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European Greenhouse Gas Emissions Trading: A System in Transition*

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To inform processes of policy development and implementation, climate change research needs to focus on improving the prediction of those variables that are most relevant to economic, social, and environmental effects. In turn, the greenhouse gas and atmospheric aerosol assumptions underlying climate analysis need to be related to the economic, technological, and political forces that drive emissions, and to the results of international agreements and mitigation. Further, assessments of possible societal and ecosystem impacts, and analysis of mitigation strategies, need to be based on realistic evaluation of the uncertainties of climate science.

This reprint is one of a series intended to communicate research results and improve public understanding of climate issues, thereby contributing to informed debate about the climate issue, the uncertainties, and the economic and social implications of policy alternatives.

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INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC) was ratified by 154 countries in 1992 with the ultimate objective to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level which prevents dangerous interference with the climate system. In 1997 the Kyoto Protocol to the UNFCCC was adopted, where a set of industrialized countries agreed to limit their greenhouse gas emissions. The Protocol entered into force in 2005 imposing emission limits for 2008 to 2012. In negotiations leading up to the Protocol, the US was the leading proponent of international emissions trading, with the European Union initially reluctantly agreeing to this inclusion. The US withdrawal from the Protocol has greatly changed the nature of the agreement. One interesting turn is that the European Union has now fully embraced emissions trading, establishing in 2003 (EC, 2003) the Emission Trading Scheme (ETS). It will run for the three year period of 2005 to 2007 with the intent of helping to prepare its member states to achieve compliance with their international commitments in 2008 to 2012 under the Kyoto Protocol. This is the first serious effort anywhere in the world to establish a cap and trade system for greenhouse gas emissions and the performance of the system is being widely watched.

The ETS was designed as a test system, and in so doing the goal from the start was to establish a relatively mild reduction requirement so that basic operations such as establishing registries and becoming familiar with the trading instrument could occur while the financial stakes were relatively low. Establishing the National Allocation Plans (NAPs) for countries has been a difficult process of negotiations between member states and the European Commission which had final approval. Just how binding the allocations would be has only gradually come into focus, but based on the estimates of the member states themselves the reductions for major countries approved early in the process was in the order of 1 percent below projected reference emissions. Countries, whose NAPs were submitted and approved later, eventually fell in line with early submitters, sometimes under pressure from the EC to reduce allocations where it was argued that initial NAPs would convey unfair competitive advantage to firms in some of the member states. Thus most analysts concluded the ETS caps would be hardly binding and the carbon prices would be very low. One attempt to measure expected carbon prices reported a median expectation of 5.50€/tCO_2 with a low and high range of 2.50 and 10.00€/tCO_2 (Pew Center, 2005, reporting results of an ongoing survey of expected prices conducted by Point Carbon). This was the expectation reported as of December 2003 before the system went into effect. Median expectations as of April 2005 reported by the same survey, when the market price was in the range of 15 to 18€/tCO_2, remained at 7.00€/tCO_2 although the high end expectation was 45€/tCO_2. Thus, observers, at least those represented in this survey, remained somewhat sceptical that the relatively high price would be supported over the longer term. One early study (See, 2005) used Monte Carlo analysis to estimated probability density function for the permit price for the ETS. Under several variants of the Monte Carlo analysis, he found the median carbon price to be under 0.5€/tCO_2 with a maximum price over all variants less than 7€/tCO_2. This study was concluded before recent downward adjustments in some countries caps.

The actual trading prices under the ETS thus have been a surprise for analysts, settling in around 20 to 25€/tCO_2 (~70 to 90 €/tC) by mid- to late 2005 having approached 30€/tCO_2 (110€/tC) in July. To put these prices in context, it is useful to contrast these with projections of the carbon price required to meet the Kyoto Protocol in its early versions before the US withdrew. At this stage, the Protocol initially envisioned that Parties would by 2008 to 2012 reduce emissions to 5 percent below 1990 levels. With continued economic growth this was widely projected to be a reduction on the order of 20 percent from reference emissions (i.e., what emissions would have been by that time in the absence of mitigation efforts). A comparison of several key models showed that 7 of 11 models estimated the carbon price needed to meet the approximately 20 percent Kyoto cut to be in the range of 20-35€/tCO_2[1] (Weyant and Hill, 1999), which is about the current trading price range for the ETS. One of the studies in that comparison estimated a lower price, and three estimated a higher carbon price but nothing that would suggest that a one percent cut might lead to a price of 20€/tCO_2 or more.

The ETS is still evolving. At the time of writing we are only partway through the first year of the three-year program, rules are still being defined, registries are still being established, market participants have little experience with the permit trading, the volume of trade is small, and expectations about the future of emissions trading in Europe beyond the ETS may be driving current prices. Further information about current ETS structure and issues related to carbon allocations can be found in Reilly and Paltsev (2005). The EC maintains the web site (http://europa.eu.int/comm/environment/climat/emission_plans.htm) with links to countries' NAPs. More information on the initial assessment of NAPs can also be found in Betz *et al.* (2004) and Zetterberg *et al.* (2004).

This chapter is an early attempt to contrast projections of carbon prices in the ETS period with actual prices to date, and speculate on what could explain the huge gap. The chapter is organized as follows. Section 2 describes the version of the EPPA model used here. Section 3 first reports the results of the central EPPA projections, and then we speculate on reasons for the gap between these results and market prices, supplementing this speculation with additional model analysis where possible. Section 4 offers some conclusions and final thoughts.

EPPA–EURO MODEL

The ETS establishes a framework for trading in carbon dioxide (CO_2) emissions across the original EU-15 nations and the 10 accession countries (Table 4.1). The ETS runs from 2005 to 2007 and covers large emitters in the power and heat generation and in selected energy-intensive industrial sectors: combustion plants, oil refineries, coke ovens, iron and steel plants and factories making cement, glass, lime, bricks, ceramics, pulp and paper. To analyze the ETS, we apply the MIT Emissions Prediction and Policy Analysis (EPPA) model (Babiker *et al.*, 2001, Paltsev, *et al.*, 2005). EPPA is a recursive-dynamic multi-regional general equilibrium model of the world economy. The EPPA model is part of a larger Integrated Global Simulation Model (IGSM) that predicts the climate and ecosystem impacts of greenhouse gas emissions (Sokolov *et al.*, 2005), but for this study is run in stand-alone mode, without the full IGSM.

The EPPA model is built on the GTAP data set, which accommodates a consistent representation of energy markets in physical units as well as detailed accounts of regional production and bilateral trade flows. Besides the GTAP data set, EPPA uses additional data for greenhouse gas (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) and urban gas (SO_2, NO_x, CO, NH_3, VOC, black carbon, and organic carbon) emissions. For use in the main version of the EPPA model the GTAP dataset is aggregated into the 16 regions and 10 sectors (Paltsev *et al.*, 2005). In order to represent the ETS in the EPPA model, we introduce additional regional disaggregation, where Europe (EUR) and Eastern Europe (EET) are disaggregated into 12 EU regions (Table 4.2) and a block of non-EU European countries. We call this version of the model as EPPA-EURO.

Table 4.1 National allocation plan CO_2 caps, 2003 CO_2 emissions, and the Kyoto Protocol targets

	2005–2007 allowance for ETS sectors, mmt	Average Annual allowance for ETS sectors, mmt	2003 national CO_2 emissions, mmt	Share of ETS allocated emissions in 2003 total national emissions	Kyoto target, percent relative to baseyear
Austria	99.01	33.0	76.2	0.43	-13
Belgium	188.8	62.9	126.3	0.50	-7.5
Cyprus	16.98	5.7	7.2	0.79	No target
Czech Republic	*292.8*	*97.6*	127.1	0.77	-8
Denmark	100.5	33.5	59.3	0.56	-21
Estonia	56.85	19.0	19.1	0.99	-8
Finland	136.5	45.5	73.2	0.62	0
France	469.53	156.5	408.2	0.38	0
Germany	1497	499.0	865.4	0.58	-21
Greece	*223.2*	*74.4*	110	0.68	+25
Hungary	93.8	31.3	60.5	0.52	-6
Ireland	67	22.3	44.4	0.50	+13
Italy	*697.5*	*232.5*	487.3	0.48	-6.5
Latvia	13.7	4.6	7.4	0.62	-8
Lithuania	36.8	12.3	12.3	1.00	-8
Luxemburg	10.07	3.4	10.7	0.31	-28
Malta	8.83	2.9	2.5	1.18	No target
Netherlands	285.9	95.3	176.9	0.54	-6
Poland	*717.3*	*239.1*	321.3	0.74	-6
Portugal	114.5	38.2	64.3	0.59	+27
Slovakia	91.5	30.5	43.1	0.71	-8
Slovenia	26.3	8.8	16.1	0.54	-8
Spain	523.7	174.6	331.8	0.53	+15
Sweden	68.7	22.9	56	0.41	+4
UK	736	245.3	557.5	0.44	-12.6
EU-15	5217.9	1739.3	3447.5	0.50	-8
EU-25	6572.8	2190.9	4064.1	0.54	

Source for allowances data: for Poland, Greece, Italy, and Czech Republic – their NAPs and the EU Commission Decisions available at: http://europa.eu.int/comm/environment/climat/emission_plans.htm; for the other countries – EC (2005).

Source for emissions data: EEA (2005).

The Kyoto Protocol targets are percentage changes in GHG emissions for 2008–2012 relative to base year levels. The target is for all six GHG (not just CO_2) and is expressed in terms of CO_2 equivalence. For Finland and France, the base year is 1990 for emissions of all GHGs. For the other EU-15 countries, the base year is a combination of 1990 emissions of CO_2, CH_4, and N_2O, and 1995 emissions of HFC, PFC and SF_6.

Table 4.2 EU regional aggregation in the EPPA–EURO model and the ETS allocation: ratio of allocated emissions in electricity (ELEC) and energy-intensive industries (EINT) to projected emissions in 2005

EPPA–EURO Region	Countries	ELEC	EINT
FIN	Finland	1	1
FRA	France	1	0.99
DEU	Germany	0.99	0.99
GBR	UK	0.99	0.99
ITA	Italy	0.99	0.99
NLD	Netherlands	1	1
ESP	Spain	0.936	0.946
SWE	Sweden	0.86	0.86
REU	Austria, Belgium, Cyprus, Denmark, Estonia, Greece, Ireland, Latvia, Lithuania, Luxemburg, Malta, Portugal	0.98	0.98
HUN	Hungary	1.05	1.05
POL	Poland	1.01	1.01
XCE	Czech Republic, Slovakia, Slovenia	1.01	1.01

Source: National Allocation Plans and Betz et al. (2004).

Note: final ETS allocations across sectors have tighter constraints on ELEC sector and relaxed constraints on EINT sector than shown here. It does not affect the analysis because sectors can trade freely.

The base year of the EPPA model is 1997. From 2000 onward it is solved recursively at five year intervals. Because of the focus on climate policy, the model further disaggregates the GTAP data for energy supply technologies and includes a number of backstop energy supply technologies that were not in widespread use in 1997 but could take market share in the future under changed energy price or climate policy conditions. The EPPA model production and consumption sectors are represented by nested Constant Elasticity of Substitution (CES) production functions (or the Cobb-Douglas and Leontief special cases of the CES). The model is written in GAMS-MPSGE. It has been used in a wide variety of policy applications (see Paltsev *et al.* (2005) for a list of EPPA applications).

We apply NAP allocation caps in EPPA as if they are national caps where only the two sectors are participating in emissions trading. Our BAU for ETS sectors are presented in Table 4.2, as a ratio of allocated to projected emissions for 2005. In economic theory, what matters in terms of trading and economic efficiency is the market clearing permit price. That is, even if a firm were given enough permits to cover its emissions (and thus could comply without abating), economic theory would argue that the firm would operate on the opportunity cost of carbon emissions – if it could abate at or below the market price it could sell excess allowances at the market price. Further, prices of goods should reflect the marginal cost of production, which would include the marginal cost of abatement. A large allocation of permits to a firm is a lump sum distribution, which according to theory, would enrich the firm's shareholders but would not affect operating decisions or competitiveness. A competing firm that got few allowances would suffer a relative loss, but again this would be a one time loss due to the small lump sum allocation, and it would not further affect operating decisions. CGE models like EPPA follow this neoclassical economic theory closely. Thus, how permits are allocated does not affect which sectors or firms abate or production decisions even if they are given away for free. The cap and trade system is thus modelled as if all permits were purchased from the government and all revenue is distributed in a lump sum manner to the representative consumer. Neoclassical economic theory would show the allocation to affect the distribution of income, depending on the extent to which different consumers own equity of firms allocated portions of the cap or affected by it (directly or indirectly), consume goods whose prices are affected by the cap, and are employed by firms directly or indirectly affected by the cap. Since EPPA has a single consumer who owns all assets and supplies all labor, it does not provide any direct information on the distributional effects. We also cannot estimate the potential distortionary effects of non-lump sum distribution of some of the permits (those that under some countries' NAPs are retained for new entrants).

We note other approximations and caveats: (1) By including sectors as a whole, we are unable to represent the exclusion of small sources, and this represents a potential avenue of leakage and inefficiency to the extent the ETS encourages production to shift to small sources. (2) We model interaction with existing energy taxes, elsewhere showing (Paltsev *et al.*, 2004) that this strongly affects economic impacts of a cap and trade system, although not the carbon price. Notably, fuel taxes are relatively low in the sectors capped under the ETS. However, the issue of interaction of multiple policies is an issue of importance given that there are a variety of other policies directed toward the capped sectors, such as targets for wind power and renewable energy in electricity production. Since our interest here is exclusively on the simulated carbon price, these broader economic effects that would be captured in other measures of cost are less relevant. (3) EPPA solves every 5 years, and we have thus taken the year 2005 as illustrative of the 2005 to 2007 ETS period and 2010 as illustrative the 2008 to 2012 Kyoto period. However, we attempt to correct for not having the mid-year of the ETS period by calculating the cap as a percentage below reference projections for emissions over the period 2005–2007 and applying this to 2005. Thus, we approximate the average reduction required over the period to the extent these sectors are projected to grow even though the simulation is for 2005. (4) Business-As-Usual forecasts are key determinants of the carbon price. As illustrated in Reilly and Paltsev (2005), there can be large year-to-year changes in emissions for countries (both positive and negative). For example, between 2002 and 2003 Finland's emissions from electricity and industry grew by 20 percent, while in Portugal they fell by 14 percent. These big changes reflect availability of hydroelectricity, changes in fossil fuel prices, and other factors that can be highly variable from year-to-year. Such variability is generally not captured in a model such as EPPA, where any one year simulation should be more properly interpreted as a multi-year average result.

RESULTS

In order to evaluate the likely development of carbon price in the ETS, we have considered the scenarios presented in Table 4.3, where we allow for different trading regimes across the EU countries. Scenario 1 illustrates the range of prices in the cases of no carbon trading among countries. This is a useful way to judge the extent to which caps are more or less binding in different countries. Scenario 2 is the closest to the current ETS design and our BAU projections. In Scenario 3 we have eliminated remaining 'hot air' from Eastern European countries. The projected carbon prices are presented in Table 4.4. Scenario 1 shows that most of the original EU-15 member states have caps that result in similar carbon prices of generally at or below 1 €/tCO_2 with the exception of Sweden, Spain, and Italy where autarkic carbon prices are just over 15, 6, and 2 €/tCO_2 respectively. In contrast, there is 'hot air' in the newly admitted EU countries of Poland, Hungary, and our aggregate of the remaining countries of Eastern Europe, and the autarkic price in these areas is zero. Trading across the EU equalizes the carbon price at 0.58 €/tCO_2 (Scenario 2). Eliminating the 'hot air' in the newly admitted countries by setting the cap at reference emissions in these areas increases the price to 0.85 €/tCO_2 (Scenario 3).

Table 4.3 ETS scenarios for 2005–2007

Scenario 1	Carbon trading across sectors within countries but not across countries.
Scenario 2	Carbon trading across sectors and countries (allowing ETS allocation above BAU projections).
Scenario 3	Carbon trading across sectors and countries but no countries' sectors get more allowances than reference emissions (no hot air).

Table 4.4 Carbon price in different ETS scenarios

Region	Scenario 1, €/tCO_2	Scenario 2, €/tCO_2	Scenario 3, €/tCO_2
FIN	0.14	0.58	0.85
FRA	0.30	0.58	0.85
DEU	0.85	0.58	0.85
GBR	0.96	0.58	0.85
ITA	1.79	0.58	0.85
NLD	0.16	0.58	0.85
ESP	6.16	0.58	0.85
SWE	15.24	0.58	0.85
REU	2.47	0.58	0.85
HUN	0.00	0.58	0.85
POL	0.00	0.58	0.85
XCE	0.00	0.58	0.85

Note: the ratio of a price per ton of CO_2 to a price per ton of carbon is 1:3.667 based on a carbon content of CO_2.

These simulated prices are completely at odds with observed ETS market prices that have been in the range of 20 to 25€/tCO_2. A number of theories or factors have been advanced to explain the unexpectedly high prices. These include:

1. Increases in energy prices (gas and oil) caused a shift to coal use especially in electric generation, which has higher carbon emissions.
2. Recent experience has emphasized the potential effects of adverse weather conditions (drought and high temperatures) on hydro and even on nuclear supply. Drought reduced hydro capacity and high temperatures have led to concerns that discharged cooling water from nuclear power installations could lead to exceedance of in-stream water temperature limits set to avoid damage to these freshwater ecosytems.
3. Expectations regarding the future evolution of emission trading beyond the 2005 to 2007 period. Banking of allowances to future periods would be one

way that expectations about 2008 to 2012 or beyond could affect current ETS prices. France and Poland allow for a limited banking into the Kyoto period, but it is not clear if such banking will be allowed by the European Commission. Another consideration advanced by some analysts is that companies may believe that baseline allocations in 2008 to 2012 will be benchmarked to actual emissions in the ETS years. This would provide an incentive not to abate now to ensure a larger allocation in future years.

4. The EPPA model (as other CGE models) may represent abatement as too easy. The model does not represent accurately the details of the market design, and it does not include transactions costs.
5. The current market prices for carbon do not reflect supply and demand interactions: confusion, speculation, incomplete registries, bad information, or manipulation of the market may be having an effect, particularly as the market gets started.

We further discuss and investigate these issues, in turn.

High Natural Gas and Oil Prices

Dispatching gas generation capacity while cutting back on the dispatch of coal capacity can reduce CO_2 emissions by more than half because the fuel specific release of CO_2 from gas is only about 60 percent of the release from coal, and gas generation, particularly from combined cycle facilities, can be more than twice as efficient (electricity produced/energy content of fuel) as a base load coal plant. Some analysts have calculated the cost of this option as gas prices have risen, and found that it could explain the high carbon prices if this were the marginal abatement option. We investigate this consideration with some additional EPPA runs.

The Business-As-Usual EPPA projections already had oil and gas prices approximately doubling from the base year 1997 level, with coal prices little changed. As of mid- to late 2005, fuel prices were considerably higher than this base EPPA projection, with crude oil at over $60 barrel and gas prices around 8€ per million BTUs (natural gas prices are even higher in the US reaching $14-15 per million BTUs). These are 3 to 4 times or more the 1997 level. In standard EPPA simulations fuel prices are endogenously determined, however, the model includes the capability to exogenously set prices. We have used this facility to exogenously set fuel prices to examine the impact on the simulated carbon price.

Table 4.5, column 1, shows the carbon price results when oil and gas prices are at 2, 3, 6, and 50 times the 1997 level in 2005, imposed under conditions of Scenario 3 (no 'hot air' in the new EU members). The 50 times the 1997 level is an obviously extreme value, intended to demonstrate the sensitivity of the model over a very wide range. The 2 times 1997 level is, as expected, nearly identical to the BAU case where oil and gas prices are endogenous. Higher oil and gas prices lead to higher carbon prices, rising to about 1.6 and 3.9€/tCO_2. At the extreme of 50 times 1997 oil and gas prices the estimated carbon price rises to about 16€/tCO_2, still less than recent market prices. The EPPA model includes a discrete NGCC technology, and so we could see the gas-coal margin reflected directly in the carbon price, however, EPPA generally represents abatement possibilities as a continuous response determined by substitution elasticities. EPPA simulates reductions in energy use, stemming from increased prices as an important abatement avenue that a simple technology cost comparison typically does not include. Not only do direct users of fuel reduce fuel use, but users of products produced from fuels (e.g., electricity) also have an incentive to use less of the good. However, if electricity prices are regulated, are based on average costs, or otherwise fail to adjust to pass through higher marginal costs associated with carbon prices, this avenue may be overestimated in EPPA. Reducing this adjustment, however, would not come close to explaining the difference between simulated and actual prices.

Table 4.5 Gas and oil price effects on the carbon price

Increase in gas and oil prices in 2005 relative to 1997	Carbon price with oil and gas price increase only, €/tCO_2	Carbon price with oil and gas price increase and 20 percent reduction in hydro and nuclear production, €/tCO_2
2	0.85	1.19
3	1.55	2.11
6	3.89	4.94
50	14.97	18.96

Restricted Hydro and Nuclear Production

Unusual weather in 2005 led to low production of hydro electricity that was largely unanticipated. To examine this factor, we restrict nuclear and hydropower to 20 percent below our reference projection for these sources. We then simulate these reductions in combination with the various oil and gas price scenarios to see the effect on the carbon price. The simulations show a 26 to 40 percent increase in the carbon price, with the larger percentage (but smaller absolute) increases occurring at lower oil and gas prices (Table 4.5, column 2).

These experiments show that reduced nuclear and hydro capacity, even in combination with higher oil and gas prices, do not allow us to simulate the current levels of market prices for carbon. There are two important considerations that limit the reality of our simulations. One consideration is that the high fuel prices and reduced hydro and nuclear capacity were unanticipated shocks but the EPPA model simulations produce results whereby firms would have had some time to adjust. While EPPA is not a perfect foresight model (that would imply full knowledge of the shocks ahead of time) the values of elasticities of substitution in EPPA reflect medium-run estimates. EPPA vintages capital, restricting substitution substantially, but only a portion of capital is vintaged, again allowing implicitly some retrofitting. This would lead one to conclude that EPPA simulations would underestimate the effect of an unanticipated shock. A second consideration, however, is that by using 2005 as representative of the full 2005 to 2007 period, we implicitly assume that the 2005 conditions (including the higher fuel prices and reduced hydro and nuclear capacity) persist over the entire period. The ability to borrow allowances should provide the capability of firms to even out such effects. This depends, of course, on firms believing that these are unusual conditions that will not persist over the full ETS period. The belief that these will persist or worsen could explain higher carbon prices than we have simulated.

Expectations for Emissions Trading beyond 2007

As already noted, there are at least two ways future periods could affect prices in the current period. If banking of allowances is allowed, then one might expect over-compliance with current limits to create extra allowances for future periods if one would otherwise expect the carbon price to be substantially higher then. Economic theory would suggest that the discounted expected future price should equal the current price. In general, the ETS disallowed banking into the Kyoto period, but two of the member States included limited banking provisions. In principle, if any one agent could bank allowances, that agent, if its banking levels where unlimited, could by itself bring the expected future discounted future price in line with the current price in a market where allowances were fungible. Such an agent could buy allowances throughout the region, accumulating them until the supply was judged to be sufficient to bring the future price in line with the current price. On the other hand, whether the EC will allow banking even to the limited extent provided for in the French and Polish NAPs is unclear, and the Kyoto Protocol that will define the rules for 2008 to 2012 does not specifically allow banking from an earlier trading system.

The second hypothesis is that firms may expect future allocations to be based on actual emissions in 2005 to 2007. The simple arithmetic of this is as follows. Suppose allowances in 2008 to 2012 are distributed to be 20 percent below actual emissions in 2005 to 2007. Further suppose that a firm has 1000 allowances in the current period of the ETS and faces the decision of abating from 1000 (its emissions if it did nothing) to 500, at an average cost of 11€/tCO_2, and could sell these in the current market at 21€/tCO_2. This would look like a profit of 5,000€. However, by our assumption that future allowances are based on actual emissions, the firm's allowances in 2008 to 2012 would be 400 (80 percent of 500) if it abates compared with 800 (80 percent of 1000) if it did not abate. In this example, even if the price in 2008 to 2012 were 20€/tCO_2 the decision to abate would mean that the firm was giving up allowances worth 8,000€ in the future by abating today. Discounting this 8,000 value back to current at 5 percent shows the value to be just under 6,300€ and so the firm would be nearly 1,300€ ahead by forgoing abatement today and the revenue from the allowance sales. Not considered explicitly here is that 2008 to 2012 is a five year period (whereas 2005 to 2007 is three years), and that the effects of lower allocation may linger into periods beyond 2012.

Table 4.6 Scenarios for 2008–2012 and ETS carbon price

Scenario	Description	Carbon Price, €/tCO_2
Scenario 4	ETS extended with unchanged quantity targets in the ETS sectors to 2008–2012, and other sectors are capped to meet Kyoto targets.	13.47
Scenario 5	Kyoto target with trade among all sectors and across EU. Emission trade in CO_2 only.	32.32
Scenario 6	Kyoto target with trade among all sectors and across EU, Canada, Japan, and Russia. Emission trade in CO_2 only.	6.28
Scenario 7	Kyoto target with trade among all sectors and across EU, Canada, Japan, and Russia. Emission trade in all GHGs.	0.70

A critical value in both the banking and the allocation-loss calculations is the expected future price of carbon. We thus construct scenarios in EPPA that represent some different ways in which the ETS could evolve in the 2008–2012 Kyoto period. Table 4.6 presents scenarios and corresponding carbon prices for the Kyoto Protocol period. In Scenario 4 we keep the current ETS sectors and their quantity targets unchanged for 2008 to 2012. This would mean the other sectors of the economy have to reduce their emissions proportionally to meet the Kyoto target, which we have enforced through a cap on these sectors without allowing trading with the ETS sectors. They have different carbon prices (not reported here) than the ETS system, and that has some effects on their demand for goods supplied by the ETS sectors. However, if these two parts of the economy are kept separate, then what matters to the ETS sectors is the price in the emissions market in which they are operating. In Scenario 5 we extend the ETS to all sectors and all EU regions, with the Kyoto targets as allocation caps. The European Commission has expressed a desire to extend the ETS to other sectors, and this is an extreme assumption where it is extended to the entire economy. This scenario does not allow any credits (JI, CDM, trading) from outside of the EU. Scenario 6 expands emissions trading to include the EU, Russia, Canada, and Japan, assuming these other Kyoto Parties will set up national trading systems covering all sectors of their economies. In Scenario 7 such trade is extended to include all greenhouse gases.

If banking on the expectation of higher future prices were an explanation for the high current price, then to support a price of 25€/tCO_2 we would expect to see the five year undiscounted price higher by about 28 to 47 percent (for a 5 and 8 percent, respectively, discount rate). The future carbon price would thus need to be 32 to 37€/tCO_2. Scenario 5 results in a price of just over 32€/tCO_2. Thus anticipation of banking could support the current price if the assumption is that trading will be extended to the other sectors, without any CDM, JI, or trading credits from abroad, and assuming the ETS excludes abatement of non-CO_2 GHGs. This is among the most extreme cases we could construct. Further, since banking is by no means a sure thing one might expect firms to not fully equate the current price to the discounted future expected price because of the risk that a large cache of banked allowances might turn out to be of no value if the EC sticks to its prohibition on banking.

The allocation-loss explanation is possibly more compelling, but it is harder to estimate the full effect. As demonstrated with the simple example, loss of allocation can lead to less abatement even if the future carbon price is no higher than today. Caution is needed in applying this example arithmetic broadly however. The ETS sectors must meet the 2005 to 2007 target assuming the EC strictly enforces the cap, and so to the extent one firm plays a game of not-abating hoping to garner a larger allocation in the next period, other firms will need to abate more. This behaviour would still cause a run-up in the current price, but by how much depends more on the differential abatement opportunities among firms and their other interests in acting strategically.

EPPA Parameterization Underestimates Abatement Cost

If the required abatement is really only on the order of 1 percent below the reference then choice of parameters that affect abatement costs within EPPA would be insufficient to generate carbon prices like those observed in the current ETS market. More compelling than simulating EPPA with changed parameters is the comparison of different model results for a 20 percent reduction that we reported earlier. We thus have not constructed new cases to illustrate this here. See (2005) using the EPPA-EURO model and conducting an uncertainty analysis considered a Monte Carlo case where elasticities of substitution between energy and non-energy inputs were subject to uncertainty and compared results with a case where they were not. He also considered a case where the proportion of capital vintaged was varied with a case where it was not. The effect of varying the elasticity substitution changed the median price by about 5 percent and the maximum price by about 10 percent. The marginal effect of vintaging was smaller on the maximum price, about 7 percent, and larger on the median price, about 15 percent. Neither of these results suggest that changing these parameters could easily explain an increase of an order of magnitude times three, which is what is required to get from 0.85 to 25€/tCO_2. If we calculate the arc elasticity that would be needed to have the price rise from 0.85 to 25 €/tCO_2, (% Δ Q/% Δ P) for a 1 percent quantity change we get $\{1/[(0.85\text{-}25)/0.85)]\}= 0.035$. Even most short run (one-year) elasticities of substitution are on the order of 0.4 or higher. And the nature of the ETS, with banking and borrowing among ETS years, allows adjustment over three years. A completely different model structure, where there was no flexibility whatsoever at low prices, but one technological option that would kick in once the carbon price reached the level that made it competitive would be more likely to yield a high price even though the required abatement was a trivial percentage of emissions. An example would be if the only near term abatement was natural gas electricity generation substituting for coal. With high gas prices, the trigger point to make this economic could well be on the order of 25€/tCO_2. To get this from EPPA, we would need to make the entire economy fixed coefficient, with the only abatement being the technological option of NGCC, an extremely different view of economic response to higher prices than is modelled in EPPA.

Another consideration is that models such as EPPA do not include transactions costs. In this regard, there are many costs to setting up registries and developing inventories within firms, but it is not obvious that these costs would be fully reflected in market prices for permits – both buyers and sellers must bear costs of creating and maintaining inventories and so there is no reason to think that the price would settle at a level where sellers would be compensated for the costs, while buyers must pay. To be sure, this is real additional cost that would be reflected in firms' bottom lines and in prices of goods in the economy but not necessarily in the carbon price. Pure transactions costs, e.g., traders' margins, seem unlikely to result in permit prices that are many multiples of the basic price if the market becomes relatively liquid.

As noted earlier, there are elements of the market design that we have not captured, such as reserved allocations for new entrants, non-functional registries in East European countries, and the fact that if facilities closed down they are required to surrender their allowances. Provisions of the NAPs are still a subject to challenge and this may be affecting market participants' expectations.

Prices Do Not Reflect Market Fundamentals

There is not much more than can be said in this regard, and we hesitate to argue that our model is smarter than the market. We repeat a quote from one trader: 'I am beginning to think there is no real supply-demand indication in this market. It doesn't react to fundamentals'. (Point Carbon, 2005). Experience with emissions trading markets for SO_2 and NO_x shows high volatility, particularly in the early stages. Thus with the ETS in its early stages it is hard to judge whether the short series of prices are representative of what one will observe over the full three years of trading.

CONCLUSIONS

The creation of a carbon market in the European Union is a watershed event in climate policy. How it performs (or as importantly, perceptions about its performance) may well determine whether there is rapid progress toward establishing an international market in permits that could eventually cover much of the world, or the world sours on permit trading and pursues other policy approaches. The EU is an interesting test bed: it is an international market in that the individual EU member states retained some control over National Allocation Plans, but with considerable enforcement power within the European Commission there is a central authority with more power to bring consistency across these plans than would be the case if trying to establish emission trading among the EU, the US, and Japan, or with Russia, China, and India.

Economic theory strongly concludes that creating a cap and trade system for controlling pollutants assures that abatement is achieved in a least cost manner. Experience in the US with such trading systems for other pollutants has been widely seen as highly successful (Ellerman *et al.*, 2000). While there are differences for CO_2 versus other pollutants that may affect how one would like to manage an emissions market, in the main nearly all economists would have a fair amount of faith that decentralized decisions guided by a market price set as an interaction of supply and demand for permits is preferable to command and control systems for pollution control. Economists might argue about other issues related to such a system such as equity, its merits compared with an environmental tax, revenue recycling, interaction with other policies, enforcement in an international regime, and the correct level of a cap. But in terms of cost-effectiveness of such an instrument as exhibited by the marginal market abatement cost, most economists would require strong proof before accepting that a cap and trade system was less effective than some other means of control. That same faith in market instruments may not necessarily hold for non-economists, and so proving that emissions trading can work may not surprise economists but may be essential to garner further support for such mechanisms.

In convincing non-economists of the value of market instruments, perception may count as much as reality. Just because the market price for carbon is high does not mean it is not working. However, the sulphur emissions trading program in the US has near legendary status among some in the environmental community because it was perceived to reduce the cost of abatement by an order of magnitude. In this case economists have showed that while there were likely gains due to use of the cap and trade system, the claim of an order of magnitude reduction in cost focused on some likely exaggerated early cost projections and some fortunate circumstances unrelated to emissions trading *per se* (e.g., deregulation of railroads that reduced the cost of transporting low sulphur coal from the Western US) (Ellerman *et al.*, 2000).

So far the experience with carbon trading in Europe is exactly the opposite of that with sulphur trading in the US. The permit trading price is an order of magnitude higher than what was expected. This would seem to create the risk of a perception that emissions trading has failed, and leads to excessively costly abatement. This would be an unfortunate and probably unwarranted conclusion. Just as casual observers of the sulphur market credited to emissions trading what were bad early estimates and lucky coincidence, the surprisingly high cost of carbon permits in the ETS may reflect overly optimistic initial estimates and unlucky coincidence. Investigating the surprising divergence between expectation and (early) reality is thus important, and this paper is a very first attempt.

In that regard, unlucky coincidence does appear to be an important explanation for higher prices than models had projected. Large increases in natural gas prices likely led to utilities relying more heavily on coal for generation than they otherwise would have, and made abatement through switching to gas an expensive option. At the same time, reduced hydro and possible concerns about nuclear electricity production likely had an effect. This could by our estimate explain a price of 2 to 5 but not 20 to 25 €/tCO_2.

The carbon market at this point is subject to very different expectations than was the sulphur market when it was established in the US. It is probably fair to say that the expectation in the sulphur market was that the cap established at the time was the ultimate cap. In contrast, in the carbon market, there is widespread recognition that the modest reductions in the ETS are part of an early test, and that caps will need to be tightened further in the future. The EU is bound by the Kyoto Protocol to make deeper cuts in the future, and the UK and France have set even more ambitious long-term reduction targets. If unused allowances could be banked, then the supply-demand situation in 2005 to 2007 would poorly predict prices because we would expect many firms to over comply and hold allowances for 2008–2012 or subsequent period when caps would tighten and prices would be higher. The hitch here is that there is no provision in the Kyoto Protocol that would allow banking into the first commitment period from some other system, and most of the EU NAPs specifically indicate banking is not allowed following guidance from the EC. Our analysis suggests that to generate prices that could support the current market price on the basis of banking would require the relatively extreme assumptions that during the Kyoto period the ETS would be extended to other sectors in Europe, but their would be no crediting of Joint Implementation, CDM, trades from other regions, or from non-CO_2 greenhouse gas abatement. It would also assume that firms were essentially certain that banking would be allowed even though, at this point, there would seem to be little reason to believe that it will and thus most banked allowances could be rendered worthless.

Another way in which future programs could affect current prices is if there is an expectation that future allocations of allowances will be based on actual emissions levels in 2005 to 2007. If this were to happen it would be a condition that would greatly concern economists because this would make the trading system work inefficiently. Essentially firms would not want to abate, expecting that high emissions would be rewarded with a high level of allowances for 2008 to 2012. We show through a simple example that this could have strong effects on prices, but to fully evaluate it would require deeper analysis than we could conduct at this point.

Another reason that expectations and model projections for the price may have been too low is that the model used here does not include transactions costs or may simply represent abatement as easier than it is in reality. There are many reasons, in addition to those already discussed, why a model might fail to reproduce the actual emission permit prices. For example, in the EPPA model there is perfect information about all markets, no monopoly power, and no government regulatory constraints on adjustments. Markets, including all factor markets, always clear immediately in the model, so there is never any unemployment or unused capacity. Output, input, and investment decisions are always just right. All of the conditions above might contribute to making the model's estimates of carbon prices lower than those that currently prevail in the ETS. Compelling quantitative analysis of these factors is difficult. Still, it is hard to reconcile the very wide difference if indeed the required reduction is on the order of 1 percent.

As economists we have a fair amount of faith in markets, and in the end models like those we have created supposedly are designed to represent market behavior. Thus, if the permit price response to the ETS remains similar to the early experience more work will be needed to reconsider model structure and the causes behind the divergence between simulated prices and reality. At this point many observers hold the view that the early market experience may not represent well the ultimate results for the three year ETS period. The market is just beginning, registries in some countries are still not operating, the first real reporting period is still several months away, and the shocks of rising gas prices and low hydro capacity have no doubt jolted firms under the ETS. The volume of trade thus far has been quite low relative to the total level of allocated allowances. Thus, there is reason to be cautious about reading too much into the early market price, and the jolts that have been experienced would be expected to push prices toward the high side. A few skittish firms could be pushing up prices on a relatively small volume of permits, while the more knowledgeable and cautious firms are waiting until they at least see results from the first year operation of the system, knowing that they can cover their emissions in that year by borrowing against the second year allocation.

The experiment with carbon trading in the European Union is important. The experience in terms of the market clearing price has been a surprise (if not a shock) based on expectations that the reductions required would be very mild. The high prices may mean that we need to reconsider the models we have used to estimate abatement costs, but unexpected shocks or expectations about the future may be strongly affecting the current market price. There are multiple real factors that may be contributing to these higher than expected prices. None of them on their own seem sufficient to explain the current prices. With over two years to go before the test phase of the ETS is complete, it is too early to make firm conclusions but it will be important to continue to monitor and evaluate the performance of the system because perceptions of its performance could well determine whether a greenhouse emissions trading system is expanded into a broader global system or not.

NOTES

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1. Estimates as published were in 1990 US$/tC, converted here to current (2005) $/t$CO_2$ and to €/CO_2 using the US implicit price deflator and the current $/€ exchange rate. The highest reported price estimate was about 100 €/tCO_2, considerably above the next highest at about 60 €/tCO_2.

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