66, 74</td>
</tr>
<tr>
<td>Required abatement (RA2)</td>
<td>140, 154, 168</td>
<td>140, 154, 167</td>
<td>140, 154, 168</td>
<td>140, 154, 167</td>
</tr>
<tr>
<td>Actual abatement (A1)</td>
<td>30, 33, 36</td>
<td>30, 33, 36</td>
<td>24, 26, 27</td>
<td>30, 33, 36</td>
</tr>
<tr>
<td>Actual abatement (A2)</td>
<td>170, 187, 204</td>
<td>170, 187, 204</td>
<td>136, 150, 163</td>
<td>170, 187, 204</td>
</tr>
<tr>
<td>Permit demand (PD1)</td>
<td>30, 33, 36</td>
<td>30, 32, 38</td>
<td>36, 38, 45</td>
<td>30, 32, 38</td>
</tr>
<tr>
<td>Permit demand (PD2)</td>
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<td>-30, -32, -36</td>
<td>4, 4, 5</td>
<td>-30, -32, -36</td>
</tr>
<tr>
<td>Borrowing</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Banking</td>
<td>1.5</td>
<td>0.2</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Equilibrium price $\sigma$ (exogenous for price-takers)</td>
<td>25.50, 28.05, 30.60</td>
<td>25.50, 28.05, 30.60</td>
<td>25.50, 28.05, 30.60</td>
<td>25.50, 28.05, 30.60</td>
</tr>
<tr>
<td>Tax rate firm 1 ($\tau_1$)</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Tax rate firm 2 ($\tau_2$)</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

### 5.3 Abatement cost deduction: static case

To further illustrate the impact of tax asymmetries, in this section, it is assumed for analytic purposes that income from permit sale is not taxable and that permit costs are not deductible, but that abatement costs are deductible. Figure 7 shows the effect of the deductibility of abatement costs for two price-taker firms. The deductibility of abatement cost may be considered as equivalent to a decrease in the perceived abatement cost. The deduction in reality affects the total abatement cost faced by firms (as well as the average abatement cost), and the shift in the MAC curve is an illustration of how the deductible amount can be assigned to the marginal unit of abatement. This illustration is coherent with the theoretical equations (14) and (15). The shift in the MACs shown in Figure 9 does not reflect a real convenience in abatement, e.g. as is the case when the availability of low cost abatement opportunities increases thanks to environmental innovation. MACs are lowered (in bold in the figures) exclusively as a result of the possibility to deduct abatement costs.

Two cases can be distinguished, in which the possibility to deduct abatement costs is different for the two firms. The difference in the tax treatment depicted in Figure 7a and 7b may be due to the fact that the firms are adopting different abatement technologies, and for one of those the government has introduced a tax preference (this issue is analysed in further detail in the literature review COM/ENV/EPOC/CTPA/CFA(2011)36). Firms 1 and 2 may also be representative of two national systems adopting different rules.
In case a) the deduction is higher for firm 2. The intersection of $\text{MAC}_2$ with the exogenously given price $\sigma^*$ shows that firm 2 is tax-induced to abate more emissions than under the initial equilibrium ($A_{2DRA2} > A_{2RA2}$). Firm 1 will set its actual abatement comparing its shifted MAC with the price $\sigma^*$, and it will be tax-induced to buy less permits to cover the remaining emissions ($A_{1DRA1} < A_{1RA1}$). In case b) the deduction is higher for firm 1, and this will imply that firm 1 sets a higher actual abatement level ($A_{1DRA1} > A_{1RA1}$), abating more than the required abatement level and becoming a permit seller. This is an extreme result, in which a firm that adopted a buyer behaviour before the introduction of abatement costs deductibility could be tax-induced to sell permits.

Table 5 includes a numerical illustrative case of the effects of abatement cost deduction, in the case in which the deduction rate is the same for the two firms. To examine the static case, the relevant column is period 1. Abatement cost deduction is modelled as decreasing MACs, consistently with equation (14) in Section 4.2

$$PD_1 = RA_i - \frac{\sigma^*}{\alpha_{LR}(1 - \tau_i)}$$  \hspace{1cm} (22)

From equation (22) it is clear that the deduction of abatement cost tends to decrease permit demand.
The deduction of abatement costs produces a decrease in the quantity purchased by the buyer firm, since the deduction makes abatement relatively less expensive. For the same reason, an increase in the quantity the seller firm is willing to sell at the exogenously given price is observed. For this additional quantity sold, firm 2 should find another buyer on the market. The higher is the deduction rate the greater is this effect on the quantities purchased and sold.

In the price-makers case, the effects on price are opposite to those observed under the taxation of income from permit sale and the deduction of acquisition costs when abatement costs are not deductible. In fact, the market clearing price decreases, as shown in Table 6 (period 1). If the rate for deduction of abatement costs is the same for the two firms, the quantity traded is not affected with respect to the initial equilibrium. The overall abatement cost (AC) decreases with respect to the no-taxation case. The effects in decreasing the price and abatement cost become more important as the deduction rate increases.

When the non-harmonised case is examined, in the price-takers case a greater impact is found on the quantity purchased than on quantity sold if the deduction rate is higher for firm 1, consistently with Figure 7. The opposite is true if the deduction rate is higher for firm 2. If the rate for abatement cost deduction is differentiated, the quantity traded is also affected in the price-makers case. In particular, it increases relative to the initial equilibrium if the seller firm is allowed to deduct abatement cost to a greater extent than the seller firm, and decreases if the opposite holds. The price decreases more in the first case than in the second one.

Such a non-harmonised case could result from a more favourable tax treatment for particular abatement costs or for abatement costs in particular sectors. Kane (2009a) points out that the existence of tax-favoured abatement options, often due to political pressures on governments, may be a tax-induced distortion that is difficult to remove.

### Table 5 – Abatement cost deduction for price-taker firms

<table>
<thead>
<tr>
<th></th>
<th>Starting point (without taxation)</th>
<th>Deduction of abatement costs</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Period 1</td>
<td>Period 2</td>
</tr>
<tr>
<td>Coefficient for MAC1 ($\alpha_1$)</td>
<td>0,85</td>
<td>0,85</td>
</tr>
<tr>
<td>Coefficient for MAC1 ($\alpha_2$)</td>
<td>0,15</td>
<td>0,15</td>
</tr>
<tr>
<td>Required abatement (RA1)</td>
<td>60</td>
<td>66</td>
</tr>
<tr>
<td>Required abatement (RA2)</td>
<td>140</td>
<td>154</td>
</tr>
<tr>
<td>Actual abatement (A1)</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>Actual abatement (A2)</td>
<td>170</td>
<td>187</td>
</tr>
<tr>
<td>Permit demand (PD1)</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>Permit demand (PD2)</td>
<td>-30</td>
<td>-33</td>
</tr>
<tr>
<td>Equilibrium price $\sigma$ (exogenous)</td>
<td>25,50</td>
<td>28,05</td>
</tr>
<tr>
<td>Tax rate firm 1 ($\tau_1$)</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Tax rate firm 2 ($\tau_2$)</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>
5.4 Abatement cost deduction: dynamic case

122. In the dynamic setting, when banking and borrowing are not allowed, the effects observed in the static case are confirmed, as shown in Table 5 for price-taker firms. The quantity demanded for purchase decreases, and the quantity sold increases. Efficient trades between the two firms, for which the net permit demand was equal to zero before taxation, are now disregarded. Also in the price-makers case the effects obtained in the static setting are confirmed, since abatement cost deduction implies a decrease in market clearing prices for the entire duration of the emission trading program.

123. If the possibility of deducting abatement costs is introduced in a context where banking and borrowing are allowed, the disequilibrium in the quantity traded by the two price-taker firms becomes greater than without banking/borrowing. Also in this case, as found for the taxation of income from permit sale and the deduction of acquisition costs, the possibility of banking and borrowing amplifies the tax-induced distortions on the quantity purchased and sold. The price-maker firms will operate in a market still in equilibrium but with a lower market clearing price.
Table 7 – Abatement cost deduction with banking and borrowing for price-taker and price-maker firms

<table>
<thead>
<tr>
<th></th>
<th>Starting point (without taxation and banking/borrowing)</th>
<th>Starting point (without taxation and with banking/borrowing)</th>
<th>Price Takers (PT) with deduction of abatement costs</th>
<th>Price Makers (PM) with deduction of abatement costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period 1</td>
<td>Period 2</td>
<td>Period 3</td>
<td>Period 1</td>
</tr>
<tr>
<td>Coefficient for MAC1 (α1)</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Coefficient for MAC1 (α2)</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Required abatement (RA1)</td>
<td>60</td>
<td>66</td>
<td>72</td>
<td>60</td>
</tr>
<tr>
<td>Required abatement (RA2)</td>
<td>140</td>
<td>154</td>
<td>168</td>
<td>140</td>
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<tr>
<td>Actual abatement (A1)</td>
<td>30</td>
<td>33</td>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>Actual abatement (A2)</td>
<td>170</td>
<td>187</td>
<td>204</td>
<td>170</td>
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<tr>
<td>Permit demand (PD1)</td>
<td>30</td>
<td>33</td>
<td>36</td>
<td>30</td>
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<tr>
<td>Permit demand (PD2)</td>
<td>-30</td>
<td>-33</td>
<td>-36</td>
<td>-30</td>
</tr>
<tr>
<td>Borrowing</td>
<td>1.50</td>
<td></td>
<td></td>
<td>1.50</td>
</tr>
<tr>
<td>Banking</td>
<td>1.50</td>
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<td></td>
<td>4.30</td>
</tr>
<tr>
<td>Equilibrium price σ (exogenous for price-takers)</td>
<td>25.50</td>
<td>28.05</td>
<td>30.60</td>
<td>25.50</td>
</tr>
<tr>
<td>Tax rate firm 1 (τ1)</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
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<tr>
<td>Tax rate firm 2 (τ2)</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

5.5 Taxation of permit income, acquisition cost deduction and abatement cost deduction combined: static and dynamic cases

124. It is expected that in practice, most income tax systems will tax income from permit sale and allow the deductibility of both permit acquisition costs and abatement costs. This section therefore combines the assumptions that were considered separately in the previous sections. Figure 8 shows the relevant effects. In this case the buyer or seller behaviour depends on the required abatement level. This analysis is coherent with Figure 1 in Section 2.1. If the required abatement corresponds to RA1, at a given price σ* the firm will choose to abate less than required (A*) and be a buyer. The deduction of permit acquisition costs implies that the firm abates less, in A* T. Then, the abatement cost deduction makes the firm abate more, up to A*TD. On the other hand, if the required abatement level is equal to RA2, the firm – having the same MAC and in presence of the same exogenous equilibrium price – will be a seller. The same reasoning as before applies, except for the fact that the shift in price will now model the taxation of income from permit sale since the firm is a seller. In both cases, the relative dimension of the two shifts will determine the final equilibrium in terms of actual abatement. Figure 8 represents the case in which the income for sale of permits and the cost of acquiring permits are taxed or deduced at one rate, while abatement costs are deducted at a different rate.

125. If the rates were harmonised, there would be no final effect on the optimal abatement level A*, since the two counteracting effect would exactly compensate each other. This is consistent with equation (16) in Section 4.2. For example, for buyers the abatement cost deduction will not influence the choice between buying permits and abating, consistently with OECD (2008b). If a firm buys a permit, the acquisition cost is deductible but this deduction replaces the deduction of abatement costs. Then, the abatement cost deduction does not constitute an additional benefit for the buyer.
Table 8 is related to price-taker firms. The numbers for the harmonised tax rates case are not reported, since they are equal to the no-taxation case, confirming the theoretical model. The table shows that the overall effect when taxation of permit income and deduction of permit costs is combined with deduction of abatement costs depends on the relative amount of the two tax rates and corresponding shifts in the curves. If the rate for taxation and deduction of permit income and costs is higher, the effects described in Table 1 prevail. Namely, the quantity sold by firm 2 decreases and the quantity purchased by firm 1 increases with respect to the initial equilibrium. By contrast, if the rate for abatement cost deduction is higher, the effects shown in Table 5 dominate. In fact, the seller is willing to sell more at a given price, and the buyer firm to purchase less permits. In both cases, it can be checked by comparing Table 8 with Tables 1 and 5 that the effects of permit taxation and deduction and abatement cost deduction compensate each other: the disequilibrium in the quantity traded by the two firms at the exogenously given price is smaller in Table 8 than in the other tables.
Table 8 – Taxation of permit income and deduction of permit acquisition costs combined with abatement cost deduction for price-taker firms

<table>
<thead>
<tr>
<th></th>
<th>Starting point (without taxation)</th>
<th>Taxation on income from permit sale and deduction of permits acquisition costs combined with deduction of abatement costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Period 1</td>
<td>Period 2</td>
</tr>
<tr>
<td>Coefficient for MAC1 (α1)</td>
<td>0,85</td>
<td>0,85</td>
</tr>
<tr>
<td>Coefficient for MAC1 (α2)</td>
<td>0,15</td>
<td>0,15</td>
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<tr>
<td>Required abatement (RA1)</td>
<td>60</td>
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<td>Required abatement (RA2)</td>
<td>140</td>
<td>154</td>
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<tr>
<td>Actual abatement (A1)</td>
<td>30</td>
<td>33</td>
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<tr>
<td>Actual abatement (A2)</td>
<td>170</td>
<td>187</td>
</tr>
<tr>
<td>Permit demand (PD1)</td>
<td>30</td>
<td>33</td>
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<tr>
<td>Permit demand (PD2)</td>
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<td>-33</td>
</tr>
<tr>
<td>Equilibrium price σ</td>
<td>25,50</td>
<td>28,05</td>
</tr>
<tr>
<td>Tax rate firm 1 (τ1)</td>
<td>25% (abatement) - 35% (income)</td>
<td>35% (abatement) - 25% (income)</td>
</tr>
<tr>
<td>Tax rate firm 2 (τ2)</td>
<td>25% (abatement) - 35% (income)</td>
<td>35% (abatement) - 25% (income)</td>
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</table>

127. For price-maker firms, when taxation of permit income and deduction of permit acquisition costs is combined with the deduction of abatement costs, if the two rates are the same, no effect is observed on prices, abatement costs and quantity traded relative to the no-taxation case. If the two rates are not harmonised, the market clearing price changes, as does the abatement cost. As in the price-takers case, the effect of permit taxation and deduction examined in Table 3 prevails if the permit taxation and deduction rate is higher than the rate for abatement cost deduction: it can be observed that price increases with respect to the no-taxation case. On the contrary, if the rate for abatement cost deduction is higher than the rate for permit taxation and deduction then the effect of abatement cost deduction dominates (shown in Table 6): price decreases. Comparing the prices in Table 9 with those in Tables 3 and 6 shows that the counteracting effects on price of the two tax treatments compensate each other also in this case.
Table 9 – Income taxation and abatement cost deduction combined for price-taker firms

<table>
<thead>
<tr>
<th>Coefficient for MAC1 (α1)</th>
<th>Coefficient for MAC2 (α2)</th>
<th>Required abatement (RA1)</th>
<th>Required abatement (RA2)</th>
<th>Actual abatement (A1)</th>
<th>Actual abatement (A2)</th>
<th>Permit demand (PD1)</th>
<th>Permit demand (PD2)</th>
<th>Equilibrium price σ</th>
<th>Tax rate firm 1 (τ1)</th>
<th>Tax rate firm 2 (τ2)</th>
<th>Abatement cost firm 1 (AC1)</th>
<th>Abatement cost firm 2 (AC2)</th>
<th>Total abatement cost</th>
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<td>25.50</td>
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<td>29.42</td>
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</table>

128. The dynamic setting without banking and borrowing confirms the results of the static case, both for price-takers and price-makers. This is shown by the trends for quantity and price respectively, in Tables 8 and 9. Also when banking and borrowing are allowed, it is confirmed that harmonised rates have no effects. When the rates are differentiated, the findings described above are confirmed. Also in the combined case, the possibility of banking and borrowing permits has a sharpening effect on the tax-induced distortions.

129. This is an important result, since the just mentioned tax-induced distortions could intervene as an additional source of inefficiency with respect to the risks associated with banking and borrowing described in Section 3.2. Clearly the distortions may also be compensated by the positive effects related to the use of banking and borrowing. This shows how introducing the possibility of banking and borrowing may have many different efficiency implications (both positive and negative), and it could be difficult to evaluate which one would prevail. On top of this, is should be taken into account that the taxation schedule may favour banking or borrowing, for example as is the case with respect to the taxation of income from permit sale (banking defers the taxation). In this case the taxation would modify the quantity sold also affecting banking – then in a direct way, differently from the results commented in this section – and the price equilibrium effects would be increased.

6 Conclusions and materiality of tax-induced distortions

130. The illustrative cases examined point out that in a simple model, taxation does not impact the efficiency of an emission trading system where taxation applies symmetrically to income from sale of permits and to costs associated with acquiring permits and abating emissions. However, they also illustrate that non-symmetric tax rates or a failure to recognise both income and costs for tax purposes on a symmetrical basis could impair allocative efficiency. In particular, tax-induced abatement displacement effects can arise both for price-taker and price-maker firms. In the price-taker case, taxation of permit income and deduction of permit costs without deduction of abatement costs (or vice versa distorts firm decisions, making them disregard transactions which would otherwise be efficient at a given price level. In the price-makers case, the deduction of abatement costs without taxation of permit income and the
The deduction of permit costs decreases equilibrium price, weakening the price signal which may constitute a driver for the development and adoption of abatement technologies in the long term. The results obtained from the illustrative cases show that allocative efficiency loss could happen even in a static setting.

The illustrative cases show that a harmonisation of the tax treatment both between different firms and different types of emission trading transactions is needed to avoid tax-induced distortions. The second level of harmonisation is in line with the theoretical analysis developed in Section 2.1 at firm level.

According to the results from the illustrative cases, avoidance of distortions requires that income from permit sales be taxable, and permit acquisition costs and abatement costs be deductible, all at the same tax rate. This seems reasonably likely to be achieved at least domestically within many real world tax systems. Potential departures from this neutrality could certainly arise, however. An example would be if gains on permit sale were taxed as capital gains at a preferential rate while deductions for permit and abatement costs were deductible at the regular corporate income tax rate. Another case could be where certain abatement expenditures receive a preferentially higher deduction (e.g., as an inducement to invest in particular technology). Differential tax rates across jurisdictions is another potential cause of non-neutrality.

This leads to the question: if tax treatment does lead to distortions in allocative efficiency, how material are the impacts? This issue appears to have been little examined to date. There are some estimates by Copenhagen Economics (2010), which do not show a strong potential for allocative efficiency distortions. Welfare losses from tax-induced abatement displacement effects are found to be relatively small if compared to the levels of abatement achieved. Although non-harmonised fiscal treatment – and lack of clarity about the applicable fiscal treatment – risks creating unnecessary compliance costs, the numerical examples and the abatement curve modelling developed in the study show only a modest impact from these issues. Further study would be merited, for example with respect to the possible change in location of the production activities and the associated carbon leakage problem.

Costantini et al. (2011) simulate the tax treatment of emission trading transactions with a CGE model. The authors develop different stylised scenarios of non-harmonised taxation of emission permits between the countries involved in the Kyoto Protocol, assuming that they were involved in a hypothetical emission trading system to reach their emission reduction objectives. Seller countries are taxed on permit sale and buyer countries are allowed a tax rebate, which can be referred as a possibility to deduct permit acquisition cost. Their analysis show that distortions on allocative efficiency and emission trading equilibrium price may arise also in a static context, increasing permit equilibrium price and implying an overall welfare loss. The results obtained for the illustrative cases are consistent with the findings just described.

The impacts outlined with the numerical examples can be considered with reference to some of the key variables related to the design of an emission trading system and to the participating firms’ economic structure. First, consider the role of free allocation of permits. In the examples developed, it was assumed that firms were allocated free permits for the emissions not exceeding the cap, and then should abate their remaining emissions or buy permits. If the level of permits allocated for free is smaller than the cap and the remaining permits are auctioned, then the impacts of an asymmetric deduction for acquisition cost are likely to be sharpened, since the possibility of deducting acquisition costs would apply.

12 In future work, it could be interesting to test using these methods the neutrality paradigms introduced by Kane (2011), namely: a similar treatment of abatement costs and permits separately across firms (inter-firm neutrality) or a similar treatment of abatement costs and permits within a firm (intra-firm neutrality). He does not find either paradigm to be neutral with respect to all the decisional margins and tax treatments modelled at firm level. More details on Kane’s analysis are provided in COM/ENV/EPOC/CTPA/CFA(2011)36.
also to auctioned permits. If firms are price-makers, this would have an impact also on the market clearing price.

136. The stringency of the emission reduction objective or cap is also a key variable. First, if the price were falling because the initial allocation was too generous, the impact of a deduction of permit abatement costs would amplify this effect, whereas the impact from the taxation of income from permit sale and the deduction of permit acquisition costs would counteract it. Second, if the emission reduction objective is represented by a constant share of emissions, a decreasing pattern in equilibrium prices would be produced, both in the no-taxation and in the taxation cases. The increasing price effect induced by the taxation of income from permit sale and the deduction of acquisition costs would counteract the decreasing price trend induced by the constant abatement objective. On the other hand, the deduction of abatement costs would imply a further decrease in prices with respect to the no-taxation case. The problem of the surplus in permit supply induced by the tax treatment when the firm are price-takers (caused by abatement cost deduction) may be sharpened by a constant or decreasing stringency of the reduction objective.

137. Turning to firm specific characteristics, the relative weight of abatement costs with respect to production costs is a relevant variable. If abatement costs are very high with respect to production costs, then the revenue from the sale of final output might not be high enough to guarantee positive profit for the abating firm. In this case, the firm would be induced to leave the market. The deduction of abatement costs may play a key role in influencing the decisions of firms operating very close to the margin where profit become nil in the presence of abatement activities. The way in which the deduction of both acquisition and abatement costs affects marginal abatement cost is fundamental to determine the overall effect on firm’s profit.

138. Strictly connected to the previous point, it is important to consider that firms may vary in their ability to pass on through increased product prices for final consumers the permit acquisition or abatement costs they pay. This does not change the choice between abating and buying permits (or between not abating and selling), but it can be assumed that a firm with a greater ability to pass-through additional costs would be less impacted by the different aspects of the tax treatment, since it would be able to transfer the MAC increases on final output prices. The variables examined in the four paragraphs above all affect the price elasticity of permit demand and supply. This is another confirmation of their relevance with respect to those aspects of the tax treatment which have an impact on the permit price. In fact, the effects of these variables on permit demand or supply would amplify or counteract the effect of taxation on the abatement decisions for both price-taker and price-maker firms, contributing to determine the overall effect on market clearing price in the second case.

139. Looking at the market features, the number of firms involved in the emission trading system may be relevant with respect to the impact of any inefficiencies created by tax treatment. In particular, if the market includes a large number of participants (making the market more competitive and facilitating market clearing), it may be easier to find a buyer for a surplus available for sale inefficiently created by the deduction of abatement cost. In the same way, it may be easier to find a seller for a surplus in permit demand induced by the deduction of permit acquisition cost. With respect to the presence of barriers to entry, they would be paradoxically more easily be removed if the tax treatment induces a surplus of permits for sale or makes the permit price lower.

140. The market form is also a relevant variable. In fact, the impact of taxation would change if we are in a perfectly competitive market, in a monopoly or in an oligopolistic market. For example, if the

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13 Analysing this issue would require a framework in which the separability assumption described in footnote 3 is removed.

14 In general, for eliminating barriers to entry for firms entering a sector covered by emission trading it is important that the government organises periodical auctions or set a reserve of permits to be allocated to new entrants.
emission trading is monopolistic on the side of market supply, then a firm selling permits will be a price-maker: it will increase the permit price to transfer onto it most of the increase in the MAC associated with the taxation of income from permit sale, and the final price will also be adjusted to reflect the decrease in MAC induced by the deduction of abatement costs. So a monopoly is likely to sharpen the price capitalisation effects induced by the tax treatment.

141. The role of these and other variables with respect to the impacts of tax treatment probably deserves more attention design of emission trading systems. For example, assigning a stricter objective (i.e. allocating less permits) to those sectors or firms which have a greater ability to pass on costs in consumer prices would reduce the impact of the tax treatment on firms, since they will be able to transfer part of it to output prices. In the example, at the end a broader price signal will be provided: consumers would reduce the consumption of polluting goods, and firms would be induced to produce less, respecting the cap more easily.

7. Future work

142. The previous section has noted a number of areas where further analysis could helpfully address more specific issues in the tax treatment of emission trading transactions, including some of the issues described in the previous literature review (COM/ENV/EPOC/CTPA/CFA(2011)36). For example, abatement cost deduction has specific features that are not taken into account in the current analysis. The analysis here implicitly assumes that abatement costs are period expenses, immediately deductible in the period incurred. The analysis would be somewhat complicated by consideration of capital expenses which provide benefits over multiple periods. It may be that as long as tax depreciation mirrors economic depreciation, however, the annual tax deductions could be appropriately modelled in the same way as single-period costs. Yale (2008) highlights that preferential tax depreciation rules (e.g., at rates faster than economic depreciation) for certain abatement options could impact regime efficiency.

143. Similarly, a differential tax treatment among different countries or jurisdictions may lead to tax-induced abatement displacement effects, affecting cross-country decisions about production levels and investments in abatement. The potential of sourcing rules for fiscal purposes could be better investigated. International tax treaties can provide a key contribution in a cap-and-trade context to ensure a harmonious interaction of national tax rules.

144. IETA (2010) highlights that firms involved in the EU ETS are currently free to choose their accounting method for emission permits. No formal recommendation for the accounting of EU ETS obligations has yet followed the publication of the international accounting guidance “Interpretation 3: Emission Rights” from the International Financial Reporting Interpretations Committee (IFRIC) in 2005. As a result, a diversity of accounting rules are seen in practice. A framework for analysing the different efficiency implications of the tax treatments of permits may provide some useful insights also for accounting purposes.

145. Further research could also be dedicated to evaluating the significance of how different variables affect the extent of a tax capitalisation effect and the relevance of tax-induced abatement displacement effects. This would, among other things, help addressing the broad question of what impact the income tax treatment of emission trading transactions has on the overall cost of achieving a fixed abatement target under a cap-and-trade program.
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