Principles of Emissions Trading

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Abstract

International emissions trading schemes include the Kyoto Protocol and the European Union Emissions Trading Scheme. This chapter documents the main principles behind the functioning of such permits markets, which represent popular environmental regulation tools. Among other design issues, this chapter discusses the various allocation mechanisms available to the regulator. Besides, this chapter underlines the role played by intertemporal flexibility mechanisms (e.g., banking and borrowing) which allow reducing overall compliance costs. Overall, the goal of this chapter is to present in standard textbook reference terms the construction of an emissions trading program, be it at the regional,

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national, or international level. The interested reader can gain valuable insights by referring to this core text, which contains a descriptive analysis of the main provisions that need to be taken care of when creating such an environmental market.

Keywords
Emissions trading • Allocation • Banking • Borrowing • Offset

Introduction

Emissions trading, or cap-and-trade program, consists in setting a quantitative limit for the emission of a given pollutant and to let the market decide on its price. How do emissions trading schemes work in practice? This chapter aims at answering this question, by casting light on the functioning mechanisms of tradable permits markets. Such markets have been created in order to be able to trade polluted assets, as if they were standard production goods. By diminishing the circulation of pollutants, environmental benefits can be awaited from such schemes. The first issue raised by the creation of a tradable permits market is linked to the distortions which can occur as a consequence of the initial allocation. Initial allocation is the amount of pollutant that is distributed to preexisting agents to start with. Whereas Hahn (1984) contributed first to this debate by demonstrating the non-neutrality of permits allocation for an agent able to exert market power[1] in a static context and concerning the spatial exchange of permits only, this chapter explicitly addresses the critical aspect of initial permits allocation in a dynamic context and concerning intertemporal emissions trading. It is important to bear in mind indeed that a permit can be exchanged across various geographical locations (e.g., from one country to another) but also through time (e.g., one firm transfers permits to the future or from the future). These different kinds of uses of permits are called, respectively, spatial exchange and intertemporal trading.

On tradable permits markets, banking refers to the possibility for agents to save unused permits for future use, while borrowing represents the possibility to borrow permits from future allocations for use in current period. Agents are a very generic term in economics which can represent individuals (e.g., consumers), firms, or governments. In our context, agents are mostly understood here as polluting firms. By allowing agents to arbitrate between actual and expected abatement costs over specific periods, banking and borrowing permits form another dimension of flexibility where agents can trade permits not only spatially but also through time. Abatement cost represents the cost to diminish the quantity of pollution by one unit. In a continuous time model under certainty, Rubin (1996) shows that an intertemporal equilibrium exists on a permits market from the viewpoint of the

[1]For an exhaustive literature review on permits trading and market power, see Petrakis et al. (1999).

regulator and the firm and that banking and borrowing allow firms to smooth emissions. Indeed, it is the role of the government (or the environmental agency) to manage the tradable permits market, which is an artificial construction coming from environmental policy. Regulator can therefore refer to the State or the environmental agency. Under uncertainty, Schennach (2000) shows the permits price may rise at a rate less than the discount rate and new public information may cause jumps in the price and emissions paths.

Such provisions enabled agents to smooth their emissions stream and played a key role in the success[2] of the US SO_2 or Acid Rain Program. Surprisingly, the inclusion of banking and borrowing does not appear as a cornerstone of new "grand policy experiments"[3] dealing with climate change.

We bridge this gap by analyzing the various effects of banking and borrowing that need to be accounted for when designing tradable permits markets. This instrument is described indeed as a double-edged sword in the literature. On the one hand, banking provides incentives to over-comply and leads to an intertemporal reallocation of emissions so as to reach lower social damages. On the other hand, borrowing may give agents with high abatement costs an incentive to delay costly investments in clean technologies by borrowing allowances from future periods and to concentrate emissions in early periods. For example, if it is costly to diminish pollution when extracting coal, firms will pollute on a business-as-usual basis at the beginning of the scheme (by borrowing future permits), and they will wait for technological innovations to diminish their quantity of pollution in the future (and the associated use of pollutants). However, more pollution has occurred in the present time, which is not the objective of the tradable permits market. That is why the provisions on banking and borrowing need to be carefully designed. While the total allocation of permits sets the present value of discounted permits prices, we will see that other effects on the permits price may arise when introducing an intertemporal trading ratio for banked and borrowed allowances. Discounted permits prices can be defined as the total value of a permit discounted through time (by applying discounting as it would apply to any savings account for individual banks).

We therefore address the following two key questions: What are the effects of the initial allocation mechanisms in emissions trading systems? What insights can we get from the existing literature concerning the use of banking and borrowing in tradable permits markets? To detail the impacts of banking and borrowing on environmental damages will also be a priority throughout our analysis.

The remainder of the chapter is structured as follows. Section "Initial Allocation Mechanics" provides a background discussion on the initial allocation mechanics.

[2]The notion of success may be approximated by various effects (preexisting regulatory environment, technology innovation and diffusion, reduction of regulatory uncertainty, aggregate cost savings, etc.), but we will focus on the efficiency of the permits price, i.e., its ability to reflect current information on spot and future prices.

[3]This expression was coined by Stavins (1998).

Section "Banking and Borrowing Provisions" deals with banking and borrowing provisions. Section "Additional Flexibility Mechanisms" introduces additional flexibility mechanisms. Section "Conclusion" concludes.

Initial Allocation Mechanics

This section addresses allocation design issues of existing international emissions trading schemes, namely, the Kyoto Protocol and the EU ETS.

The Kyoto Protocol

The Kyoto protocol is the first of its kind at the international level to introduce carbon trading, i.e., the exchange of carbon dioxide units worldwide. The question of the Kyoto Protocol as an "unfinished business" is often evoked. Very heterogenous sectors were included under the same regulation, which could be detrimental to find the right method to allocate permits depending on price elasticities between sectors.

Since there exists no historical data for carbon emission reduction cost, it may prove particularly difficult to induce a cost-effective allocation of the initial quotas to participating countries. In the context of the Kyoto Protocol, the case of countries supplied with allocations in excess of their actual needs has been coined as *hot air* in the literature.[4] The distribution of a large number of permits to Former Soviet Union (FSU) and Eastern Europe countries (Russia, the Ukraine forming two thirds) may be seen indeed as an imperfection of the Kyoto Protocol, as those countries were given generous allocations to foster agreement during the first phase (2008–2012). Market power concerns arise as industrial firms may benefit from the gap between their initial permits allocation (based on 1990 production levels) and their real emission needs in 2008 (after a period of recession), and the use of these permits surpluses remains unclear.

This situation emerged as a conflict between the internal and the external consistency of the permits market:

- The *internal* consistency refers to the situation where agents freely receive or bid for permits according to their real needs. The regulator may be interested however in distributing more permits to a country than strictly needed (according to business-as-usual emissions or a benchmark for instance) in order to ensure participation to the permits market.[5] As a consequence, one agent may achieve a dominant position which in turns threatens the efficiency of the permits market itself.

[4]See Baron (1999), Burniaux (1999), Bernard et al. (2003), Bohringer et al. (2006), Holtsmark (2003).

[5]Such negotiation with Russia was determinant for the Kyoto Protocol to enter into force on February 16, 2005.

- The *external* consistency of the permits market is linked to the broader debate of climate change as the purchase of a "global public good."[6] This altruistic view embodies the notions of "burden sharing" or "common but differentiated responsibilities"[7] attached to the Kyoto Protocol, whereby developed countries agree to spend a higher income share on fighting climate change than developing countries.[8]

Those conflicting views undermine the negotiation of the cap, which is fixed at a suboptimal level compared to what would be needed to minimize the total damage to the environment. The cap can be defined as the overall quantitative limit of pollutants that can be emitted. The regulator sets the cap, and the market defines the price of the permit. Greenhouse gas (GHG) emission targets under the Kyoto Protocol represent a mere 5 % reduction below 1990 levels. Now if early movers like EU countries are willing to ratchet down the cap, little progress can be achieved without luring in major players like the USA, India, and China. Thus, many difficulties arise to pierce the "veil of uncertainty" around international negotiation.[9]

The fact that the creation of a permits market gives some countries the opportunity to draw a financial advantage without a direct environmental gain (i.e., in the absence of effective emissions abatement) may be puzzling. Yet as stated by Maeda (2003),[10] "[this debate] seems misguided because it focuses on the political importance of the issue, rather than addressing it from an economic perspective."

Overall, the hypothesis that generous allocations that broaden the scope of a cap-and-trade program might also give birth to dominant positions shall not be neglected. Recall that in a cap-and-trade program, the regulator sets the cap, and agents freely exchange permits to define their price.

The European Union Emissions Trading Scheme

This section deals with possible design flaws in the allocation of permits on the European carbon market.

The EU ETS Design: An Overview

The European Union Emissions Trading Scheme (EU ETS) has been established by the European directive 2003–7: this regional trading system for CO_2 emissions

6 See Guesnerie (2006).

7 See Muller (2002).

8 Note that the implicit assumptions of the existence of such an environmental Kuznets curve (the environment is a superior good and environmental regulation becomes stricter through time at higher levels of GDP per capita) are left out of the debate.

9 See Kolstad (2005).

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covers, across the EU-27 member states, around 11,000 installations[11] representing close to 46 % of Europe's CO_2 emissions. In order to help EU member states to achieve their Kyoto target of reducing emissions by 8 % from those of 1990 level in 2008–2012, the European Union began this commitment in a pilot period from 2005 to 2008. The third European commitment period has started in 2013. Since 2005, the ETS operates independently of the Kyoto Protocol but has been linked to International Emissions Trading (IET) and other flexibility mechanisms in 2007. In this framework, the "Linking Directive" provides the recognition of Kyoto projects credits, Clean Development Mechanism and Joint Implementation credits from the second period in 2008, known as Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs), respectively, for compliance use within the EU ETS.[12] CERs are traded worldwide and not only in Europe as for the EU ETS. Therefore, they can be understood as world proxy for the carbon price.

The EU ETS draws on the US sulfur dioxide (SO_2)[13] trading system for much of its inspiration but relies much more heavily on decentralized decision-making for the allocation of emissions allowances and for the monitoring and management of sources (Kruger et al. 2007). Within the EU-wide Kyoto target, each member state has its own national emissions target as determined under the EU Burden-Sharing Agreement that defines each member state's emissions reduction obligation. Each country is required to develop a National Allocation Plan (NAP), which, among other design features, addresses the national emissions target. A NAP contains the amount of permits allocated to each firm for each country. Each member state has its own registry where changes in the portfolio of its companies are recorded. Furthermore, there is a European Central Administrator, the Community Independent Transaction Log, to oversee the registry systems that will be standardized under European legislation. In that registry, allocations are reflected along with the purchases and sales for each company of the country (Mansanet-Bataller et al. 2007).

The EU ETS is expected to allow for cheaper compliance with the targets under the Kyoto Protocol by letting participating companies buy/sell their emission allowances. In this institutional framework, an amount of two billion allowances has been created each year during phases I and II (before the shift to auctioning in phase III). The EU ETS has started during 2005–2007 with the phase I, followed by phase II during 2008–2012, and phase III during 2013–2020. The price of the allowance is established by the supply and demand of market participants and the level of the scarcity created by the initial allocation.

[11]The definition of an installation effected in the EU ETS is the same as for Integrated Pollution Prevention and Control (IPPC) that is a principal environmental regulatory directive in the EU. Installations are defined as a stationary technical unit where one or more activities covered by the EU ETS are carried out and any other directly associated activities, which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution.

[12]See Table 2 for a quick review of Kyoto units.

[13]The EU CO_2 emissions trading scheme was inspired by successful cap-and-trade programs for SO_2 and NOx in the USA (Ellerman and Montero 2007).

Over-allocation or Relative Success?

The EU ETS gently constrains emissions (8 % reduction for EU-27) so as to enforce a low carbon price. Yet the debate has shifted toward a possible over-allocation of permits. The production decisions of private actors are under scrutiny: do permits surpluses constitute a relative success (i.e., firms have reduced their emissions above projected levels) or an imperfection in the design of the system?

As long as governments continue to allocate allowances to existing facilities based on historic emissions, the scheme is flawed by a perverse "updating" incentive. Firms have indeed an incentive to delay early action in abatement technologies since higher emissions today will be rewarded with bigger allocations in future periods.

Buchner and Ellerman (2008) provide a first empirical assessment of the EU ETS allocation process based on 2005 emissions data. They estimate a slight over-allocation of 4 % during the first period of allocation, while there are strong signs that some emissions abatement measures have occurred. But the analysis is not straightforward since "*a long position is not per se evidence of over-allocation*."[14] The difference between 2005 allocation and verified emissions suggests too many allowances were allocated, but the benchmark against which this conclusion is reached may be biased by insufficient data reporting on emissions before 2005 and by a lack of comparability at the EU-wide level. Firms may also be long because of differences in marginal abatement costs or in expectations (regarding economic activity, energy prices, etc.) under uncertainty.

This section has provided an overview of two major tradable permits market along with their allocation methodology. It revealed a wide range of opportunities for strategic behavior in the design of international permit trading regimes. The presence of countries with large permits holdings increases the probability of price manipulation and the risk of efficiency loss in the allocation of abatement efforts between countries.

Banking and Borrowing Provisions

This section develops three kinds of issues surrounding banking and borrowing: *(i)* the environmental and economic effects, *(ii)* the distribution of the emissions stream through time, and *(iii)* the focus on the EU ETS experience (see also the paper by Chevallier (2012)).

Environmental and Economic Effects of Banking and Borrowing

We review the main effects of banking and borrowing provisions from the theoretical literature and empirical experiences on the environmental performance and

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economic efficiency. When abatement together with endowment of emission allowances is above emissions levels, then regulated industrials bank surplus allowances for potential later use. Thus, an allowance issued for one compliance period may be used by an affected unit for a later compliance period. In the same way, if regulated industrials do not abate enough to cover their emissions level with their allowances endowment, they may borrow allowances from the future allocation. We already know as Haites (2006) noted,[15] "*allowance banking provisions affect basically environmental performance, economic efficiency and market participants' behaviour*." Hence, the regulator's decision of allowing banking creates the significant effects listed below:

Environmental effects:

- Allowance banking and borrowing change the temporal pattern of emissions and may change aggregate emissions and can have environmental, including public health, effects. Allowance banking and borrowing should facilitate adjustment to changes in the emissions cap.
- Banking provisions could also affect the rate of noncompliance and the resulting excess emissions. Evidence suggesting that allowance banking increases the rate of noncompliance is limited. In their experiments, (Cason and Gangadharan 2006) found that allowance banking increases noncompliance and total emissions in a hypothetical scheme with weak enforcement.

Economic effects:

- Allowance banking links future allowance prices to the current ("spot") market price as stated by Maeda (2004).
- Allowance banking and borrowing should improve liquidity[16] in the allowance market. Allowance banking tends to increase the quantity of allowances available to the market and increase the volume of allowances traded. In their experiments, Godby et al. (2000) and Cason and Gangadharan (2006) find that allowance banking increases trading activity.
- Allowance banking and borrowing should improve price stability. If banking is not allowed, allowance prices are likely to be unstable at the end of each compliance period. With no banking, if actual emissions are lower than the cap for the compliance period, the price of allowances should fall to zero at the end of the period since any remaining allowances have no value. With no banking, if actual emissions are higher than the cap for the compliance period, the price of allowances should rise sharply at the end of the period. Allowance banking should dampen such end-of-period price fluctuations and improve price stability.

[15]p. 7

[16]The liquidity market is defined as a market where a large volume of trades can be immediately executed with minimum effect on price (Kyle 1985).

These theoretical considerations on the banking provisions are also supported by Ellerman et al. (2000) on the US Acid Rain Program and by the results of a business simulation game and controlled experiments (Schleich et al. 2006) on the EU ETS. The US Acid Rain Program has been one of the most successful attempts to introduce tradable permits markets in environmental policy. That is why the EU ETS draws mostly on it.

The US Acid Rain Program provided empirical support to the view that market-based instruments may be more environmentally efficient than command and control regulation. SO_2 emissions fell, and the program was characterized by a quick implementation, a positive role of banking (twice as much as required), a good compliance, and no hot spots.[17] These optimistic results may be limited to flow pollutants since for stock pollutants like CO_2, the incentive to abate is less temporally and spatially constraining.

As documented by Ellerman and Montero (2007)[18] for the US SO_2 Program, "*banking of allowances remains the predominant form of emissions trading in Phase I (. . .) nearly three-quarters of the 9.5 million allowances freed up for emissions trading in the first three years of Phase I were banked for later use in Phase II*." This citation confirms the view of banking and borrowing as a key determinant for the success of a program.

In fact, the salient example is the US Acid Rain Program, where banking has been a major form of emissions trading (Ellerman and Montero 2007; Ellerman et al. 2000). During the first 5 years of the program constituting phase I, 1995–1999, only 26.4 million of the 38.1 million permits distributed were used to cover emissions. The remaining 11.65 million allowances (30 % of all the distributed allowances) were banked and have been gradually consumed during phase II (2000 and beyond). As a result, the phase II cap was expected to be reached sometime between 2008 and 2010. Ellerman et al. (2000) analyze in depth the efficiency of this banking behavior in the Acid Rain SO_2 program. The economically optimal level of banking depends first on the SO_2 emissions in the absence of the trading scheme, second on the SO_2 emission reduction cost function, and third on the discount rate. Using ranges of reasonable values for the discount rate and the rate of growth of SO_2 emissions in the absence of the trading scheme, Ellerman et al. (2008) find that banking behavior has been reasonably efficient during phase I and the first few years of phase II. We report in Table 1 the main features of banking provisions in existing trading schemes.

In a game simulation of the EU ETS, Ehrhart et al. (2005) find that a ban on banking pre-2008 allowances into 2008–2012 leads to an inefficient adjustment to the more stringent cap assumed for the latter period. In their simulation of the EU Emissions Trading Scheme, the ban on banking leads to a low price for allowances during 2005–2007 and underinvestment in emission reduction measures. The more stringent cap triggers a price spike during 2008 and 2009. The higher allowance

[17] Typically, the *cheapest* abatement source is found where the *larger* sources are located.

[18] p. 161

Table 1 Summary of banking provisions and liquidity data for different emissions trading schemes

Scheme	Gas	Banking and related provisions	Bank amount	Allowances traded as % of annual emissions
Current emissions trading schemes				
Acid Rain Program for electric utilities	SO_2	No limit on allowance banking	11.62 million	75–180 %
RECLAIM (Greater Los Angeles Area)	NOx	No allowance banking; can sell surplus allowances to a buyer with a later compliance deadline and buy allowances with a later vintage	0	20–125 %
	SOx	idem	0	10–105 %
Future emissions trading scheme				
Kyoto mechanisms	GHGs	Banking of different units from 2008–2012 period to the subsequent commitment period is restricted as follows:		
		RMUs may not be carried over		
		ERUs, which have not been converted from RMUs, may be carried over up to a maximum of 2.5 % of the party's assigned amount		
		CERs may be carried over up to a maximum of 2.5 % of the party's assigned amount		
		CERs and lCERs may not be carried over		
		AAUs may be carried over without restriction		
		The quantities of RMUs, ERUs, CERs, tCERs, and lCERs are likely to be small relative to the quantity of AAUs, so the banking restrictions can effectively be avoided by using units other than AAUs first for compliance and then banking surplus AAUs		

prices induce overinvestment in emission reduction measures, which causes the price to fall back to the optimal level by 2012.

The comparison of the banking case with the banning banking case is based on the assumption that prices will develop differently in the two cases (Ehrhart et al. 2005):

- If banking is allowed, it is reasonable (under some assumptions like participants having complete information and emission targets being known) to expect that the price development does not exceed Hotelling's rule (i.e., prices develop according to the interest rate or more slowly). Otherwise, arbitrage between periods is possible (Kling and Rubin 1997). In practice, excess emissions permits can be saved for future use or present emissions can be extended for future abatement. As a result, the permit price becomes arbitraged over time.
- In the banning banking case, a lower price is assumed in the first period than in the free banking period case because first period allowances cover only one period instead of two. Analogously, the price in the second period is assumed to be higher due to increasing scarcity of allowances in comparison to the banking case.

Distribution of the Emissions Stream Through Time

Another question needs to be addressed when assessing the relative merits of allowing banking and borrowing in tradable permits systems: how do firms adjust their emissions stream when they benefit from the possibility to freely bank and borrow permits?

A key issue lies in the discount rate picked by firms. Higher or lower discount rates imply respectively more or less borrowing, while a zero discount rate leads to the same level of pollution at each period.

Our analysis therefore highlights potential *negative* consequences of the use of unrestricted borrowing: the concentration of emissions on early periods by delaying abatement decisions and borrowing may aggravate environmental harm. The positive effects of banking on total present environmental damages are reversed, and the level of global pollution is higher than in a situation without borrowing.

Concerning banking, firms invest in abatement technologies and bank allowances when they anticipate an increase in abatement costs superior to the discount rate; otherwise they would not bear additional abatement costs in the current period. This mechanism corresponds to a situation where standards are stricter through time, which is often the case. In the presence of a convex damage function coming from emissions and stricter future standards, the decision to allow banking *reduces* social damages.

This *positive* effect of banking counterbalances the negative aspects of borrowing detailed above and gives us a more precise picture of the task of the regulator when tailoring regulation for permit trading systems. When social damages are an increasing function of the pollution level at time t, our policy recommendation consists in authorizing banking and enforcing stricter pollution standards through time. When the cap is constant or becomes less constraining, the decision to allow borrowing leads to either increasing social damages or decreasing costs for firms.

We have seen how permits alter the *timing* and the *magnitude* of marginal damages. We address in the next paragraph the question of introducing a non-unitary Intertemporal Trading Ratio (ITR) including interests on banking and discouraging borrowing to correct these unwanted permits path.

On the Use of the Intertemporal Trading Ratio

In this section, we evaluate the merits of a modified model of banking and borrowing that explicitly takes into account the distribution of the emissions stream through time. Using the interest rate on allowance balances, the regulator may change the time profile and cumulative quantity to approximate more nearly the social optimum.

There are two sources of inefficiencies that might affect the social optimum:

1. The discount rate used by firms
2. The fact that total damages depend on the distribution of the emissions stream through time

A modified banking system may correct the first type of inefficiency highlighted above, but not necessarily the second type.

Due to the effect of discounting future abatement costs, we need to penalize borrowing by an ITR exogenously chosen by the regulator[19] so that if firms borrow a lot of allowances in early periods, they will reimburse more allowances than actually used in the next period.

This "banking and restricted borrowing" according to Kling and Rubin's (1997) contribution yields the following comments:

- Setting $ITR < 1$ provides an efficient incentive to banking, since firms need to reimburse **more** allowances in second period than were borrowed in first period.
- The weight of debt is greater under a modified banking system than under the original system.
- Such a modified banking and borrowing system allows the private and social solutions to converge, assuming constant and linear social damages.

Assuming both banking and borrowing are allowed and there is a positive private discount rate, the introduction of an ITR yields:

- Concerning banking, the opportunity cost of not using the permit is compensated by the ITR payment.
- Concerning borrowing, for each ton of CO_2 non-abated, the gain from agents' private interest rate is reduced by the ITR.
- The primary effect of a nonzero ITR is on time profile, not quantities: there is a change in marginal stock damages over time (more banking and less borrowing relative to a permit system without ITR) and a small effect on quantities intertemporally exchanged.

For greenhouse gases, the optimal rate of intertemporal substitution has been suggested by Leiby and Rubin (2001) as being "*the ratio of current marginal stock damages to the discounted future value of marginal stock damages less the decay rate of emissions in the atmosphere*[20]," increased by the difference between the firm's discount rate and the social planner's discount rate. This result is obtained in a different setting since they distinguish between *flow* (emissions flow) and *stock* (accumulated) pollutants. Typically, CO_2 emissions are characterized by stock damages that do not stop at the end of the program.

We have seen in this section that the correct determination of the intertemporal discount rate may yield greater efficiency gains. With reference to the discussion on the intertemporal trading ratio above, we may cite several time devices used in

[19]Kling and Rubin (1997) suggest the implementation of a discount rate equal to the industry average rate of interest used to finance medium-term capital expenditures (p. 112).

[20]p. 251

tradable permits programs: the Progressive Flow Control in the US Northeastern NOx Budget Program, changed redemption ratios in US Clean Air Interstate Rule (2:1 from 2010; 3:1 from 2015), and growth indexed caps.

To sum up, characteristic features of intertemporal emissions trading include the fact that at the equilibrium abatement costs are equalized among sources and that the distribution of emissions through time need not yield to a concentration in early periods. The decision to allow or not borrowing depends on the arbitrage between the firm's cost efficiency and a higher pressure on the environment. Firms tend to use borrowing if the environmental constraint is constant or does not become a lot stricter over time. That is why it is recommended to introduce a discount rate specific to borrowed allowances.

Prospective Use of Banking and Borrowing in the Kyoto Protocol

This section offers a description of the possible use of banking and borrowing in the Kyoto Protocol. On the one hand, provisions on banking are cited by Klepper and Peterson (2005)[21]: "*Assigned Amount Units (AAUs) resulting from the Kyoto commitment can be banked without a time constraint. Credits from Joint Implementation (JI) or Clean Development Mechanism (CDM) can be banked up to a limit of, respectively, 2.5 % and 5 % of a Party's initial assigned amount. Sink credits can not be banked.*"

On the other hand, implicit provisions on borrowing may be found in the United Nations Framework Convention on Climate Change or UNFCCC (2000) report.[22] As explained by Newell et al. (2005)[23]: "*International climate policy discussions have implicitly included borrowing within possible consequences for noncompliance under the Kyoto Protocol, through the payback of excess tons with a penalty (*i.e.*, interest).*" This penalty could be fixed to 40 % of additional emissions reduction for the next period of the Kyoto Protocol despite uncertainties regarding the enforcement of this particular provision. This question is addressed in depth by Alberola and Chevallier (2009).

In the next section, we discuss the efficiency of the EU ETS intertemporal market. We also question the presence of institutional learning in the EU ETS.

A Focus on the EU ETS Experience

The EUA price path reflected the evolution of market participants' expectations about the scarcity of allowances. Beginning at 8€ on January 1, 2005, EUA prices increased to around 30€ in July 2005, fluctuated during the six following months in the range from 20€ to 25€, then to 30€ until the end of April. This price development surprised most experts and market participants. According to

[21]p. 295

[22]Paragraph II.XV

[23]p. 149

Sijm et al. (2005), the increase was largely due to political decisions on unpredictably strict national allocation plans, but the market reaction was to some extent exaggerated. Behind the price increase there were also high fuel prices, cold weather, the absence of suppliers in the market, and uncertainty about the political environment (Lecocq and Kapoor 2005). The price fell suddenly at the end of June because of weaker UK gas price and the entrance of Czech Republic into the market. The price fluctuated around 21–23€ for the rest of the year. At the beginning of 2006, the price increased to way above 25€ in consequence of cold weather and high fuel prices. For a couple of months the price stabilized, and then it reached a maximum of over 30€ in April driven by fuel prices.

Around April 25, 2006, first rumors occurred about contents of the national emissions reports for the first year of compliance by the EU member states. The official publication of these emissions reports on May 15 verified the rumors. It became apparent that the market was not as short as expected; especially the power producer needed less EUAs than anticipated (Seifert et al. 2008). The release of the emissions data had a market effect on EUA prices, causing a sharp break in the price of all maturities of EUAs. There were further less severe price fluctuations until the complete data were released on May 15; however, the essential adjustment was made in these 4 days, and after May 15, the spot price remained close to 15€ until late September when a further less-pronounced adjustment occurred.

As noted by Buchner and Ellerman (2008), "*this price "collapse" demonstrated a readily observable characteristic of markets of reacting quickly (and from the standpoint of some, brutally) to relevant information*." This is a significant sign of the informational efficiency of the EU ETS. The EUA market can be considered as efficient if prices fully reflect all available relevant information divulged. And there should be no doubt that the release of reliable information concerning emissions covered by a cap-and-trade program is highly relevant. According always to Buchner and Ellerman (2008),[24] "*one plausible explanation is that market observers had over-estimated the level of CO_2 emissions and the demand for allowances caused by rising real output, the adverse weather in 2005, and the higher prices for natural gas relative to coal. But, another more intriguing possibility is that market observers under-estimated the amount of abatement that would occur in the first year of the EU ETS (. . .)*." The cap is always known, but until the release of aggregate emission data, no one has a really good idea of either the level of aggregate emissions or how much emission reduction/abatement is required to comply with the cap. The same phenomenon was observed in the US SO_2 emissions trading program when the first auction revealed emissions and the implied demand for allowances to be much less than expected (Ellerman et al. 2000). Each year, the European Commission will disclose the verified emissions, playing the role of a "banker." After a new increase to 20€ in June, EUA prices stabilized in a range from 15€ to 17€ and then, in consequence of a less cold winter, they have been

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declining these last 3 months. Recall that European Union Allowances are the carbon trading unit that is exchanged under the EU carbon permit scheme for each ton of carbon dioxide emitted in the atmosphere.

With two trading periods, EU ETS futures markets are divided in two segments which respond to two distinct fundamentals. As it approached the end of 2007, the EU ETS was characterized by two price signals responding to different dynamics, because of the very limited opportunity to carry over unused EUAs from phase I to phase II. While the prices of spot and futures contracts for the first period were down sharply, the prices of futures contracts for the second period surpassed 18€/t. This increase of the second period allowance price is primarily due to institutional factors: the European Commission issued its opinion on ten National Allowances Plans for the second period since the end of November 2006. In doing so, it established the basis for the institutional framework for 2008–2012 and gave indications regarding three factors that will have a decisive effect on the allowance price:

- The Commission has requested that the allowances awarded to installations be reduced. The Commission also reaffirmed its rejection of ex post allowances based on adjusted projections of growth and emissions. Brussels has therefore sent a clear signal of the scarcity of the allowances that will be available in 2008–2012.
- The possible carryover of unused allowances from the first to the second period ("banking") is now subject to conditions that are so restrictive as to make it practically impossible. Nevertheless, banking between the second and subsequent periods is still permitted, which could further increase the scarcity of allowances in 2008–2012.
- The use of credits originating from project mechanisms created by the Kyoto Protocol (JI and CDM) has been significantly restricted. Ireland has thus been forced to reduce its ceiling from 50 % to 21 %, which corresponds to 35 $MtCO_2$ less over the period; Sweden will have to reduce its own ceiling from 20 % to 10 %, i.e., 11 Mt CO_2 less than planned.

As Ellerman and Parsons (2006) noted,[25] "*it is virtually certain that the EU ETS will then be either long or short; the likelihood of a perfect match between 1st period EUAs and emissions are extremely small. This binary outcome places a limit on 1st period prices that, when coupled with the constraint on inter-period banking, allows a probability of shortage to be calculated taking into account all the uncertainties weather, economic growth, energy prices, and the abatement response to carbon prices.*" Without banking between the two trading periods, they measure the probability of shortage at any point in time by the ratio of the first period price to the second period price plus 40€, which represents the penalty. The penalty will be 100€ thereafter and companies will also have to surrender a compensating amount of allowances.

[25] p. 1

To wrap up, during the first 3 years, banking and borrowing of allowances are allowed. Therefore, we can expect that first period CO_2 prices follow Hotelling's rule which in its simplest model predicts that, under perfect information, the price of an exhaustible resource will rise at the rate of interest r. However, in the case of the ban of banking between the two periods 2005–2007 and 2008–2012, we highlighted a total disconnection between each exchange market and a decline of the first period prices.

Evidence of Institutional Learning Within the EU ETS

The previous discussion suggests that EUA prices are affected by institutional events such as the simultaneous release in April 2006 of 2005 verified emissions by the Walloon Region of Belgium, France, and Spain. Trading based on information before this price adjustment may be characterized as hazardous or speculative, and only these 2005 verified emissions could give a hint about the long and short positions at the installation level. Most of the verified emissions were reported by mid-May. The fact that the EUA price responded quickly to such relevant information may be interpreted as a strong sign of the efficiency of the intertemporal market in the EU ETS. The EU Commission has greatly learned from the 2005–2007 warm-up period. Namely, most of the issues regarding banking and borrowing have been fixed between 2007 and 2008. The transition from phase II to phase III has mostly been characterized by a change in the allocation methodology, going from free allocation (i.e., grandfathering) to actually having to bid for permits (i.e., auctioning).

Additional Flexibility Mechanisms

In this section, we highlight the possibility for firms to achieve their abatement targets not only by intertemporal emissions trading but also by getting credits from projects (Clean Development Mechanism, Joint Implementation, Domestic Offset). Firms may also take advantage of other tradable permits markets options designed to stabilize prices, such as a safety valve or minimum-price auctioning. Table 2 provides a useful glossary of Kyoto units.

Clean Development Mechanism and Joint Implementation

Projects provide more flexibility to operators to fulfill their obligations and increase market liquidity. The use of credits generated by projects, additionally to the number of allowances distributed, may reduce EUA prices even in the presence of high transaction costs for early projects. It also enlarges the range of abatement opportunities for firms and may lower the compliance costs if it is cheaper to invest in JI or CDM projects than trading.

But this hypothesis crucially depends on the relative price of credits, the possibility to access project credits at a lower cost than through trading on the

Table 2 Glossary of Kyoto units

Assigned Amount Unit	AAU means a unit derived from an Annex 1 Party's assigned amount. They are tradable units that Annex 1 Parties may count toward compliance with their emissions target. Each AAU is equal to one ton of carbon dioxide equivalent gases
Certified Emission Reduction	CER means a unit issued pursuant to Article 12 of the Kyoto Protocol. These are tradable units generated by projects in non-Annex 1 Parties under the Clean Development Mechanism. They may be counted by Annex 1 Parties toward compliance with their UN and EU emissions target and are equal to one ton of carbon dioxide equivalent gases
Emission Reduction Unit	ERU is a unit issued pursuant to Article 6 of the Kyoto Protocol. These are tradable units generated by projects in Annex 1 Parties under Joint Implementation. Annex 1 Parties may count them toward compliance with their emissions target. Each ERU is equal to one ton of carbon dioxide equivalent gases
Removal Unit	RMU is a tradable unit issued on the basis of removals of greenhouse gases from the atmosphere through LULUCF activities under Articles 3.3 and 3.4 of the Kyoto Protocol. Annex 1 Parties may count them toward compliance with their emissions target. Each RMU is equal to one ton of carbon dioxide equivalent gases.

Note: These are units derived from Annex 1 Party's emissions target under the Kyoto Protocol. They may be counted by Annex 1 Parties toward compliance with their emissions target and are equal to one ton of carbon dioxide equivalent gases. AAUs, RMUs, ERUs, and CERs are Kyoto units.

market, and the size of the firm (due to informational and administrative requirements). If banking allows to reduce uncertainty on the delivery of CDM or JI projects, those two instruments may be complementary.

From the viewpoint of economic rationality, carbon assets delivered by projects (be it AAUs, EUAs, CERs, or ERUs) should be fungible. This question implies creating gateways between different frameworks. As the second period of the EU ETS coincides with the first commitment period of the Kyoto Protocol, every transaction of EUA is simultaneously backed by a transfer of AAU between the registries of the different countries concerned. The Linking Directive recognizes JI/CDM credits as equivalent to EU ETS allowances. To maintain a single currency within the EU ETS, the participant delivers project credit to the national authority and gets issued an allowance in exchange for it.

Since credits from the CDM projects can be used for compliance during both phases of the EU ETS,[26] they should cap the price of 2008 allowances and provide a better long-term price signal than the price of 2005–2007 allowances to guide decisions as to which emission reduction measures are cost-effective during 2005–2007. No JI credits are available before 2008.

In this context of interlinked schemes at the regional and international levels, the price stabilization properties of banking and borrowing may prove to be useful to convey a unique carbon price. Next, let us discuss innovative schemes at the domestic level.

[26]As soon as they are connected by the International Transaction Log

Domestic Offset Projects

According to Egenhofer and Fujiwara (2007), "*domestic offset projects (DOPs) mirror the concept of project mechanisms articulated in the Kyoto Protocol, but are used within the home country to reduce emissions in the non trading sectors*."

Those voluntary agreements may incentivize low cost reductions in non-ETS sectors that were not identified previously due to the diffuse nature of polluters, provided the reductions are additional. In return, installations get credits in their respective carbon market.

To overcome the potential complexities of administrative requirements for small units and to keep transaction costs at low levels, there is a need for pilot schemes with simplified rules for additionality, baselines, and discounting and that allow pooling.

Some examples may already be found in New Zealand, New South Wales (NSW 2006), and proposals have emerged in Canada (Bramley 2003) and in the USA at the regional level.[27]

An experimental scheme is currently being implemented in France by the CDC Climat. Eligible projects have a concentration on waste, renewable energies, agriculture, and forestry but also concern the sectors of transport and energy efficiency. Within the JI framework, the CDC Climat selects for each project a foreign partner and will buy at a predetermined price ERUs that will be granted by the French government. The upper limit is set to five million ton equivalent CO_2 between 2008 and 2012. Those emission reduction projects will impact the Kyoto target by an equivalent reduction in the national inventory.

Such an innovative scheme is designed to foster the discovery of new low-cost emission reduction sources at the national level. However, its development may be hampered by the EUA price volatility that we commented above. That is why we recommend the adoption of a clear EU-wide institutional framework where a careful use of banking and borrowing may contribute to dampen allowance price fluctuations.

Next, we discuss another flexibility mechanism to limit price volatility called a safety valve.

Safety Valve

Some propositions to cope with the EUA price volatility deal with the inclusion of a "safety valve" in the EU ETS.

A safety valve is a hybrid instrument to limit the cost of capping emissions at some target level whereby the regulator offers to sell permits in whatever quantity at a predetermined price. If prices are greater than expected, the marginal cost of

[27]See for instance the Regional Greenhouse Gas Initiative at *http://www.rggi.org/* and a review of regional initiatives by Roy (2007).

abatement would be limited to the safety valve price. The regulator tries to set the emissions cap at a level where the expected marginal cost of meeting the constraint will match the beliefs about marginal benefits. To avoid being too far away on the high-cost side, the regulator includes a provision to sell emissions permits at some price near that expected cost level.

Jacoby and Ellerman (2004) report this idea emerged out of discussions in the USA around the costs related to the Kyoto Protocol as a way of raising the likelihood of Protocol's ratification by blunting criticism that the cost of meeting the Kyoto targets would be too high. The best example to date of a system that would have required a safety valve is the RECLAIM Program in California.[28]

The inclusion of a safety valve to a tradable permits market is not new, despite strong criticisms about this instrument:

- If the safety valve price is too high, it will have no effect.
- If the safety valve is too low, the quantity constraint is not binding anymore and may be associated with a permanent tax.
- There is a potential loss of "environmental integrity," i.e., a fear of relaxing toward target reduction instead of supporting economically efficient implementation.

These negative effects lead us to be skeptical about the inclusion of a safety valve as a policy recommendation for the EU ETS.

Finally, we discuss another flexibility mechanism linked to the allocation process.

Minimum-Price Auctioning

To improve the stability of EUA pricing during 2005–2012 (before the shift to auctioning), the National Allocation Plans may have included a provision to allocate permits not only by grandfathering, whose "updating" effects based on past emissions may be detrimental to the efficiency of the scheme, but also by auctioning. While it is beyond the scope of this paper to deal with auctioning mechanisms in detail, it is worth emphasizing the benefits of a specific technique called "minimum-price auction" whereby governments could fix a minimum bid level that would serve as a price floor.

[28]According to Harrison (2003), this multisource program regulating SO_2 and NO_x emissions had overlapping control cycles and trading between control groups, so de facto 6-month banking and borrowing. But the temporal flexibility was not enough for such a limited geographic scope, and as unusual weather conditions and lack of new capacity placed high demand on existing units, the permit price rose from $5,000 to $90,000 per ton, i.e., multiplied by 18. The disconnection of electricity and environmental markets associated with other program design failures led the State to eventually take over and provide adequate electricity supply. At the same time, prices of future vintages (borrowing) revealed the short-term nature of the crisis and recognized that it was an unusual case. This experience raises the question of adding several sectors in the same permit market like the EU ETS: wouldn't it be preferable to have different prices for different markets?

Such an allocation process requires a certain degree of coordination between member states on basic auction rules, while the Commission supervises its enforcement as for each NAP. This device guarantees that prices will not drop below a predetermined level and helps restoring confidence in the efficiency of the EU ETS for market participants. But it needs to be configured in accordance to the quantitative limit on projects that might enter the EU ETS for instance.

In this section, we stressed that the banking and borrowing mechanisms should not be seen in isolation of other flexibility mechanisms that firms could use to achieve compliance at a lower cost. Those include mainly projects (JI, CDM, DOP), whose efficiency may be increased by a careful use of banking and borrowing. We discard the use of a safety valve as a useful flexibility mechanism, but we recommend political savvy in auctioning permits using a minimum price.

Conclusion

This chapter summarizes the main functioning principles of tradable permits markets for use in environmental regulation along two dimensions: initial allocation and intertemporal trading.

Among the international emissions trading schemes, we may cite the Kyoto Protocol and the EU ETS. From a political economy perspective, this chapter highlights the difficulties encountered by the European Commission during the validation of the EU ETS Second National Allocation Plans where each national regulator needs to arbitrate between various interests at stakes and reveals the necessary compromise that needs to be found between various conceptions on the role of environmental regulation.

The negotiation process of each NAP at the member state level is typically an example of a manipulable rule whereby industries may conduct lobbying activities to extract more permits as a monopoly rent. With reference to the debate "rules versus discretion" in monetary economics, this unhealthy lobbying by major industries calls for further research to ascertain the conditions under which it would be optimal to delegate the determination of the cap and the distribution of permits to an independent agency (Helm et al. 2003).

Regarding intertemporal flexibility, the theoretical studies agreed on the fact that when it is effective, banking and borrowing allow a reduction of climate policies costs. The incentive to bank emerges more especially with more stringent future environmental targets. Our review of the main theoretical results on the use of banking and borrowing for tradable permits markets provides a balanced picture of the pros and the cons of this instrument: while banking provides incentives for early compliance, unrestricted borrowing may aggravate the environmental harm by a concentration of the emissions stream over specific periods.

Combined with generous and free permits endowments, this situation confirms the view that the EU ETS is only "warming up" in its first phase at the expense of suboptimal abatement choices. The regulator could adopt an intertemporal trading ratio specific to borrowing as discussed by Kling and Rubin (1997), allowing for a better grasp of the possibilities offered by intertemporal emissions trading.

Indeed, a greater reliance on banking and limited borrowing (i.e., with a specific discounting factor) should be promoted to allow firms to smooth their emissions and take investment decisions in abatement technologies with a better capacity to react to the evolution of the carbon constraint over time.

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