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The future of the European Emission Trading System and the Clean Development Mechanism in a post-Kyoto world ☆

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ABSTRACT

This paper discusses developments in the markets for CO_2 emissions rights since the Kyoto Protocol was signed. The different emissions trading schemes, dominated by the Emission Trading System of the European Union and the Clean Development Mechanism, are surveyed. These schemes will need to be incorporated into any post-Kyoto multilateral agreement. Drawing on a simple model, the paper analyzes the incentives that developing and developed countries face for continuing or transforming the Clean Development Mechanism in the light of future agreements for a worldwide emissions control program.

1. Introduction

The challenge of reaching an agreement to mitigate greenhouse gas emissions after the Kyoto Protocol expires in 2012 seems increasingly difficult to master. Climate change is apparently progressing faster than previously expected by the academic community, including the Intergovernmental Panel on Climate Change (IPCC), and faster than predicted by climate models. Emissions have been rising faster than envisaged in the IPCC's worst-case scenarios (Raupach et al., 2007). The worldwide economic crisis has for now slowed economic growth, and with it growth in CO_2 emissions, but it has also made significant action politically less likely, at a time when reaccelerating economic growth seems more important to many than controlling emissions. The build-up of atmospheric concentrations from past emissions, together with current emissions trends, combined with new insights about the dynamics of the climate system, seem to suggest the need for either an immediate worldwide curb on emissions or drastic reductions in the coming decades, to zero and possibly even negative net emissions, if dangerous climate change is to be avoided as required by Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC), which practically all countries have signed. Yet despite these findings, the Conference of Parties in Copenhagen in December 2009 did not make the progress needed to control emissions in the near future.

Despite these challenges, and despite an apparently insufficient emissions reduction target agreed upon in the Kyoto Protocol, the period since the Kyoto conference has brought about a number of institutional and market developments that may provide a foundation for a post-Kyoto agreement. The Emission Trading System of the European Union (EU ETS) controls about half of EU CO_2 emissions, but more important, its introduction has led to a well-developed market for carbon permits. Carbon has now become a traded commodity in Europe, and a price has been established – although it is too low at the moment to provide sufficient incentives for significant reductions – that can guide business in its energy input decisions. Other markets, such as the market for project credits from the Clean Development Mechanism (CDM), are also now well established in the business community.

It has been debated whether emissions trading is a sensible concept for a post-Kyoto agreement at all.[1] That discussion will not be taken up here. Instead I will start with the presumption that emissions trading in one form or another will remain a major instrument in climate policy. The question raised here concerns the experience with

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[1] Prominent examples are Nordhaus (2006) and Barrett (2006).

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the two major emissions trading schemes, the EU ETS and the CDM, and the challenges that they face in a possible climate regime after 2012. In particular, the role of the flexible mechanisms established under the Kyoto Protocol, such as the CDM, has come into question in discussions of post-Kyoto climate policy instruments.

For example, Hagem and Holtsmark (2009) argue that the CDM is actually an obstacle to a global climate agreement, as it provides developing countries with an instrument that raises considerable income from selling emissions rights to the developed world without requiring those countries to take on binding agreements to reduce emissions. If the developed world were to accept a cap on its own emissions sufficiently strong to reach the emissions targets advocated by climate scientists, such as a 550-ppmv goal for atmospheric CO_2 concentrations, the CDM system would not, they argue, be able to handle the huge demand for CDM projects created by the countries facing emissions caps.

The European Commission proposes to reform the CDM. In particular, "for advanced developing countries and highly competitive economic sectors, the…CDM should be… gradually replaced by a sectoral crediting mechanism and cap-and-trade systems" (European Commission, 2009, p. 11). This position has been strongly criticized by the International Emissions Trading Association, which has asked for a "clarification, at the earliest possible date, about which sectors will remain open to CDM activity over the medium and long-term (e.g. after 2020)" (IETA, 2009, p. 2).

Any climate agreement in the post-Kyoto period will need to subject the industrialized world to significant emissions reduction commitments and achieve sustainable economic development in the poor regions of the world without too large an increase in their greenhouse gas emissions. This requires that a number of developments will be realized: Energy and carbon efficiency will need to strongly improve world-wide requiring a smooth diffusion of new low carbon technologies. Such innovation will need to be supported by private and public R&D but its diffusion to developing countries by market mechanisms will only take place if appropriate carbon prices make these technologies profitable. The instruments with which such a challenge can be met have so far been the flexible mechanisms of the Kyoto Protocol: emissions trading, the CDM, and Joint Implementation (JI). The question is how these instruments might be improved upon, and whether they can contribute to the above objectives, and if so, how.

The challenge for the next rounds of negotiations toward a post-Kyoto agreement will therefore be to find solutions that achieve the transfers of knowledge and financial resources necessary to accomplish the transformation from a fossil fuel-based to an essentially carbon-free energy system, and do so in the most economical way. The now-well-established carbon markets could provide such an efficient instrument. Nevertheless, the current negotiations show that a post-Kyoto climate framework is unlikely to consist of a simple carbon market. Rather, it will be a complex international agreement that accommodates the different interests in a multidimensional system of climate mitigation and adaptation policies. This paper is concerned with one issue in particular, namely, the impact of the CDM on the incentives for reaching agreement on some form of global emissions constraint.

The next section of the paper discusses the experience with the existing carbon trading schemes, most notably the EU ETS and the CDM, which together currently dominate world carbon markets.[2] I then present a simple model for a post-Kyoto carbon market and use it to identify the impacts of different institutional arrangements on the distribution of the cost of achieving a meaningful degree of climate change mitigation, one that comes close to the objective set out in Article 2 of the UNFCCC and meets targets like those advocated by bodies like the IPCC. The paper concludes with some implications that can be drawn from the results of the analysis.

[2] A summary of many smaller trading systems is given by Kristiansen et al. (2008).

Table 1
Size of the main emissions allowance markets, 2007 and 2008.
Source: World Bank (2009). NSW, New South Wales Greenhouse Gas Abatement Scheme; CCX, Chicago Climate Exchange; RGGI, Regional Greenhouse Gas Initiative (mid-Atlantic U.S. states); n.a., not available.

Market	2007		2008	
	Volume ($Mt\ CO_2e$)	Value (millions of $)	Volume ($Mt\ CO_2e$)	Value (millions of $)
Project-based transactions				
Primary CDM	552	7433	389	6519
Joint Implementation	41	499	20	294
Voluntary market	43	263	54	397
Total	636	8195	463	7210
Secondary CDM	240	5451	1072	26277
Carbon credit markets				
EU ETS	2060	49065	3093	91910
NSW	25	224	31	183
CCX	23	72	69	309
RGGI	n.a.	n.a.	65	246
AAUs	n.a.	n.a.	18	211
Total	2108	49361	3276	92859
Total, all markets	2984	63007	4811	126345

2. Experience with carbon trading schemes

This section provides an overview of the two largest carbon trading schemes currently in operation, the European Emission Trading System (EU ETS) and the Clean Development Mechanism (CDM). Particular emphasis is given to the development of prices and volumes within the EU ETS. I also discuss some of the specific features of the EU ETS that have prevented it from exploiting the potential efficiency gains from a market-based system. The decision to allocate all the emissions allowances to incineration facilities, i.e., the points of emission, has led to a substantial divergence of marginal abatement costs between the sectors covered by the EU ETS and all others. This inefficiency has been aggravated by the free allocation of allowances, which has led under political pressure to a cap on emissions that was higher than would be required by an efficient sharing of the abatement burden across all emissions sources.

Emissions trading is now well established as a theoretical idea and is covered in practically every economics textbook. However, applying the theoretical idea, with its elegant approach to controlling a global externality, in the form of a workable trading mechanism for day-to-day transactions is a difficult task. In addition, there is not just one solution to establishing a carbon market but many. Consequently, several carbon markets coexist with sometimes very different designs.

The EU ETS is the largest carbon trading scheme operating in the world today, issuing about two-thirds of the total volume of carbon credits (which in this system are called EU allowances, or EUAs) worldwide, and accounting for almost 80% of carbon credit markets in terms of the value of credits traded. (Table 1 provides details on the size of the EU ETS and other markets.) The second-largest market is that for CDM credits (called certified emission reductions, or CERs). Compared with these two markets, the other carbon markets, in the United States and Australia, are tiny, with less than 2% of the world market in terms of value traded.

The EU ETS controls the emissions of large energy installations in the European Union, those with a net energy input of more than 20 MW. As a consequence, the major emissions sources within the ETS are the electricity generating companies and the chemical and steel industries. Other industries with smaller installations are not included,[3] nor are

[3] The minimum size threshold has been raised over time, and there has been some discussion about increasing it even further. This would exclude a large number of small installations that contribute only a small percentage of the total emissions currently covered by the ETS, thus reducing the administrative burden significantly.

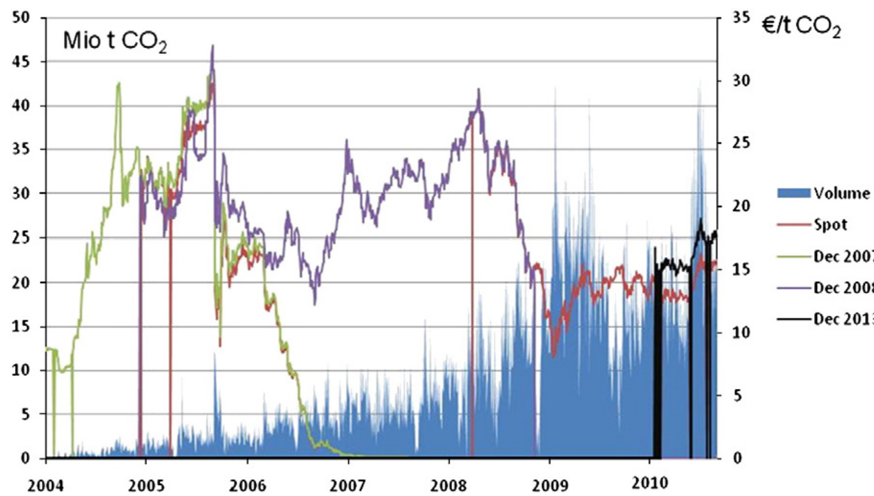

Fig. 1. EUA volumes traded and prices in the EU-ETS.
Source: PointCarbon. “Dec 2007” etc. are delivery dates of futures contracts.

other sectors such as transport and household heating, which likewise emit a considerable amount of CO_2. The EU ETS currently covers about 11,500 installations.

The allocation of emissions allowances takes place through National Allocation Plans (NAPs). These determine the amount of emissions that each country is allowed during a given period within the facilities covered by the EU ETS. A corresponding number of EUAs are then distributed to the emitters. The first NAP, which covered the period from 2005 to 2007, was intended as a test. As it turned out, the amount of allowances given to the covered facilities was rather generous. These allowances, moreover, could not be carried over, or “banked,” to the next NAP period, from 2008 to 2012, and consequently their price fell to zero by the end of the first period (Fig. 1). A number of lessons were learned in this test phase, among them[4]:

- The collapse of the market was a consequence of the generous allocation of allowances. At first, no information about the actual demand for emissions permits was available, but as soon as the first data on actual emissions were published in the late spring of 2006, it was clear that the allocation was too generous.
- This overgenerous allocation, if continued in the second and third periods, would lead to an inefficient distribution of emissions reduction activities between covered and noncovered sectors. To meet their Kyoto targets, the EU countries would have to rely on abatement activities outside the EU ETS, which generally have much higher abatement costs than activities within the EU ETS — up to 10 times greater in simulation exercises (Klepper and Peterson, 2006b). Without reliance on the flexible mechanisms established under the Kyoto Protocol – JI and the CDM – several member states would have to impose high costs on the sectors outside the EU ETS that would have to compensate for the emissions levels within the system.

The allocation of emissions allowances in the second National Allocation Plans (NAP2) is somewhat tighter, following the European Commission's rejection of most of the member countries' proposed plans and its demand for a smaller overall allocation. As a consequence, substantial imports of emissions rights from CDM and JI projects will be required in many EU member states in 2012 in order to meet the Kyoto targets, although the pressure is somewhat reduced by the slowdown of economic activity in the wake of the global financial crisis. Another option would be a much stronger reduction of emissions from households, automobiles, and small installations, which, however, is rather unlikely given the relatively low price elasticities of energy demand, especially in the transport sector and by households.

2.1. Debated features of the EU ETS

A number of generic problems have impaired the acceptance and credibility of the EU ETS, at least in the public perception. One of the system's most widely debated features was the free allocation of emissions allowances to the emitting installations, as demanded by industry but opposed by many economists. Another problem arises from the fact that only half of EU emissions are subject to an explicit carbon price, whereas the rest are more or less tightly regulated under a large number of national instruments but not under a harmonized European policy. The reason is that the EU ETS is designed as a downstream system in which emissions are controlled directly at the source, thus preventing mobile sources and small facilities from being included in emissions trading. I will discuss each of these two features in turn.

In the first EU ETS commitment period, national governments allocated practically all allowances to the covered installations for free. Under the system's rules, up to 5% of the allocated allowances could have been auctioned, but most countries decided not to use this option. In the second period up to 10% of the allocations can be auctioned, and several countries will take advantage of this opportunity. The allocation rule for the post-Kyoto period, starting in 2013, is still being debated. The European Commission has called for full auctioning for sectors (such as the electric power sector) that are able to pass through their costs to users, and a gradual phasing in of auctioning (from 20% in 2013 to 100% in 2020) for those sectors exposed to international competition and thus at risk of carbon leakage.[5] However, this proposal is strongly opposed by some member states.

The experience with free allocation, combined with the allocation of emissions directly at the point of entry into the atmosphere, i.e., at the level of the incineration facility, has been a political disaster. The haggling among companies over these allocations has been fierce and prolonged. After the EUAs had been allocated and their price started to rise above 20 €/t CO_2, and on two occasions even beyond 30 € (Fig. 1), it became apparent that many companies were passing these costs on to consumers. The public reacted strongly to what they perceived as windfall profits, and the EU ETS lost credibility.

[4] For a detailed analysis of the first experience with the EU ETS, see, e.g., Ellerman et al. (2010), Convery (2009), and Grubb et al. (2010).

[5] Carbon “leakage” refers to the shift in economic activity, and with it carbon emissions, from a country where emissions are regulated to one where they are less tightly regulated or not at all.

The negotiations for the allocation of EUAs in the second NAP were equally demanding, and the resulting political compromises have created some perverse incentives. The number of EUAs that newly built power plants receive varies according to the type of fuel they use: a coal-fired power plant receives twice as many EUAs as a plant fired with natural gas. This provision undermines the competitiveness of natural gas vis-à-vis coal and provides no incentives for fuel switching.

The negative experience with free allocation has convinced the European Commission to move toward auctioning emissions allowances in the third commitment period starting in 2013. The latest directive on the ETS states that “full auctioning should be the rule from 2013 onwards for the power sector, taking into account its ability to pass on the increased cost of CO2” (European Union, 2009, p. 15). Exceptions should be made for industries that face world market competition and sectors in which carbon leakage is a threat. Their share of freely allocated allowances will be slowly reduced until it reaches 30% in 2020, and from 2027 on all allowances will be auctioned.

The choice between an upstream and a downstream emissions trading scheme was decided early and without much discussion. The decision to cover only large incineration facilities was seen as the only reasonable solution for administrative reasons. The alternative of going upstream has the advantage that small emitting sources can also be covered without creating a large administrative burden.

The divergence of EUA prices in the ETS from the expected marginal abatement costs outside the ETS sectors, as given by the implicit carbon prices for reaching the Kyoto targets, indicates that the EU ETS, with its downstream approach combined with the free allocation of emissions credits, has created a system in which governments for many reasons have decided not to impose an emissions path that leads efficiently to the achievement of the Kyoto targets. Instead, they have decided either to rely on tougher targets in the second allocation period or to impose the additional cost of meeting the targets on consumers instead of on the large-scale incineration facilities.

Even in the second commitment period, the NAPs seem to favor the EU ETS sectors over the rest of the economy. The simulation results in Fig. 2 illustrate this for the target of a 20% reduction of CO_2 emissions under NAP2. A price of 53 €/t CO_2 for EUAs (the red line in Fig. 2) would be accompanied by shadow prices for the non-ETS sectors of up to 260 €/t CO_2 in Scandinavia. This has also a negative impact on innovation in the industrial energy sectors (Schleich et al. 2008). Only the EU member states not listed individually (rest of EU, or REU, in Fig. 2) have prices slightly below the EUA price, indicating an excess supply of EUAs in the other countries.

Some features of the EU ETS have unnecessarily created inefficiency in climate policies as well as problems of political economy. These could have been avoided by auctioning the emissions rights and moving the emissions trading upstream so that it covers essentially all

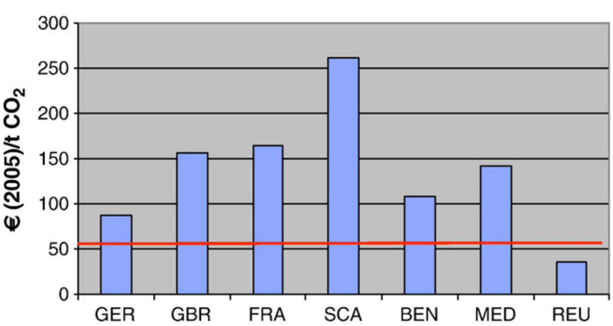

Fig. 2. Simulation-based shadow prices of CO_2 in non-ETS sectors in selected EU member states.
Source: Kretschmer et al. (2009). GER, Germany; FRA, France; GBR, United Kingdom; SCA, Scandinavian EU members; BEN, Benelux countries; MED, Mediterranean EU members (except France); REU, rest of EU 25.

emissions. The auctioning of permits would have been easy in the first allocation period, since the prices for emissions rights would have started at a very low level because of the relatively large amount of permits issued. Switching to auctioning when the caps are more tightly binding will be more difficult. In fact, the phase-in outlined by the European Commission has already created a debate, similar to that over the original process of free allocation, as to who will get the free allowances and who will have to bid for them.

3. The CDM market for the Kyoto period, 2008–2012

Outside the EU ETS, the market for emissions credits is dominated by the CDM markets. Table 1 gives an overview of the latest developments in this market. Both the volume and the value of emissions credits (CERs, each giving the right to emit 1 t CO_2-eq) traded almost doubled from 2007 to 2008. Essentially three-quarters of the activity in the carbon market worldwide took place within the EU ETS in 2008, and another 20% in the secondary CDM market. The other credit markets have played hardly any role so far. The market for project-based transactions is also dominated by CDM projects, where there is a direct transaction between the project in the developing country and a buyer in an industrialized country. JI and voluntary markets have traded only 65 Mt CO_2, compared with 463 Mt CO_2 of emissions contracted in CDM projects.

The basic idea behind the CDM is that a project that is financed and developed by an investor in a developing country generates a certain amount of emissions savings, which are additional to measures already taken within the country. Once such a project has been approved by the governing board of the CDM, it will, over a determined length of time, create a flow of emissions credits, which an emitter can then use to meet its obligations under a cap-and-trade system like the EU ETS or the Kyoto targets for Annex I countries (industrialized countries and economies in transition). The EU ETS accepts CERs and has thus created a market for these project-based credits. Since the project planner and the emitter are, in general, not the same entity, the project credits (primary credits) are often resold by the project developer to emitters or to third parties (secondary credits) before they are used to cover emissions in a cap-and-trade system.

From the start of the program through June 2009, issuance of CERs has totaled 296.5 million (PointCarbon, 2009). This is significantly less than the number of tons of CO_2-eq saved in CDM projects that have been approved but not yet been certified to become CERs (and which therefore cannot be traded within the EU ETS). That number stood at roughly 500 Mt CO_2-eq in 2009 and is expected to grow to 1.52 Gt CO_2-eq by the end of the Kyoto period, in 2012 (CARBONfirst, 2008). Emissions avoided by CDM projects in the pipeline amount to almost 3 Gt by 2012 and 7.4 billion Gt by 2020, according to the UN Environment Programme's Risoe Centre on Energy, Climate and Sustainable Development, which is responsible for the bookkeeping of CDM projects (Fenhann, 2009). Whether these claimed emissions savings will actually become issued and registered as CERs is an open question.

Given the emissions reduction commitments of the Annex I countries within the Kyoto Protocol (roughly 700-1000 Mt CO_2-eq) and current Annex II country emissions of about 14 Gt CO_2, and taking into account the 5-year span of the Kyoto period, up to one-third of the reduction requirements over that period could be supplied by CDM credits. The World Bank has estimated, based on official communications from the participating countries, that total demand for emissions credits from the Kyoto mechanisms (AAUs from Annex I parties, CERs from CDM, and ERUs from JI projects) will be around 2.4 Gt CO_2-e over the period 2008-2012.[6] Private sector demand accounts

[6] Assigned amount units (AAUs) are emissions credits related to the caps under the Kyoto Protocol; emission reduction units (ERUs) are credits created under the Joint Implementation program.

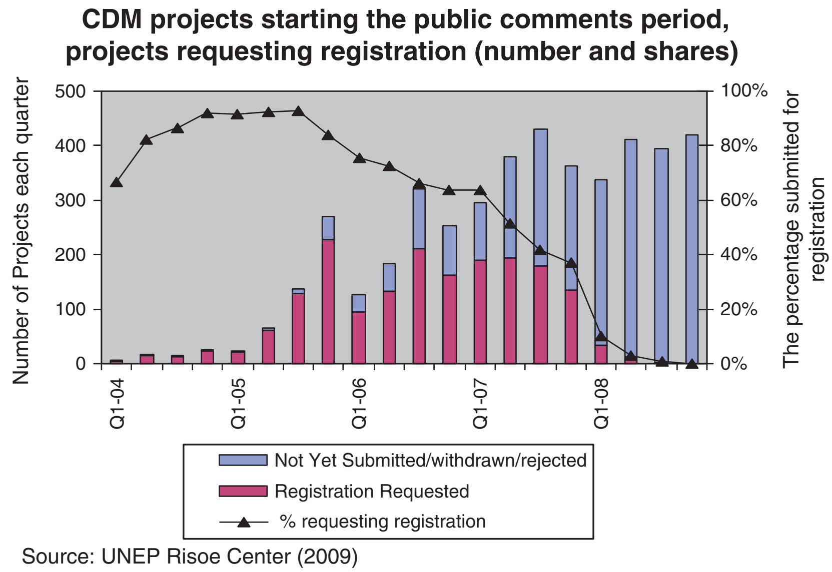

Fig. 3. CDM project submissions, 2004–2008.
Source: Risoe Centre on Energy, Climate and Sustainable Development.

for 73% and government demand for the remainder. Private demand is likely to be almost completely met by CERs, whereas the World Bank (2008a) assumes that 50% of government demand will be met by AAUs. This also results in a CDM demand in the range of somewhat over 1.5 billion CERs.

Whether these projections are indeed likely to materialize becomes doubtful when one considers that the number of projects submitted for registration declined drastically in 2008. As of the end of that year, essentially no projects had been submitted for registration to the CDM authorization bodies, although the number of new projects in planning remained at a level of 300 to 400 each quarter in 2008 (Fig. 3).

The World Bank (2010) reports that the global economic crisis is the main factor in the slowdown in the volume and value of project-based transactions, i.e., the primary CDM market (Fig. 4). Reduced demand for ERUs is seen as the main factor. At the same time, the allowance markets – especially the ETS – continue to grow by almost 100% a year. The secondary CDM market grew almost fivefold during 2009 despite the crisis. Given these developments, it seems more likely that the uncertainty about the role of CDM project credits in a post-Kyoto agreement, or in a situation where no international agreement is reached, has led to a reluctance to engage in long-term projects in the CDM market. This conjecture is supported by the fact that other markets, especially the voluntary market, continue to grow, whereas the flexible mechanisms of the Kyoto Protocol (CDM and JI) see a contraction in transactions.

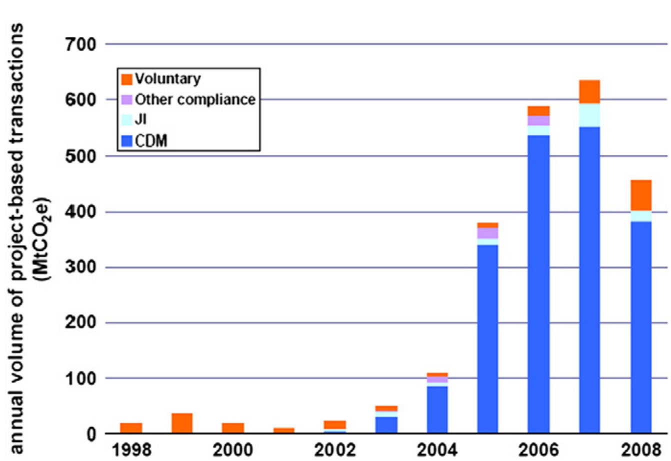

Fig. 4. Volume of emissions reductions in project-based transactions.
Source: World Bank (2009). Includes projects of vintages up to 2012.

The results of the Copenhagen conference will put further pressure on markets for credits from the flexible mechanisms. Since the ETS is likely to be the only system with a cap-and-trade approach, and many countries are setting only intensity targets in terms of emissions per unit of GDP in their voluntary emissions reduction commitments, an emissions cap beyond that of the ETS is unlikely to exist after 2012. Such a cap is a prerequisite for a market in credits from CDM and JI projects that will lead to prices sufficiently high to create incentives for continued activities in the spirit of these mechanisms. Activity in developing new CDM projects has fallen substantially since the Copenhagen conference; prices for CERs for the post-Kyoto period have dropped as well.

Currently, market participants seem to believe that there will be some demand from the ETS and that some additional demand will come from institutions that intend to buy credits despite not being subject to a cap-and-trade scheme. As a consequence, the market for CDM-like credits will continue to exist, either outside of a post-Kyoto protocol on the basis of bilateral, national, or regional climate policy frameworks, or on the basis of an international agreement for the post-Kyoto period. However, the question remains whether demand for these emissions credits will be sufficiently high to make such investments profitable. The ongoing negotiations for a follow-up to the Kyoto Protocol do not indicate in what direction the future of flexible mechanisms will be moving.[7]

The recent decline in CDM-related activities is therefore due in part to these uncertainties, but it is also driven by a number of other events, such as the repercussions of the financial crisis and the ensuing economic downturn, uncertainties about the credibility of the certification processes within the CDM, and the fraud of value added taxes through trading EUAs in the EU by illegally exploiting differences in value added taxes. The decline in economic activity due to the financial crisis has put pressure on prices in the large carbon markets, endangering the profitability of some projects. In addition, China, the largest supplier of CERs, requires a minimum price

[7] Christiana Figueres, executive director of the UNFCCC, quoted in "Trust, or Bust," *Carbon Finance*, June 16, 2010 (www.carbon-financeonline.com/index.cfm?section=features&action=view&id=13010).

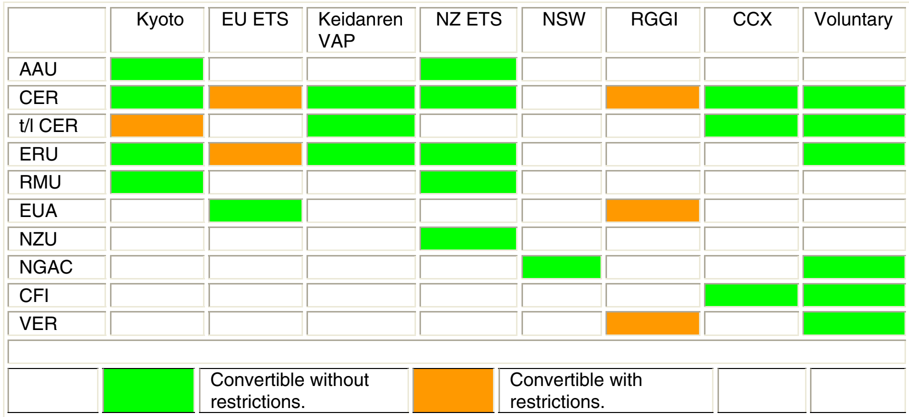

Fig. 5. Convertibility of currencies in different carbon regimes.
Source: World Bank (2008a). VAP, Voluntary Action Plan; see Tables 1 and 2 for other abbreviations.

for credits — a fact that, when the risk premium is included, threatens acceptance of many projects by the Chinese government.

So far, CDM projects have concentrated on the reduction of hydrofluorocarbons (HFCs), methane, and other non-CO_2 greenhouse gases. In fact, HFC reduction so far accounts for around 55% of CERs issued, and most of these projects have been created in China. In particular, smaller developing countries and many African countries have not been successful in attracting CDM projects. This may be due to a lack of expertise in these countries, but it may also be the result of a general lack of profitability of suitable projects. Since the carbon credits created in a CDM project are supplemental to the project's overall profitability, they may not sufficiently compensate for low market returns (World Bank, 2008b).

This geographical concentration of CDM projects goes hand in hand with the small shares of projects in the areas of transport, infrastructure, and rural energy supply.[8] Such projects would have significant accompanying benefits in terms of sustainable development in impoverished areas.[9] Yet the emissions reduction opportunities in the area of deforestation and forest degradation have been excluded from the CDM mechanism completely, despite their large potential, on the order of 1.6 Gt CO_2 annually.

The concentration of CDM projects in large-scale HFC and methane reduction projects has spurred interest in improvements in the CDM that would make it more attractive to engage in smaller projects and in areas that have not yet seen CDM activities. High transaction costs, among other factors, have so far prevented such projects. Two types of proposal are currently under discussion, the so-called programmatic CDM (pCDM) projects and sectoral approaches. Programmatic CDM projects have been described and distinguished from other policies by the UNFCCC: "A local/regional/national policy or standard cannot be considered as a clean development mechanism project activity, but project activities under a programme of activities can be registered as a single clean development mechanism project activity" (quoted in Figueres and Streck, 2008, pp. 24–25). The methodologies for pCDM were accepted by the executive board of the CDM as early as 2007, but so far no projects have been approved. In principle, these projects have the advantage that they can encompass a large number of smaller regional projects, even across countries, thus reducing transaction costs. At the same time, the risk of misrepresenting emissions reductions increases, and the Designated Operational Entities (DOEs) responsible for the correct performance of CDM projects have not been willing to accept the liability for the functioning of such projects. Nevertheless, the pCDMs are a step toward regional and even transnational CDM projects.

In the sectoral CDM approach, credits would be defined not for a single project but rather in terms of a certain policy that a government imposes on a particular sector. The procedures would be similar in that a target would be set by the government, and, upon reaching the target, the carbon credits created could be sold on international markets. Such approaches will become relevant only in the post-Kyoto phase, and it remains an open question how they will be integrated into regional or global carbon trading schemes.

The sectoral approach requires the definition of a baseline against which the emissions reductions within a sector can be measured. Such a baseline and the emissions reduction to be achieved against this baseline amount to little less than a sectoral cap on emissions. The country engaging in sectoral CDM activities would introduce a partial cap-and-trade system, with the baseline being the defined cap. This would not create a substantial constraint on emissions in that sector, but it would establish a publicly defined emissions path that could be easily interpreted as a "business as usual" baseline. Determining such a path itself could generate a debate that could trigger demand for a revision of baselines that seem too high in the light of economic developments, resulting in stronger political pressure to agree to reduction targets. This has happened in the context of the recent rapid increase in China's CO_2 emissions.

4. Market segmentation and convertibility

This section provides a short overview of the indirect links among the different carbon markets.[10] A large number of such markets, with many "currencies" (emissions reduction units) but only limited convertibility, are now in existence. In fact, most markets are connected only through the CDM market and to some extent through the JI project mechanism. Fig. 5 and Table 2 list the various markets and their currencies.

It is apparent that the CERs from CDM projects are the permits most easily exchanged across markets. The EU ETS, as the largest market, imposes restrictions on the use of CDM and JI credits and does not accept other emissions reduction currencies at all. On the other hand, most small national emissions trading schemes and the voluntary markets do accept permits from other systems. However, given the lower prices in these markets, the incentive to use EUAs from the EU ETS is essentially nonexistent.

[8] See, e.g., Grubb et al. (2010), World Bank (2010), and Carbon Trust (2009).

[9] A few projects have been approved to the so-called "Gold Standard" that certifies additional benefits for sustainable development and have received a significant premium for the credits generated.

[10] An overview about many linking issues for carbon markets is given in Tuerk et al. 2009.

Table 2
Currencies of emission permits in different emission trading regimes.

Trading regime	Currencies of emission units
Kyoto Protocol	Assigned Amount Units (AAUs)
CDM	Certified Emission Reductions (CERs)
Afforestation/deforestation in CDM	Temporary/long-term CERs (t/l CERs)
JI projects	Emission Reduction Units (ERUs)
Land Use Change in CDM	Removal Units (RMUs)
EU ETS	European Union Allowances (EUAs)
New Zealand Emission Trading Scheme (NZ ETS)	New Zealand Unit (NZUs)
NSW	NSW Greenhouse Gas Certificates (NGACs)
CCX	Carbon Financial Instrument (CFIs)
Voluntary market	Verified Emission Reductions (VERs)

This multitude of carbon markets poses a challenge for reducing market segmentation and creating a common carbon market with a uniform price. This cannot be done by simply making all carbon currencies convertible. The different systems rely on different types of restrictions on emissions, with differing levels of restrictiveness of their emissions caps; their validity and credibility may differ depending on the monitoring and verification scheme; and, most important, they sometimes cover the same geographic area, thus contradicting the idea of a unique cap on emissions as a prerequisite for emissions trading.

It is therefore likely that some small markets will remain independent, whereas larger ones will need to assimilate their procedures and coverage to those of the EU ETS, the most developed and largest market so far. This situation may change if the United States moves toward an emissions trading scheme, which would quickly reach a size similar to that of the EU ETS.

Another feature of the CDM that influences the possibility to segment markets is “buyer sovereignty” for CERs: each CER carries a unique identifier that allows each potential buyer to choose or – in the case of a state – regulate from which country or from which type of project CERs can be brought into a domestic trading system. In that sense the CDM could in principle develop into a network of locally determined markets. A continuation of project-based credits as they were developed under the CDM is possible without an international agreement if countries decide to honor particular credits derived from projects in a particular country.[11] Such a system of credit markets unilaterally created by importing countries would lead to a differentiation of carbon prices and to a limited convertibility of credits. This raises the danger that the emerging global market for CERs would be curtailed and turn into a number of separate local carbon markets.

5. The distributional effects of CDM in a post-Kyoto framework

This section develops a stylized analytical model of the interaction between a CDM and future emissions reduction commitments by non-Annex I countries. It shows how the existence of the CDM influences the incentives of countries to agree on limits to their emissions.

The project-based mechanisms of the Kyoto Protocol were designed to create incentives to reduce emissions for countries not subject to caps on their emissions. These incentives consist of the ability to receive technology from industrialized countries as well as financial transfers for the carbon credits created. To be effective, a post-Kyoto framework will require a much stronger involvement of developing countries that are currently not participating in mitigation activities. Even more important, emerging economies will need to reduce their emissions substantially from their expected baseline. This will require new forms of incentives that go beyond the current framework of CDM projects. At least for the largest emerging economies, such as China and India (which already provide most of the CDM projects), some form of commitment to reduce emissions below some specified level will be necessary if global emissions are to be substantially reduced. At the same time, most CDM projects last for many years, and many will do so well into the post-Kyoto period. The question, therefore, is how activities such as emissions reduction through CDM projects will interact with possible future cap-and-trade systems. In what follows, a simple model is developed that illustrates the role of multiperiod CDM projects in a post-Kyoto global emissions trading scheme.

Suppose that there are two countries (i, d), the first an industrialized country facing an emissions constraint $c_i=\gamma c$, and the second a developing country facing no constraint. The constraint c could be a globally desired emissions reduction below some unconstrained level that, e.g., puts global emissions on a path toward a goal of limiting global warming to 2 °C. Suppose further that the industrialized country's cap, like the limited emissions targets of the Kyoto Protocol, achieves only part of that objective. The share of c that is allocated to country i in the Kyoto period is given by γ. To stay within the constraint, country i can engage in CDM projects in the developing country that reduce the latter's emissions by e_d, and thus get credit for saving the same amount in country d by buying the CERs. Both countries are assumed to exhibit quadratic marginal abatement cost (MAC) curves, where a is the relative cost difference between the two countries[12]:

$$MAC\left(e_j\right) = ae_j^2 \qquad j = i,d \text{ and } a > 1 \text{ if } j = i\,;\, a = 1 \text{ if } j = d.$$

Assume there is a competitive national and international market in emissions permits[13] such that the price for such permits p equals the marginal abatement cost[14]:

$$MAC(e_i) = MAC(e_d) = p \qquad j = i,d.$$

Without a CDM option, and with an emissions constraint γc for country i only, the carbon price in country i will be $p=a(\gamma c)^2$. The corresponding welfare cost of meeting the target γc can be computed as $W_i(\gamma c) = \frac{1}{3}a(\gamma c)^3$.

Now suppose a CDM market is available such that country d still faces no emissions constraint but can sell emissions permits to country i through CDM projects. This resembles the current situation under the flexible mechanisms of the Kyoto Protocol.[15] The emissions constraint for country i remains the same, γc. The new equilibrium will be given by emissions abatement in both countries such that the marginal abatement costs are equalized and the sum of emissions reductions $e_i^*+e_d^*$ just meets the emissions constraint γc:

$$e_i^* + e_d^* = \gamma c$$
$$e_d^{*2} = ae_i^{*2}.$$

[11] I owe this insight to an anonymous referee.

[12] Such cost curves have been computed with computable general equilibrium models. For an example see Klepper and Peterson (2006a and 2006b).

[13] An analysis of emissions trading and CDM can be found in Hagem (2009).

[14] The transactions costs of CDM projects are ignored here since they do not influence the qualitative results. However, the redistribution of resources is reduced for both sides in the presence of transactions costs, as these costs are essentially not available for redistribution. These costs can substantially influence the price of carbon, as is shown by Klepper and Peterson (2004).

[15] This is true not only for CDM but also for JI projects, which can be undertaken between companies located in countries that have agreed to emissions targets under the Kyoto Protocol. Such JI projects are most likely in countries that have a supply of “hot air”; i.e., their benchmark emissions are smaller than the emissions constraint.

The corresponding welfare costs of the two countries are given by

$$W_i(e_i^*, e_d^*) = \int_o^{e_i^*} a e_i^2 de_i + p_{CDM} e_d^*$$
$$W_d(e_i^*, e_d^*) = \int_o^{e_d^*} e_d^2 de_d - p_{CDM} e_d^*.$$

A simple computation shows that

$$e_i^* = \frac{k\gamma c}{\sqrt{a}} \quad \text{with } k = \frac{\sqrt{a}}{1+\sqrt{a}} \geq \frac{1}{2}$$
$$e_d^* = k\gamma c$$
$$p_{CDM} = (k\gamma c)^2$$

and the corresponding welfare costs of the two countries are[16]

$$W_i(e_i^*, e_d^*) = \left(1 + \frac{1}{3\sqrt{a}}\right)(k\gamma c)^3$$
$$W_d(e_i^*, e_d^*) = -\frac{2}{3}(k\gamma c)^3$$

As mentioned above, CDM projects often last for several years to over a decade. Thus, many CDM projects signed in the Kyoto period will have an impact on the costs and benefits of a cap-and-trade system in a post-Kyoto climate agreement. Without going into the details of CDM projects of different lifetimes, I simply assume that all old CDM contracts have a lifetime that extends beyond the first post-Kyoto phase.

One can build scenarios for the post-Kyoto phase in several ways. If there is a worldwide consensus for emissions reductions by the amount c, the essential question for the distribution of the costs and benefits of climate mitigation is the allocation of emissions rights:

$$c = \gamma c + (1-\gamma)c.$$

In other words, $(1-\gamma)c$ denotes the reduction that is now imposed upon country d.

There are essentially two possibilities for allocating emissions reductions in a post-Kyoto framework given an agreed overall emissions goal of c. Either the CDM contracts remain valid, or they are discontinued or phased out.

Start first with the case in which CDM projects are discontinued. In this scenario (designated PK−) there will be just one emissions reduction constraint for each country, defined by γ and c. International emissions trading will equalize carbon prices. The corresponding welfare functions are

$$W_i^{PK-}\left(e_i^{PK-}, e_d^{PK-}\right) = \int_o^{e_i^{PK-}} a e_i^2 de_i + p_{PK-}\left(\gamma c - e_i^{PK-}\right)$$
$$W_d^{PK-}\left(e_i^{PK-}, e_d^{PK-}\right) = \int_o^{e_d^{PK-}} a e_d^2 de_d - p_{PK-}\left(\gamma c - e_i^{PK-}\right).$$

In this case emissions levels, carbon prices, and welfare costs amount to

$$e_i^{PK-} = \frac{kc}{\sqrt{a}} \text{ and } e_d^{PK-} = kc \quad \text{with } k = \frac{\sqrt{a}}{1+\sqrt{a}} \geq \frac{1}{2}$$
$$p_{PK-} = (kc)^2$$
$$W_i^{PK-}\left(e_i^{PK-}, e_d^{PK-}\right) = \left\{\frac{\gamma}{k} - \frac{2}{3}\frac{1}{\sqrt{a}}\right\} k^3 c^3$$
$$W_d^{PK-}\left(e_i^{PK-}, e_d^{PK-}\right) = \left(\frac{1-\gamma}{k} - \frac{2}{3}\right) k^3 c^3$$

If both countries face equal marginal abatement cost curves, they will reduce emissions by the same amount, and trade in emissions will be determined only by the distribution parameter γ. The steeper the marginal abatement cost curve of country i, the higher the carbon price and the larger the emissions reduction in country d.

In the second scenario, designated PK+, both countries agree on national caps and continue to honor the CDM projects signed in the past. Credits from these projects continue to be traded in the post-Kyoto period, but at the prices set in the CDM contracts. In addition, international emissions trading allows countries to obtain emissions permits from abroad. There will be two carbon prices if the price of the CERs agreed upon in a CDM project has been negotiated for the whole period, and a unique price if only the quantity of the CERs created in a CDM project has been set and the price of a CER depends on when it is transferred. In reality, it is most likely that the CER price will be determined in a competitive market at the time the project is created. In other words, the prices of CERs from the Kyoto period are given in the post-Kyoto period.[17]

The welfare of the two countries can be written as

$$W_i^{PK+}\left(e_i^{PK+}, e_d^{PK+}\right) = \int_o^{e_i^{PK+}} a e_i^2 de_i + p_{CDM} e_d^* + \left(\gamma c - e_i^{PK+} - e_d^*\right) p_{PK+}$$
$$W_d^{PK+}\left(e_i^{PK+}, e_d^{PK+}\right) = \int_o^{e_d^{PK+}} a e_d^2 de_d - p_{CDM} e_d^* - \left(\gamma c - e_i^{PK+} - e_d^*\right) p_{PK+}.$$

The corresponding emissions levels and carbon prices are given by

$$e_i^{PK+} = \frac{kc}{\sqrt{a}}; \; e_d^* = k\gamma c \; ; \; e_d^{PK+} = (1-\gamma)kc$$
$$p_{CDM} = (k\gamma c)^2; \quad p_{PK+} = (kc)^2$$
$$W_i^{PK+}\left(e_i^{PK+}, e_d^{PK+}\right) = \left(\frac{\gamma}{k} - \frac{2}{3\sqrt{a}} + \gamma\left(\gamma^2 - 1\right)\right) k^3 c^3$$
$$W_d^{PK+}\left(e_i^{PK+}, e_d^{PK+}\right) = \left(\frac{1-\gamma}{k} - \frac{2}{3} + \gamma\left(1-\gamma^2\right)\right) k^3 c^3.$$

It is clear that the market price for post-Kyoto emissions rights ("post-Kyoto AAUs") will be the same in both scenarios. The CER prices for CDM credits, however, will be lower, since they have been negotiated in a setting where there were no restrictions on the emissions of country d. In fact, in this example with quadratic marginal abatement cost curves, the CER price p_{CDM} will be lower by γ^2 than the post-Kyoto permit price. A low γ means a soft target in the Kyoto period and a low CDM price, but also a high additional constraint on country d, and thus a high post-Kyoto carbon price.

[16] Notice that a negative welfare cost is a welfare gain, i.e., country d benefits from engaging in the CDM market.

[17] One could argue that the existence of a secondary market would move CDM prices from the Kyoto period up to the post-Kyoto carbon prices. If this is the case, the welfare analysis in this simple model remains valid. The question then is only who obtains the windfall profit that results from the switch from the Kyoto to a post-Kyoto agreement. In fact, if the CDM credits are owned by country i, then scenario PK+ applies. If they are owned by country d, then scenario PK- applies, as country d can sell the credits in the post-Kyoto phase at the then-prevailing market price, which will be higher than the original (primary market) CDM price.

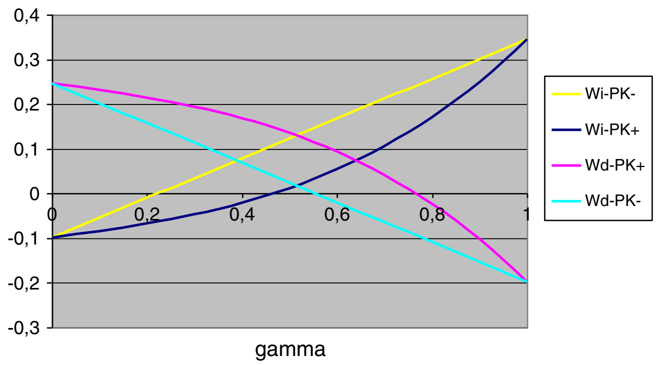

Fig. 6. Welfare effects for different emissions sharing targets. Figure shows welfare for industrial (i) and developing (d) countries under alternative scenarios in which CDM projects are discontinued (PK−) or CDM credits continue to be honored (PK+) after expiration of the Kyoto Protocol. Results are for relative marginal abatement costs $a=4$ (costs in i are 4 times those in d).

Since the CER prices have been set in advance, the overall emissions reduction for both countries will be the same in scenario PK+ as in scenario PK−. The only difference is the price at which the emissions permits are sold from country d to country i. Hence there is only a distributional effect and no allocation effect.

In this quadratic example, the welfare effects in all scenarios and for both countries are scaled by the overall cap c. The welfare functions show that the welfare cost of a tighter target rises with a power of 3 for all countries and in each scenario, because of the quadratic marginal abatement cost function. Hence, the distributional impacts can be identified within this framework for agreements with different restrictions on emissions. Essentially, the welfare effects for the two countries depend on the interplay between the allocation of the caps among countries i and d as well as the differences in abatement costs.

A comparison of the distributional effects of scenario PK+ with those of scenario PK− for any given $\gamma<1$ and given $a>1$ gives a clear result. The industrialized country is better off if it continues the CDM projects (PK+), and the developing country is better off if it phases them out (PK−). The difference in welfare costs in country i between scenarios PK+ and PK− depends on the degree to which country i has contributed to the reduction (γ). The higher the share of country d in the reduction commitment, the higher its welfare costs. The difference between scenarios PK+ and PK− at first increases with a higher reduction commitment and then falls as the share of old CDM projects declines (Fig. 6). For $\gamma=0$, no CDM projects are carried over, since country d bears the complete reduction burden.

The impact of the future of CDM contracts on the welfare of country d is determined by the share of the reduction imposed on country d, i.e., on γ. If the post-Kyoto agreement imposes only a small reduction share on country d, its welfare effect from selling emissions permits remains positive. In this case the gains from selling CDM credits outweigh the cost from complying with the small reduction target. If country i's reduction (a low γ) becomes small, then the reduction commitment for country d starts to dominate the positive effect of the CDM market. In the scenario with a phase-out of CDM contracts (PK−), the income generated at low CER prices will be replaced by higher carbon prices for all emissions traded, but this is counterbalanced by the increasing cost of additional emissions reduction requirements. In scenario PK+ the fixed CER prices lead much more quickly to a situation where the sales of emissions permits do not compensate for the required emissions reduction. In other words, the trajectory of welfare effects in γ for country d is much steeper in PK+ than in PK− for $\gamma<1/2$.

In summary, if country d were to accept an emissions cap, it would prefer to discontinue the CDM contracts. And if the CDM contracts instead remain in place, only very small contributions from country d

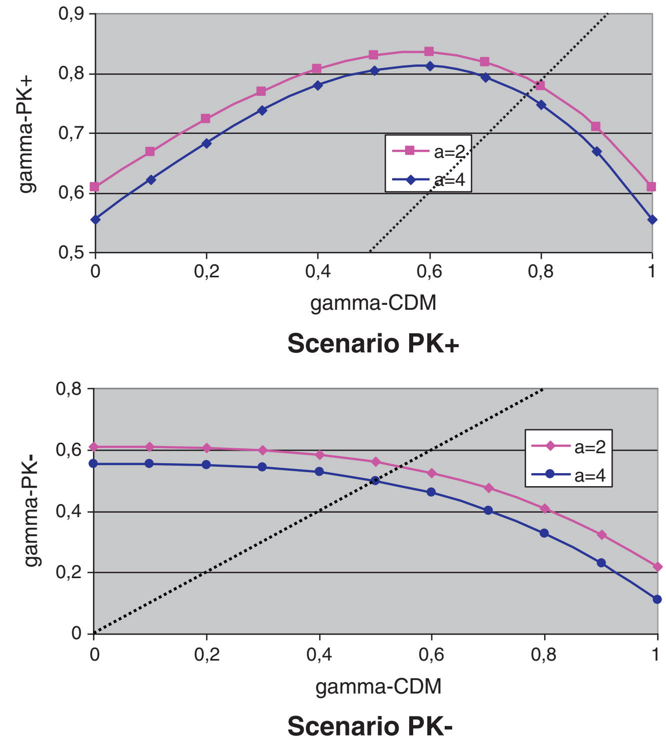

Fig. 7. Allocations of emissions rights between Kyoto and post-Kyoto periods yielding zero welfare costs for developing countries under alternative CDM scenarios. In scenario PK+, CDM projects continue; in scenario PK−, CDM projects are discontinued. a indicates relative marginal abatement costs. Dotted line indicates equal permit allocations in both periods.

toward overall emissions reductions would keep it in the range without welfare losses. In fact, in this stylized framework, country d would agree to an allocation of emissions rights only if its reduction commitment remained below 25% of the worldwide reduction.[18]

Of course, it is unrealistic to assume that the reduction commitment of the industrialized countries in the Kyoto period will be maintained in the post-Kyoto phase and that an additional cap will be imposed on the developing world as assumed above. Instead, one would expect that the low γ in the Kyoto period will be replaced by a higher γ in the post-Kyoto phase, reflecting the need for stronger action by the developed world before a commitment is to be expected from the developing world.

To illustrate the interaction between the emissions reduction by country i in the Kyoto period with that under a post-Kyoto agreement, the top panel of Fig. 7 illustrates the relationship between the Kyoto commitment (γ-CDM) and the commitment in a post-Kyoto scenario (γ-PK+) where the CDM projects are continued. The figure shows the combinations of the two shares that result in zero welfare costs of emissions reductions for country d. Points under the curves yield positive welfare costs, i.e., a negative welfare effect, for country d, and points above the curves yield negative welfare costs of abatement, i.e., a welfare gain. For example, if in the Kyoto period country i has agreed to reduce emissions by 50% of the needed overall reduction, then it would need to commit to a more than 80% share of the worldwide reduction in the post-Kyoto agreement in order to make country d indifferent between joining the agreement and having no agreement at all. The marginal abatement costs are assumed to differ between the countries by a factor of either 2 or 4 (i.e., $a=2$ or $a=4$), which is

[18] This analysis does not take into account differences in country size, which in reality would lead to an even smaller share of reduction commitments with nonnegative welfare effects.

not too unreasonable given estimates in the literature.[19] The effect of the difference in marginal abatement costs is small compared with the impact of the Kyoto commitment of country *i*.

In the alternative case, where the CDM projects are discontinued, one can illustrate which post-Kyoto sharing of reduction commitments would leave country *d* as well off as it was in the Kyoto period with CDM projects. The bottom panel of Fig. 7 essentially reveals that a γ of roughly 50% in the Kyoto period could be maintained in a post-Kyoto agreement, whereas a lower γ, which seems more likely given the minimal effectiveness of the Kyoto Protocol, requires a substantially higher commitment.

The current Kyoto targets are in general viewed as much too low to stabilize atmospheric CO_2 concentrations. Suppose the current reduction targets achieve only about one-fifth of what would be needed in the Kyoto period up to 2012. This means that γ would be in the vicinity of 0.2 in the scenario of the Kyoto phase with a CDM market, and γc would be the reduction commitment under the Kyoto Protocol. In other words, the worldwide reduction in a post-Kyoto agreement should be five times higher than in the Kyoto period. To make the developing world (country *d*) willing to accept an emissions cap of $(1-\gamma)c$, the share of the industrialized world (country *i*) in total emissions reduction would need to increase to between 68% and 72% if the CDM projects remain in place, and to between 55% and 60% percent if they are discontinued. The impact on prices would be very strong: the post-Kyoto prices for AAUs would be 20 times the CER prices in the CDM market.[20] At the same time, the welfare cost to country *i* would rise from close to zero to somewhat less than one-third of the cost if all the reduction requirements were to be allocated to country *i*.[21]

One could imagine the industrialized countries unilaterally imposing a much stronger reduction commitment but maintaining the CDM projects without requiring a cap on emissions in the developing world. Suppose again that the current Kyoto commitments of the Annex I states (country *i*) amount to 0.2 of the necessary reductions (denoted by *c*) and that these countries agree to take on the whole reduction requirement (implying $\gamma = 1$) in the post-Kyoto agreement. This would lead to much higher costs for country *i* and large welfare gains for country *d,* as shown in Fig. 6. In contrast, to maintain the same welfare gain for country *d* that it achieves in the Kyoto period with CDM projects, a sharing of the reduction requirements of about 75:25 would be necessary. In this regime country *i* would be able to cut its welfare cost by more than half; hence a Pareto improvement from the Kyoto period to the post-Kyoto period could be realized for all sharing arrangements where country *i* takes on more than 75% of the reduction.

Of course, this numerical example highlights only some of the interactions between the CDM projects and a future cap-and-trade scheme. These relationships should be investigated within a larger numerical model calibrated more closely to real-world parameters and taking into account the different sizes of the country groups.

6. CDM and emissions trading in a Post-Kyoto regime

As already noted, the CDM will last well into the post-Kyoto phase, since the majority of projects already approved will lead to the issuance of CERs for many years to come. Crediting for CDM projects is either for a fixed period of 10 years, or for 14 years with a mid-term review, which means that projects starting today may generate credits beyond 2020. Data on approved projects indicate that already around 3.4 billion credits, equivalent to 3.4 Gt CO_2, will be available between 2013 and 2020 (Fenhann, 2010), and this number will continue to grow if more projects are approved during the remainder of the Kyoto period. The fundamental problem with these credits is that they do not lead to additional emissions reductions but rather simply replace existing reduction commitments by the industrialized countries, especially the EU member states. To create a real reduction in emissions, any increase in CERs would need to be matched by a tightening of emissions targets in the country in which the CERs are to be used. Hence, the incentive to maintain the CDM mechanism or even to develop it further in a post-Kyoto agreement should be very unequally distributed. If the Annex I countries are interested in a strong climate regime, they will need to accompany the CDM with very ambitious reduction commitments to compensate for the lack of reductions in the non-Annex I countries.

The simple example above highlights the fact that expanding the CDM without restricting the emissions of developing and emerging economies would sharply raise the cost to the Annex I countries and would lead to large benefits for the developing world (see Fig. 6). Some form of a commitment to restrict emissions by the developing world would be needed to lower the welfare cost to the Annex I countries and move toward a more equitable sharing of the burden of global abatement costs. If one takes as a benchmark the notion that the emerging economies and the developing world should at least not gain from emissions reductions constraints in the industrialized countries, then a sharing of emissions reductions commitments is necessary. Given such a benchmark, the degree to which a sharing of reduction commitments remains in this sense fair depends on how the CDM mechanism is dealt with in a post-Kyoto agreement.

At first sight, a continuation of CDM projects would seem to favor developing countries. But in fact it entails a redistributive element, since the low-cost abatement options would have already been allocated to the CDM projects, leaving only the higher-cost options to count against the reduction commitment in a post-Kyoto agreement. Therefore, the developing countries are unlikely to accept a large share in reduction commitments if the bulk of already-signed CDM projects do not count against their emissions cap. At the same time, a phase-out of the CDM would make it easier for developing countries to accept a larger share of the emissions reduction obligation.

A phase-out of CDM has been proposed by the European Commission. In a communication to the institutions of the European Union, it states (European Commission, 2009, pp. 11–12):

> In order to ensure that a large part of EU emission reductions is done domestically, and to enhance environmental integrity, the EU ETS limits the use of CDM credits based on quantitative and qualitative criteria. In the UNFCCC context, the CDM should be reformed, crediting only those projects that deliver real additional reductions and go beyond low cost options. In addition, for advanced developing countries and highly competitive economic sectors, the project based CDM should be phased out in favour of moving to a sectoral carbon market crediting mechanism. Such mechanisms can be an efficient tool to drive development and deployment of low-carbon technologies in developing countries, and pave the way for the development of cap and trade systems. To ensure a coherent transition, the EU should seek common ground with the US and other countries implementing cap-and-trade systems and generating demand for offset credits in a coordinated manner.

This proposal would effectively eliminate all major emitters if India were included among the “advanced developing countries,” and the CDM would then refer to a group of developing countries accounting for less than 10% of global emissions. In a sense this implicitly sets the stage for a system where the poorest countries do not participate in a cap-and-trade system but only benefit from the CDM. This has the advantage that mechanisms like the CDM offer a transfer both of funds and of advanced technologies to these countries. Both are urgently needed to place these economies on a

[19] See Klepper and Peterson (2006a) and the literature cited there.

[20] CER prices are $(k\gamma c)^2$, with $\gamma = 0.2$, whereas the new PK+ prices for AAUs are $(kc)^2$.

[21] $W_i^{CDM}(c) = 0.35\ \ W_i^{PK+}(0.70c) = 0.12\ \ W_i^{PK-}(0.55c) = 0.15\ \ for\ a = 4.$

growth path that is sustainable both in terms of economic development and in terms of energy consumption and environmental preservation. Since the potential for climate mitigation through efficiency improvements in these countries is great, their contribution to overall climate protection should not be underestimated. In fact, if one envisages some form of regional emissions limits based on the idea of contraction and convergence, most African countries, as well as India, could increase their emissions over the next decades even if a global reduction of emissions by 50% in 2050 is envisaged (Klepper and Peterson, 2006b).[22]

The incentive, in a post-Kyoto agreement, to agree to some form of a cap-and-trade system that includes the existing CDM is strongly diminished for those countries that have already committed to a large volume of CDM projects, leading to a flow of emissions reduction services well into the post-Kyoto phase. In particular, advanced emerging economies like China, where the majority of CERs have been created, will have little incentive to accept such a system. The emerging economies would increasingly be able to benefit from higher permit prices and their low cost abatement opportunities if the CDM projects are discontinued and counted toward a national emissions constraint.

The EU proposal favors sectoral CDM approaches, which would effectively result in sectoral cap-and-trade approaches in the major non-Annex B countries. However, as long as emissions reductions are counted against some business-as-usual baseline, the reduction in global emissions could be achieved only through a further reduction of emissions in Annex I countries. The financing of all abatement costs would remain with the industrialized countries that are buying the CERs.

Sectoral CDM approaches also carry the danger of creating separate carbon markets with unequal prices, similar to what has happened in the EU ETS but with the price divergence having the opposite sign. In the European Union under the ETS, the non-ETS sectors face higher implicit carbon prices than those within the ETS. In a sectoral CDM the sector subject to a sectoral crediting would face higher carbon prices than the rest of the economy. In both cases, such a market segmentation would result in distortions.

The EU ETS will continue to work regardless of whether a post-Kyoto agreement is reached. This means that a substantial part of the emissions permit market will remain in place, stabilizing the market for CERs at least to some extent. This is reflected in the fact that companies are now setting up funds for post-2012 CDM projects.[23] Uncertainty remains about the treatment of the flexible mechanisms after the Kyoto Protocol phases out in 2012. There seems to be some demand coming from the EU ETS, where investors are seeking to secure credits for the system's third phase, but as long as the negotiations for a post-Kyoto regime provide no hints about the future of the flexible mechanisms, the market will remain small (World Bank, 2010).

7. Summary

CO_2 emissions and other greenhouse gases are today being traded in many markets. The largest of these markets by far is the EU ETS, whose introduction has led to a well-established carbon market in which spot as well as futures contracts are traded in several venues. There is also a significant over-the-counter market. The second-largest CO_2 market is that for secondary emissions reductions (CERs) under the CDM, followed by the primary CDM market. Together these markets dominate carbon markets worldwide, with other national schemes and the voluntary market taking only a very small share.

The EU ETS market has a relatively clear structure in which only one carbon permit, the EUA, is traded. In contrast, the CDM market has a large number of different products, so that the market is quite lacking in transparency. Discussions about the future of the CDM seem to suggest that even more new products will be added. Sectoral and programmatic CERs are intended to expand the market, but they will also make it more segmented.

The convertibility of emissions permits across different markets is rather limited. In particular, the EU ETS is currently not open to most other carbon credits, except for a limited amount of CERs. This restriction is understandable, since most other markets rely on emissions constraints that are either less tight or nonexistent, thus resulting in much lower carbon prices than within the EU ETS. This situation might change if another large carbon market is established, e.g., in the United States. However, the caps imposed in the two markets would need to be comparable if the credibility of and prices in the European market are to be maintained.

The EU ETS will continue to exist after 2012, whether or not a post-Kyoto agreement is reached that includes a global trading mechanism, or at least one that covers the most important emitting countries. The next trading periods for the EU ETS have already been determined, and a plan for moving to a complete auctioning of emissions rights has been decided upon. The institutional framework established for the EU ETS includes a registry, trading venues, and companies and funds specializing in carbon trading. These institutions could provide the basis for an expanded trading mechanism that includes other countries willing to set caps on their emissions. The benefit of having a more or less functioning European carbon market should be realized through a stronger integration of other national markets and, it is hoped, through a commitment by more countries to limit their emissions.

The CDM has created important incentives in developing and emerging economies for investments in greenhouse gas reduction projects, and over the last few years the CDM market has been growing rapidly. However, in the light of the economic crisis and the uncertainty surrounding the future of the CDM in a post-Kyoto agreement, the number of projects submitted for approval has fallen to almost zero. On the other hand, the CDM projects already in operation will create a significant number of carbon credits for many years to come.

These projects currently provide a low-cost source of emissions reductions for industrialized countries. However, they also move those countries that have provided the bulk of CDM projects up their marginal abatement cost curve. The willingness of these countries to agree to a limit on their emissions is limited, given that their abatement activities are essentially counted toward emissions constraints in the industrialized countries. The treatment of these CDM projects in a post-Kyoto agreement is therefore interlinked with the ability and willingness of developing countries to accept a significant limit on their emissions. The aim of achieving significant reductions in global emissions leave several options open, all of them equally difficult politically. A continuation of the CDM would require very large emissions reduction commitments by the industrialized world, which then would be implemented in part through imported CDM credits. Given the rapid growth of emissions in the emerging economies, this would drive the emissions caps of the industrialized countries rather quickly toward zero. On the other hand, a discontinuation of the CDM would require that the emerging economies agree to a cap on their emissions if a reasonable climate protection objective is to be achieved. This would require establishing a process in which the existing CDM projects are slowly phased out and the caps take these CDM projects into account.

[22] This calculation is based on the assumption that by 2050 emissions rights are distributed on an equal per capita basis. In the intermediate periods a linear path from current per capita is selected.

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