Carbon Trading: A Review of the Kyoto Mechanisms

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Abstract

The three Kyoto flexible mechanisms—emissions trading, the clean development mechanism (CDM), and Joint Implementation (JI)—have always been controversial. Proponents saw the mechanisms as clever tools to ensure environmental outcomes were achieved at least cost. Reducing the costs of compliance, they argued, would make tighter environmental targets possible, and certainly more politically feasible. Detractors have argued that the flexible mechanisms commoditize Earth's atmosphere in a manner that will allow dubious projects and the exchange of "hot air" to substitute for serious engagement on climate change. This chapter reviews the Kyoto flexible mechanisms, which will become fully operative during the period 2008 to 2012. The review assesses their progress and success to date, examines the problems that have emerged, and considers suggestions for future developments in climate policy.

Contents

1. INTRODUCTION

Over the past few years, climate change economics and carbon trading have moved from the academic arena to front page headlines in mainstream newspapers. This is partly because climate change has itself moved up the political agenda, promoted by weather events such as the European heat wave in 2003, Hurricane Katrina in the United States in 2005, and the droughts, bushfires, and snow (almost simultaneously) in Australia in 2006. Not only has climate change been placed at the top of the Group of Eight (G8) nations (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States) and the European Union (EU) agendas, carbon offsetting has captured the interest of individuals and businesses who want to "do their bit" for the atmosphere. Media interest has been heightened by introduction of the pan-European Emissions Trading Scheme (EU ETS) in 2005 and the publication of the *Stern Review on the Economics of Climate Change* (1).

All this recent activity and publicity might give the impression that carbon trading is a radically new idea. However, the conceptual underpinnings for carbon trading began with in 1920 with Pigou (2), who pointed out the social benefits of forcing companies to pay for the costs of their pollution, and were developed by Coase (3), who showed that allocating property rights and allowing trade can yield efficient results.[1] The first explicit application of these ideas to pollution was proposed in 1968 by Dales (5). In a typical "cap and trade" scheme, the government issues a total number of permits, or allowances, which give firms the right to emit pollution. Because fewer allowances are issued than firms need, allowances are valuable and trade with a positive price. The price provides firms with an incentive to reduce their emissions when this is cheaper than purchasing allowances. In short, the basic theory of emissions trading has been established for almost four decades.

Nor is the practice of emissions trading particularly novel. Trading of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) began in the United States in the 1990s (6). It was greeted with skepticism but is now viewed by many as a success. Carbon trading, which

ETS: Emissions Trading Scheme

[1]Pearce (4) provides a valuable intellectual history of environmental economics.

refers to the trading of emissions of six major greenhouse gases,[2] is more recent. The EU ETS is the largest scheme to date, although it is by no means the first, and it only caps Europe's carbon dioxide emissions from fixed industrial installations, leaving the other five major greenhouse gases, and the other sectors, to be addressed through other policy measures. Before the EU ETS, several governments had implemented carbon trading schemes, including the United Kingdom in 2002 and the Australian state of New South Wales in 2003. The 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) provided for carbon trading through three "flexible mechanisms," over its first commitment period from 2008 to 2012. Even though the first commitment period has not yet commenced, the first forward carbon trades occurred many years earlier, long before the Protocol came into force on February 16, 2005, and the very first voluntary trades (by parties not subject to regulatory requirements) occurred almost two decades ago, in the late 1980s.

What is new, however, is the sheer scale of the enterprise. The Kyoto Protocol has prompted the emergence of major international markets in carbon, the largest of which by far is the EU ETS. In 2006 alone, the international carbon markets were estimated to have turned over $30 billion, and the aggregate annual value of the permits to emit carbon dioxide on the EU ETS, called EU Allowances (EUAs), were worth more still. Any analysis of the bigger picture (see Section 2 below) suggests that this is just the tip of the iceberg if humanity is going to achieve the emission reductions necessary to avoid dangerous anthropogenic interference with the climate, which is also economically sensible (1).

A great deal rides on the success or failure of this global socioeconomic experiment in commoditizing and trading carbon. This chapter provides an overview and an assessment of carbon trading and the Kyoto flexible mechanisms. What has been achieved so far? What are the crucial problems? What future developments are likely? Finally, what are the directions for future policy-relevant research? Section 2 provides a brief overview of the bigger picture, outlining the scale and nature of challenge that carbon trading is intended to address. Section 3 reviews the three Kyoto mechanisms. Section 4 examines how these mechanisms have facilitated or stimulated carbon trading around the world. Section 5 attempts an assessment of the results so far of this grand experiment. Section 6 considers future directions, and Section 7 concludes.

UNFCCC: United Nations Framework Convention on Climate Change

EUA: European Allowance

2. CLIMATE ECONOMICS: THE BIG PICTURE

Any examination of carbon trading must be informed by the magnitude of the problem it is being asked to address. The size of the challenge is apparent from some simple arithmetic in the Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) (7, 8). Since the onset of the Industrial Revolution, almost 300 gigatonnes of carbon (GtC) have been released into the atmosphere. Stabilization of the atmospheric concentration of carbon dioxide at around 450 parts per million by volume (ppmv), which may involve an ~50% probability of exceeding 2°C warming (1), requires cumulative emissions since the Industrial Revolution to be below 670 GtC (7, §3.8.3).

Extremely roughly, then, a 450 ppmv target leaves us with an "atmospheric reserve" of around 370 GtC. However, consuming proven conventional oil and gas reserves would add another 200 GtC to the atmosphere, and there are likely to be substantial oil and gas reserves beyond 200 GtC that are not currently considered "proven" or are "unconventional." Moreover, there is more than

[2] These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

1000 GtC available in proven coal reserves (7, §3.8.3). The IPCC Fourth Assessment Report (8) estimates that in 2004, annual global emissions of all greenhouse gases weighted by their global warming potentials totaled 49 $GlCO_2e$ (approximately 13 GtC) of which fossil CO_2e emissions (including from cement and natural gas flaring) constituted ~30 $GtCO_2e$ (approximately 8.2 GtC). These numbers have often been translated into a call for reductions of between 60% to 80% on 1990 emissions by 2050, which has led to the adoption of 2050 targets by the United Kingdom (60%), France (75%–80%), and California (80%).[3]

By way of comparison, the emission reductions generated by the multibillion dollar market created by the EU ETS will almost certainly represent less than 1% of global emissions.[4] For carbon trading to make a significant contribution to achieving global emission reductions of 60% to 80% by 2050, the carbon markets will need to expand extremely rapidly over the coming decades. Net flows of up to US$40 billion per year could be required, assuming that developed countries take responsibility for reductions of 90% by 2050 and assuming that 50% of their financial effort is directed to developing countries (1). Ideally, the lessons from our experience to date would be learned and applied before any such expansion occurs.

The significance and nature of the climate change challenge implies that other policy instruments will have to be employed in addition to carbon trading. Taxes and subsidies can also create an explicit price for carbon, and regulation creates an implicit carbon price. Information provision and other explicit programs focused on behavioral change also have an important role to play. However, in part because of its central place under the Kyoto Protocol, carbon trading is currently the most significant instrument within global climate policy. Although taxes are more efficient under uncertainty for climate change over short policy horizons such as 5–10 years (11), there are at least seven reasons why trading is dominant:

1. International harmonized taxes are difficult for countries to approve.
2. Unlike trading, taxes do not automatically support the international wealth transfers necessary to decarbonize the developing world's economies.
3. Unlike trading, taxes do not create a private-sector lobby in favor of tighter targets.
4. Industry lobby groups are often stridently against taxes.
5. Environmental lobby groups are often against taxes because taxes do not place a quantity restriction on emissions.
6. Unless a system of tax credits was constructed, carbon taxes would be less effective at promoting the creation of specialized firms with specific expertise and a core business in reducing carbon emissions.
7. Trading may increase management attention on carbon owing to the "carrot" of profit opportunities, whereas taxes operate only by the "stick" of additional business costs.

Furthermore, even though trading is clearly less efficient under uncertainty than taxes over short time horizons, careful design of trading schemes to make them more "price like" (12) would reduce the efficiency difference between carbon taxes and trading, as would longer trading periods. So although it is not impossible that governments could shift the focus to coordinated global carbon taxes, these reasons suggest that trading should and

[3]A more complete list of government targets on climate change and clean energy is provided by Stern et al. (1, Chapter 21).

[4]It has been suggested that in 2005 the EU ETS delivered emission reductions of between 50 megatonnes of CO_2 ($MtCO_2$) and 200 $MtCO_2$, corresponding to reductions of between 0.1% and 0.4% of global emissions (9). Over the 2008 to 2012 period, the annual EU ETS cap is just over 2000 megatonnes of CO_2 equivalent ($MtCO_2e$) per annum (10), and the EU ETS is extremely unlikely to stimulate net emission reductions of 300 $MtCO_2e$ per annum, which is 1% of global fossil CO_2e emissions, let alone achieve reductions of 490 $MtCO_2e$ per annum, which is 1% of the total greenhouse gas emissions.

will continue to play a central role in providing carbon price signals after the first commitment period ends in 2012.

3. CARBON TRADING AND THE KYOTO FLEXIBLE MECHANISMS

After examining the conceptual underpinnings of the Kyoto flexible mechanisms, this section reviews carbon trading on the international level, under the European ETS, through the clean development mechanism (CDM), through Joint Implementation (JI), and through other carbon markets.

3.1. Conceptual Underpinnings

The three Kyoto Protocol "flexibility mechanisms" are designed to enable emission reductions to occur in the cheapest locations across the globe. The first mechanism, emissions trading, can occur between countries with binding targets, so that countries can meet their domestic targets by purchasing credits from other countries that have exceeded their targets. The largest implementation of emissions trading to date has been the EU ETS. Second, the CDM is a project-based mechanism that allows credits from emission reduction projects in poorer countries to be used by rich countries to meet their own commitments under the Kyoto Protocol. Third, JI is also a project-based mechanism that enables countries with binding targets to get credit from projects carried out in other countries with binding targets.[5]

All three mechanisms rest on the Coasian solution for the tragedy of the commons—privatize the commons and trade the resulting property rights. It is clear from economic theory, if not also common sense, that well-informed trade between two consenting parties is likely to improve the lot of both parties.[6] Every time you go to your local store to purchase some bread you are engaging in mutually welfare-enhancing trade. Similarly, with environmental assets, under some relatively straightforward conditions, economic theory implies that an ETS will deliver emission reductions at least cost to society. There is evidence to support this assertion from experience in other environmental and nonenvironmental contexts (14, 15).

CDM: clean development mechanism

JI: Joint Implementation

Nevertheless, many people consider that the creation of markets in environmental assets is ethically dubious at best, if not obnoxious (16; see also 17). Some conceptualize the emerging carbon markets as neoliberal "accumulation by decarbonisation" (18). Noting with concern that the Kyoto flexible mechanisms were "made in the USA" (19), Lohmann (20) argues against carbon trading on the grounds that it "reduces the political space available for education, movement-building and planning around the needed fair transition away from fossil fuels." And some environmentalists have denounced carbon trading by comparison with the sale of indulgences by the Catholic church in the early sixteenth century (21).

In addition to these (more fundamental) ethical disagreements, mainstream economic theory also stresses that an efficient outcome—where it is impossible to make someone better off without making someone worse off—is not necessarily fair, equitable, or desirable (4). In environmental markets, fairness depends in large measure (but not entirely) on the initial allocation of the property rights. Some have argued that these new property rights will be acquired by "those who have the most power to appropriate them and the most financial interest in doing so" (20). This review examines equity issues involved in

[5] Joint Implementation (JI) is different than emissions trading in that more industry sectors are included and joint participation is expected. At a practical level in Europe, JI allows credit for reducing any of the six major greenhouse gases, whereas the EU ETS only covers carbon dioxide.

[6] This proposition is probably more robust for developments in behavioral economics, unlike other propositions such as "more choice increases welfare" (13).

CER: certified emission reduction

ERU: emission reduction unit

carbon trading and addresses its shortcomings in practical implementation without entering any further into deeper debates about the legitimacy of the market system in which most of us operate.

3.2. International Emissions Trading and the Carbon Markets

Article 17 of the Kyoto Protocol allows Annex B[7] countries to "participate in emissions trading for the purposes of fulfilling their commitments," provided that trading is supplemental to domestic action. This allows nation states who would not otherwise meet their commitments to purchase units from other states in the form of

- Assigned amount units (AAUs), the unit assigned directly to nation states under the Kyoto Protocol
- Certified emission reductions (CERs) from project activities under the CDM (see Section 3.4, below)
- Emission reduction units (ERUs) from JI projects (see Section 3.5, below)
- Removal units on the basis of land use, land-use change and forestry (LULUCF) activities.

The merit and likelihood of any direct trade of AAUs between nation states is currently controversial. Targets for the Kyoto Protocol commitment period of 2008 to 2012 are referenced to the emissions baseline in 1990, and the recession following the collapse of the Soviet Union has left Russia and the Ukraine with a significant surplus of AAUs, which might exceed the net demand for AAUs from other nation states.[8] Because this surplus has not resulted from efforts to transition to a low-carbon economy, it is widely referred to as *hot air*, and countries such as Austria, Germany, and The Netherlands have stated that they will not buy Russian or Eastern European hot air unless the payments are "greened" by being directed to producing other environmental benefits through a "Green Investment Scheme" (22).

In contrast to AAU trades, trading through the major subsidiary scheme of the Kyoto Protocol, the EU ETS, is vigorous. Carbon trading on the EU ETS in 2006 comprised 67% of the global carbon markets by volume, and 81% by value, as shown in **Figure 1** (23). Because of the importance of the EU ETS, it is examined in more detail in Section 3.3 below. The CDM (Section 3.4) comprises the vast majority of the remaining volume of trades, with very small quantities traded thorough JI (Section 3.5) and other carbon markets (Section 3.6).

3.3. The European Emissions Trading Scheme

The EU ETS was launched by the 25 countries of the European Union on January 1, 2005, and was intended to be the primary mechanism for achieving compliance with the EU-15 target of an 8% reduction in emissions under the Kyoto Protocol.[9] The first commitment period of the Protocol runs from January 2008 to December 2012, so this initial phase of the EU ETS (Phase 1), which concludes in December 2007, was designed to familiarize European firms with emissions trading and to promote learning by doing.

[7]There are essentially the Organisation for Economic Co-operation and Development (OECD) countries along with countries undergoing transition to a market economy. In total, there are 38 countries (39 entities including the European Community) listed in Annex B of the Kyoto Protocol. This is almost identical to the list of countries in Annex I of the Framework Convention on Climate Change. The differences are (*a*) Belarus and Turkey are not in Annex B because they were not Parties to the Convention when the Protocol was adopted, and (*b*) Croatia, Liechtenstein, Monaco, and Slovenia are in Annex B but are not in Annex I.

[8]Russia and Ukraine would be expected to engage in tacit collusion, restricting the AAU sales to maximize revenue. Hence, a theoretical excess supply would not be expected to yield zero prices.

[9]Fifteen EU countries agreed to a so-called "bubble" target under the Kyoto Protocol, so that the EU-wide target is an 8% reduction. Internal "burden sharing" arrangements reflect a much wider range of targets from a 28% reduction (Luxembourg) to a 27% increase (Portugal) in emissions.

The scheme covers over 11,000 installations, including combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, ceramics, pulp, and paper. However, land and air transport are notably absent, and the EU ETS only covers the most important greenhouse gas, CO_2. Nevertheless, because it covers almost half of the total European CO_2 emissions, it is the most important European climate policy instrument. As **Figure 1** illustrates, it is the largest carbon market in the world by a substantial margin, both by value and by volume. Moreover, the EU ETS is driving much of the activity in the CDM, and these two markets combined comprise over 96% by volume and over 98% by value of the world's carbon markets.

The tradable instrument is termed an EUA and is distributed to firms according to National Allocation Plans (NAPs). The NAPs are determined by discussion and negotiation between member states and the participating firms, and the NAPs are then submitted to the European Commission for approval. The NAP development process is not particularly transparent, but well over 90% of the EUAs in both phases 1 and 2 are given to firms for free (rather than being sold at auction) and are primarily based upon historical emissions (24). In phase 2, member states can increase the share of auctioning up to 10% "without prior acceptance by the Commission," and no member state has proposed auctioning a proportion greater than 10%.

The EU ETS has become the hub of the global carbon markets through the implementation of the "Linking Directive" (2004/101/EC), which came into force November 13, 2004, and allows for the use of credits from CDM and JI projects by firms in the EU ETS.

3.4. The Clean Development Mechanism

Under Article 12 of the Kyoto Protocol, the CDM was established to help non-Annex I countries in "achieving sustainable development" and to provide Annex I countries with an alternative mechanism for complying with their targets. The CDM does this by allowing Annex I governments or private entities to accrue CERs from project activities in non-Annex I countries from the year 2000. CERs are only created if all parties give their voluntary approval and if the emissions reductions are real, measurable, and additional.

The process for putting together a project under the CDM requires the project developer to satisfy a number of procedural stages. These hurdles can involve relatively high transaction costs, although there are simplified procedures for small-scale projects. Projects are proposed in a formal Project Design Document, which presents detailed information, including a study of what would have occurred without the project (the "baseline"), a monitoring and verification plan to determine the quantity of emissions reduced that are "additional" to the status quo, coupled with an estimate of expected emission reductions. Projects are assessed against approved methodologies for determining the baseline and monitoring process. If the project is novel and employs a methodology that has not yet been approved by the CDM Executive Board (CDM EB), further cost and delay are involved in submitting the methodology for approval.

The Project Design Document must then be validated by a Designated Operational Entity, which assesses whether the project passes the relevant criteria, most crucially the additionality criteria. After validation, formal acceptance of the CDM project occurs once it is registered by the CDM EB. After registration, the project's monitored emission reductions are periodically verified and certified by a Designated Operational Entity. On the basis of a certification report, the CDM EB issues CERs via the CDM registry and forwards them into the account(s) specified by project participants.

Typical projects to date have included renewable energy projects (wind, smaller-scale

hydro, renewable biomass) and the capture of destruction of damaging greenhouse gases such as methane, nitrous oxide, and hydrofluorocarbons (see Section 5.2, below). Although CERs produced by a CDM project will, in due course, be effectively fungible with EUAs by virtue of the Linking Directive, they currently trade at a variety of price discounts as a function of the various risks that may be applicable. These include the risk that the project will deliver fewer emission reductions than planned, that problems or delays will arise in the UNFCCC administrative process (such as problems with the project methodology, project registration, or verification of CERs), that national caps will restrict the ability CERs, and some residual risks relating to UNFCCC "International Transaction Log" and the European "Community Independent Transaction Log," the technology that links registries together and allows CERs to be employed within the EU ETS.

Despite these various hurdles, in June 2006, the UNFCCC announced the milestone that projects conducted under the CDM would reduce emissions by the equivalent of 1 billion tonnes of CO_2 by 2012, and by May 2007, there were over 1800 CDM projects in the pipeline. At the time of publication of this article (i.e., late 2007), this figure is expected to have doubled. A more detailed assessment of the CDM is contained in Section 5.

3.5. Joint Implementation

JI under article 6.1 of the Protocol allows the transfer or acquisition of ERUs between Annex I states, which are also engaged in emissions trading. These ERUs can result from projects in any sector of the economy (not just the sectors covered by the EU ETS), and they have to be approved by the relevant parties and be considered supplemental to domestic actions. JI processes have similar processes and institutions to the CDM. Sellers of ERUs are primarily from Russia and Eastern Europe, whereas the buyers are primarily Western European countries with tighter Kyoto targets. More background information on JI is presented in References 25 and 26.

3.6. Other Carbon Markets

The remaining carbon markets form a tiny fraction of the total volumes and do not come under the umbrella of the Kyoto Protocol. The largest of the remaining markets in terms of physical volume (66%) and financial value (90%) is a scheme in New South Wales, Australia, which results from a mandatory cap on power suppliers (27). Like the EU ETS, this market allows offset projects, but at present, only Australian projects are permitted. Another peripheral market is a voluntary scheme run by the Chicago Climate Exchange.

In addition to these markets, there has been an explosion of interest in voluntary offsetting by individuals and corporations over recent years, especially to cover emissions from air travel. A thriving consumer-led market, which has not arisen in response to government regulation, is developing. One consequence of this is that standards have been patchy, although more recently offset retailers and nongovernmental organizations (NGOs) have collaborated to develop standards and procedures that are similar to the procedural requirements of the CDM but are more closely tuned to consumer demands. Being closer to consumer needs, this market is also the subject of more probing criticism by journalists (21, 28, 29) and NGOs. Nevertheless, because voluntary markets enable more direct finance of small community projects, they may be better than the CDM for encouraging sustainable development (18). Some commentators forecast that as individuals come to understand climate change and want to take personal action, voluntary markets will increase rapidly in volume, potentially to several hundred million tonnes of CO_2e per annum by 2009–2010 (30, 31). Although there is speculation that the voluntary markets could eventually overtake compliance markets (32), it seems unlikely that altruistic sentiment alone could

form the main driver of global emission reductions. (See Reference 33 for more discussion of voluntary markets.) However, both the Carbon Trust (**http://www.carbonlabel.co.uk/**) and the Climate Group (**http://theclimategroup.org/assets/carbon_stewardship_council_discussion_paper.pdf**) are supporting carbon labeling of consumer products, which, among other things, may stimulate the market for goods and services with bundled voluntary offsets.

4. ASSESSMENT OF THE EU ETS

Assessment of the performance of current carbon trading arrangements requires two preliminary stages, namely the specification of a plausible counterfactual and the specification of criteria of assessment. Different counterfactuals are responsible for a great deal of debate about the merits of carbon trading. If the counterfactual is "no action, and no prospect of future action, on climate change," then carbon trading inevitably receives a positive report card. In contrast, if the counterfactual is an idealized state (e.g., rigorous carbon reduction policies that would be put in place by an omniscient global government), then carbon trading as it currently exists is an unambiguous failure. A more realistic counterfactual might consist of a patchwork of different carbon taxes in different countries, with some attempt at global harmonization and with some (probably limited) side payments designed to encourage participation.

The criteria employed here include effectiveness (in delivering emission reductions), efficiency (at least cost), and equity (with acceptable distributional consequences). Dynamic issues and political factors are kept in mind.

4.1. Achievements

Perhaps the most remarkable feature of the EU ETS is that it exists at all, given that its creation involved extraordinary challenges of coordination between European bodies, member states, and a variety of different private entities—each with different interests. The most important single feature of the EU ETS so far is that Europe now has a coordinated and explicit carbon price that is being reported across the continent in mainstream newspapers. The carbon markets have stimulated private-sector interest and finance and have contributed to the shift in the attention of European board rooms toward climate change as a pressing problem.

Although the spot carbon price has been extremely volatile and is currently (in June 2007) at an all-time low, there is some evidence that it has prompted some abatement efforts from European firms. Ellerman & Buchner (9) attempt to determine the extent to which the current low prices in the EU ETS are the result of overallocation or abatement. Their results are very tentative, but their analysis suggests that CO_2 emissions were reduced by "an amount that was probably larger than 50 million tons and less than 200 million tons." Interestingly, a 2006 survey of European firms found that the EU ETS had prompted 15% of respondents to take abatement measures, and the same survey, repeated in 2007, found that 65% of respondents had taken some abatement measures (27).

4.2. Problems

These achievements, however, are simply too modest when compared with the magnitude of the challenge. Moreover, there are a substantial number of problems with the design of first Phase of the EU ETS, which do not appear to have been corrected for Phase 2.

Perhaps the most egregious problem is the fact that EUAs are distributed for free, as a rough function of past emissions. As is well known within economics, this leads to perverse dynamic effects where firms have an incentive to emit more now in order to receive a larger free allocation in the future. Furthermore, allocating EUAs for free inevitably results in rent-seeking behavior by firms as

they invest valuable resources in lobbying to obtain a higher allocation.

Hepburn et al. (34) note that these problems can be resolved by auctioning the EUAs. As well as resolving the above flaws, auctioning brings three additional benefits. First, auctions induce the private sector to reveal their expected abatement costs to government, reducing problems of asymmetric information. Second, auctioning allowances promotes greater managerial focus on emissions trading, which is likely to increase (cost-effective) abatement effort. Third, free allocation is a regressive transfer of wealth from (relatively poor) citizens to (relatively wealthy) shareholders. Hepburn et al. (35) estimate the proportion of allowances that should be given to firms if policy makers are to leave firm profits unchanged before and after the introduction of the scheme. They find that in many industries more than 50% of the allowances could be auctioned without damaging firm profits. It is not surprising, therefore, that utilities in the United Kingdom are estimated to have made £800 million in "windfall profits" (36). Policy makers elsewhere are taking heed of these lessons from the EU ETS, and current policy proposals in the United States and Australia contemplate auctioning at least a significant proportion of allowances (generally above 50% and often 100%). Strangely it is within the Europe that these lessons appear to be being ignored: No member state is contemplating auctioning any more than 10% of allowances in Phase 2 of the EU ETS.

Another important problem with the EU ETS is that the determination of the NAPs involves asymmetric information and lobbying. Government is relying upon firms to reveal their abatement cost curve in order to determine an appropriate NAP. Yet firms have an incentive to bias their cost estimates upward in order to obtain a more generous allowance and a looser cap. Uncertainty is important in this context (37), and although Ellerman & Buchner (9) do find some evidence of abatement, they also conclude that overallocation of EUAs has been partly to blame for the extremely low market prices. Although the European Commission has acknowledged these lessons and cut allocations for the 2008 to 2012 period, uncertainty in future economic conditions and emissions implies that even these cutbacks cannot guarantee that the market in phase 2 will not show a similar overallocation with prices close to zero.

One of the most crucial tests of whether a climate policy is "fit for purpose" is whether it provides appropriate long-term incentives. Investment in energy generation assets, in particular, is forward looking over several decades, so the expected carbon prices from 2012 to 2030 are more important than the spot price today. Unfortunately, both the Kyoto Protocol, with its five-year commitment period, and the EU ETS, with five-year phases, provide little or no incentive for long-term low-carbon investment today. Firms making such investments have to gamble that governments will be able to agree on tight targets and that the regime in place in a decade or more is one that will provide them with an adequate return on low-carbon assets to make investment worthwhile. And stimulating low-carbon investment is important if emission reductions of 60% or greater are to be achieved by 2050. Under such circumstances, designing policy instruments to focus on the least-cost emission reductions in the short term may be suboptimal in the long term if these reductions result in locked-in use of carbon-intensive technologies for the next decade.[10]

A final problem arises with the way information has been revealed to the market. In late April and early May 2006, installation-level data for verified emissions and allowance allocations were released, indicating that the market was oversupplied with allowances by around 80 million tonnes (9). Prices fell by

[10] Additionally, achieving the lowest global cost for a near-term emissions target may not be particularly important at a time where the focus should be on institutions, experience, trust, and ensuring that structures are in place to support developing countries (38).

70% in just three weeks, from €30 to €9, reflecting an overestimate by the market of counterfactual emissions (owing to rising real output, adverse weather, and higher gas prices relative to coal) and an underestimate of abatement. In either case, it is arguable that market-sensitive information should be released as gradually as possible to reduce price volatility.

5. ASSESSMENT OF THE CLEAN DEVELOPMENT MECHANISM

This section considers the achievements and problems of the CDM. The most important achievement has been substantial emission reductions at relatively low cost, accomplished through international carbon finance transfers. However, the Mechanism has come under attack for a variety of reasons.

5.1. Achievements

In some respects, the CDM has been the success story of carbon trading to date. The UNFCCC announced in late 2006 that the CDM was expected to generate 1 billion tCO_2e in CERs. This number is predicted to increase, and the CDM is projected to deliver over 275 $MtCO_2e$ annually of emission reductions over the first commitment period from 2008 to 2012 (39, 40). It has provided a platform for engaging the developing world in efforts to mitigate climate change and has, along with the EU ETS, played an important role in driving private-sector interest in projects to reduce emission reductions.

As a market, the CDM is functioning largely as one would expect it to. Despite the costs and barriers described in Section 3.4, the private sector has developed a wide range of methodologies to reduce emissions, which have been submitted for approval to the CDM EB, and efforts have focused on the "low hanging fruit," or the cheapest emission reductions. In short, the CDM market has directed private-sector efforts to the short-term efficient outcome.

5.2. Problems

The short-term efficient outcome, however, involves emission reduction projects being concentrated in relatively few countries, particularly China and India, and further being focused on non-CO_2 gases in relatively few industry sectors, in particular on HFC-23 from refrigerant manufacturing, as shown in **Figure 2**, which is derived from the data from the UNEP CDM pipeline of 1885 projects (as of May 1, 2007) (see **http://cdmpipeline.org/**). The preponderance of CERs from HFC-23 projects reflects the fact that HFC-23 has a very high global warming potential: Reducing one tonne of HFC-23 emissions has the same impact on atmosphere as reducing 11,700 tonnes of carbon dioxide emissions. As such, it is easy to generate large amounts of CERs from HFC capture and destruction. So although the CDM is functioning as it would be expected to, its design is failing to achieve two important objectives. First, as with the EU ETS, the CDM is doing relatively little to address the crucial long-term need to reduce CO_2 emissions from the energy sector at a time when high-carbon capital assets are being locked in. For instance, the CDM has done very little to stop China from rapidly adding coal-fired power-generating capacity, most of which is likely to still be operating in several decades, and most of which will be expensive to retrofit with carbon capture and sequestration technology (41).[11] The relatively slow and cautious approach of the UNFCCC has, to date, failed to produce any clear signal to these developing economies about the technologies, programs, and policies that may be of central importance—carbon capture and sequestration and energy efficiency being good examples. Second, it is contributing very little to

[11] China is estimated to add 546 GW of coal-fired power capacity (net of requirements) between 2003 and 2030 (39), corresponding to an average of 20 GW a year, or 400 MW a week. A large proportion of all coal-fired power plants currently under construction are in China: The proportion of global orders from China was 77.7%, 85.8%, and 90.5%, respectively, in the years 2001, 2002, and 2003 (42).

sustainable development in the poorest countries, which was one of the original objectives of the mechanism.[12] In particular, projects in Africa constitute a tiny percentage of the total.

The CDM can also be viewed as a subsidy (44), rather than a market, because it is a mechanism by which the nations with Kyoto targets fund less-developed countries to reduce their emissions. A well-designed subsidy would achieve the desired objective of reducing emissions at the lowest cost to the public purse. Although the CDM seeks out and finds the cheapest projects, it performs rather poorly as a subsidy because buyers in Western Europe are paying high prices that are set primarily by the balance of supply and demand in the EU ETS. Indeed, in some instances, the price paid is approximately 10 times the marginal cost of abatement for HFC-23 projects in China. So, although the CDM is efficient as a market mechanism—it seeks out the cheapest projects, it is not a very cost-effective subsidy because it allows large transfers of rents to project developers in the less-developed world.

As the CDM market is an artificial one designed to achieve social goals, there is no reason the government should not work to improve its design to better achieve those goals. One approach would be to restrict the CDM to carbon dioxide (and perhaps methane) and rely on financial inducements to encourage China (and others) to ban the emission of gases such as HFC-23 with a high global warming potential (GWP) (44). A complicated and unappealing alternative would be to retain one market for all gases, but to adjust the exchange rate between gases. For instance, gases could be valued according to their maginal cost of abatement, instead of their GWP (which reflects the marginal damage of emissions). However, agreeing to standardized marginal abatement costs would be a scientific, economic, and political nightmare. A third alternative would be to organize a buyers' cartel, so that the buyers could pay around the marginal cost for emission reductions, thereby achieving far greater reductions for the same amount of (Western European) money. Similar questions are arising in the forestry sector, which may have much lower marginal abatement costs than the energy generation sector.

The CDM has also created some perverse incentives (1, p. 505). Both private participants and governments of developing countries face issues of moral hazard. Governments have an incentive not to impose regulations on emissions if this means that lucrative CDM projects are incorporated into the baseline. In other words, the CDM reduces the incentives of developing country governments to enact policies reducing emissions. Project participants have an incentive to design their projects so that they just, at the margin, fail to be economically sensible without the support of carbon finance through the CDM.

As alluded to above, transaction costs of the CDM can be rather high because of the requirement to demonstrate project additionality on a case-by-case basis. This requires showing that the project will reduce emissions above and beyond the business-as-usual or baseline scenario. Although this might sound fairly straightforward, in practice additionality is an extremely subtle and complex concept, largely because it inevitably involves speculation about what would have happened in the absence of the project obtaining carbon finance.[13] Stern et al. (1, p. 505) note that it has proved difficult to establish methodologies to demonstrate project additionality for transport and energy efficiency in sectors dominated by small- and medium-sized

[12] Boyd et al. (43) highlight the tension between sustainability and emissions reduction criteria and critically assess how the sustainable development criterion is currently being implemented.

[13] The UNFCCC helpfully provides an additionality tool to guide the assessment of whether a project is additional (see **http://cdm.unfccc.int/methodologies/PAmethodologies/AdditionalityTools/Additionality_tool.pdf**).

enterprises because transaction costs are more difficult to overcome.

Criticisms have been leveled at the United Nations bureaucracy running the CDM, including the assertions that the CDM EB has been too weak or too onerous and certainly too slow. Until extra funding was provided at the Conference of the Parties (COP) 11 at Montreal in 2005, there was broad agreement that the CDM EB and methodology panel were seriously underresourced (45). More recently, industry participants were expressing the view that the CDM EB should be "professionalized" such that its members are paid for their services.

Finally, almost by definition, the CDM can only ever serve as a transitional mechanism because it does not generate emission reductions above and beyond those required by developed country targets (1). Indeed, one might even argue that the CDM is responsible for a net increase in emissions (46). The conclusion rests upon the assumptions that (*a*) the targets agreed to in Kyoto would have been identical without the CDM; (*b*) those targets would have been met entirely through domestic emission reductions in the absence of the CDM; and (*c*) a proportion of the emissions reductions under the CDM are not actually real and additional. If these assumptions hold, then it follows that incorporating the CDM actually increases net global emissions. The conclusion, of course, is only as good as its assumptions, which may be debated. Irrespective, like the EU ETS, it is clear that at present the scale of the problem (the need to decarbonize growing developing economies) and the scale of the response (the CDM) are clearly mismatched.

6. FUTURE DIRECTIONS

Carbon trading is likely to expand to cover more countries, more sectors, and longer time periods. This section considers some of the issues arising from the expansion of carbon trading.

6.1. Geographical Expansion

The Linking Directive of the European Commission integrated the EU ETS with the CDM and JI markets. Now other fledgling markets are considering the possibility of potential linking with the EU ETS. These include the U.S. Regional Greenhouse Gas Initiative (RGGI), which covers emissions from the power sector in the northeastern United States,[14] various initiatives on the West Coast of the United States,[15] and the schemes under development in Australia at both the State and Commonwealth levels.[16] Although participants within the EU ETS cannot use credits from other markets for compliance with Kyoto targets, the converse may well end up being possible, and it seems likely that one-way links will be devised where CERs are used for compliance on other emissions trading markets.

Indeed, a survey by Point Carbon, a provider of news about the carbon markets, revealed that ~50% of responding subscribers thought that a Canadian and U.S. federal ETS would be linked with the EU ETS post-2012.[17] A major advantage of linking markets is that this establishes related (or identical)

[14]In May 2007, the RGGI included Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. It is scheduled to begin in 2009, will stabilize CO_2 emissions from power plants by 2014, and reduce emissions by 10% by 2019.

[15]The Western Regional Climate Action Initiative was established in February 2007 and comprises Arizona, California, New Mexico, Oregon, and Washington as well as the Canadian province of British Columbia, and its overall emissions target is scheduled to be fixed by August 2007.

[16]A coalition of the Australian states created a National Emissions Trading Taskforce, which has details of a very sensible proposal (**http://www.emissionstrading.nsw.gov.au/**), and at the federal level, the Australian Prime Minister has established a Task Group on Emissions Trading (**http://www.dpmc.gov.au/emissionstrading/index.cfm**).

[17]Although subscribers to Point Carbon are likely to be relatively well informed about the carbon markets, they are also likely to have a strong interest in the continuation and expansion of the carbon markets as well as an optimism bias (47), which suggests that their views are not necessarily a reliable predictor of future events.

carbon prices in different geographies. Furthermore, deepening the carbon markets is likely to reduce transaction costs and increase efficiency.

Nevertheless, at present, the emissions covered by the EU ETS and the CDM amount to a very small fraction of the global total. Extending the EU ETS such that it covers the power and industrial sectors in Australia, Canada, the European Union, Japan, and the United States would correspond to a 2.5-fold increase in the scale of the scheme (1). Extending the scheme to cover all fossil emissions from the top 20 global emitters would expand the ETS by a factor of almost five, so that 80% of global CO_2 emissions would be covered with annual allowances worth up to US$350 billion (at an assumed carbon price of $40/t$CO_2$e).

6.2. Sectoral Expansion

As the commencement of the first commitment period of the Kyoto Protocol draws nearer, calls to expand the sectoral coverage of carbon trading have grown louder, particularly with regard to aviation and also to the reversing current trends in deforestation. Other developments, motivated in part by the logic of broader investments in energy efficiency, have concerned the introduction of "programmatic" and "policy"-based CDM.

Proposals to include the aviation sector within the EU ETS have been advanced by both the EU Commission and the EU Parliament.[18] This now seems a likely outcome, because on December 20, 2006, the EU Commission adopted a proposal for legislation (**http://ec.europa.eu/environment/climat/aviation_en.htm**) that would include flights both departing and arriving within Europe in the EU ETS as of 2011 and that would extend coverage to all flights to or from Europe in 2012.

Despite the disproportionate focus of the popular press on forestry-based voluntary offsets, projects within LULUCF have not yet been a significant feature of the Kyoto flexible mechanisms. To start with, the scope of forestry activities eligible for the CDM is limited to afforestation and reforestation projects, thereby excluding projects that prevent deforestation. Moreover, it was not until relatively recently that initial baseline and monitoring methodologies for CDM LULUCF projects were approved. Finally, unlike other CDM projects, LULUCF projects carry a risk of fire or conversion of forests back to pasture. As such, CERs from LULUCF projects have a limited duration and have to be replaced upon expiry. Various proposals are now under consideration to provide economic incentives for avoided deforestation (49).

Finally, at the Montreal COP 11 in 2005, the UNFCCC approved the concept of programmatic CDM, which allows for developing world countries to gain credits from programs that aggregate up many smaller emission reductions (such as those from households, small businesses, and transport). This will likely allow broader inclusion of sectors that have diffuse, rather than point, emission sources and that simply would not make profitable projects without the economies of scale accessible through a larger program. Further extensions to yet more sectors might involve policy-based CDM, which would provide developing country governments with CERs for the introduction of broader policies that reduce emissions (50). This would reduce some of the perverse incentives noted above.

6.3. Temporal Expansion

As discussed, a central problem facing investors in low-carbon technologies is that

[18] Müller & Hepburn (48) proposed a global levy, which reflects both responsibility for emissions and capability to pay, as a way of providing finances for adaptations to climate change.

there is no carbon market over the relevant investment period. In its current form, the EU ETS runs until 2012 (coincident with the Kyoto commitment period), after which there are no binding targets, only a reassurance from the EU commission that the market will continue. This imposes political risk on investors, who are left to predict what governments will do after 2012 when the duration of their project may be 30–40 years. Uncertainty about future carbon markets effectively transfers political risk from the government to the private sector, which is an inefficient risk allocation.

The problem is not resolved by long-term aspirational carbon targets of the sort announced by the United Kingdom, France, and California because the party making the promise is unlikely to be in power for the next 30 to 40 years and may not have to abide by the promise. A clear signal from governments about the likely acceptability of different types of projects would reduce private-sector risk. So, for instance, the private sector would be interested now in the types of large-scale programs that could become eligible for accelerated recognition. For example, a signal on whether and how carbon capture and storage may be eligible for crediting under the CDM could provide important incentives. However, the question remains as to whether government is subject to any penalty for breaking its word.

What is needed is a policy structure that has predictability and credibility, which might be designed by building a respected institution by analogy to the Monetary Policy Committee of the Bank of England (51) or by using legal means to contractually bind the government to its promise (52). At the time of writing (i.e., May 2007), the U.K. government is taking the former idea seriously through the establishment of a "Committee on Climate Change," which will advise the government on reaching its 2050 target and will report annually on progress toward this goal (53). In the absence of these stronger mechanisms, agreement on commitment periods longer than five years (as under the Kyoto Protocol) is desirable to provide clearer long-term carbon price signals (1, p. 332).

6.4. Caps and Allocations

As noted above, tighter caps would increase the carbon price and ratchet up the incentives for low-carbon investment. Moreover, a very strong conclusion from the economic literature is that a large proportion of the cap should be auctioned (35).

7. CONCLUSIONS

Climate change is a market failure without parallel, on the "greatest scale the world has seen" (1), so it is not surprising that the ETS created to address it should eventually be seen as representing the world's greatest ever privatization of a natural asset. Despite this, current carbon markets represent a very small and highly imperfect step. Indeed, one of the most pressing challenges in climate policy over the next decade, once the manifest and serious flaws in the current system are corrected, is to increase the scope of emissions trading to cover more countries, more sectors, and over longer time periods. Ultimately, caps must be tightened to improve environmental effectiveness, and allowances must auctioned to address serious inefficiencies in allocation and important issues of fairness.

Other climate policies are, of course, available and well understood, including regulation, carbon taxes, and information provision. These approaches will continue to play an important role. But extraordinary human, social, and negotiating capital has been invested in the institutions of the flexible mechanisms under the Kyoto Protocol. Although the flexible mechanisms currently have some serious problems, they nevertheless provide a very important basis on which to construct a more sensible and effective global climate policy.

SUMMARY POINTS

1. Carbon markets are expanding rapidly: A new global commodity has been created.
2. Carbon trading directs financial flows to the cheapest emission reductions.
3. Carbon trading has created a lobby for tighter targets and clearer long-term policies.
4. Trading has prompted a shift in climate discourse from the negative (intractable, high costs) to the positive (new business opportunities).
5. Current allocation procedures are regressive and unfair, and more allowances should be auctioned in future.
6. The CDM has not achieved its goals of sustainable development, and financial flows are concentrated in relatively few sectors and countries.
7. Although the CDM is probably efficient in the short term, it is probably inefficient in the long term.
8. Linking of regional carbon markets is sensible and is likely to continue.

FUTURE ISSUES

1. The expansion of carbon trading to new countries and sectors will create challenges related to how schemes are designed and linked.
2. Permits will be increasingly allocated by auction, so important questions of auction design will arise.
3. Improved incentives for long-term low-carbon investment are urgently required.
4. Policy risks associated with carbon trading will gradually be shifted from the private to the public sector.
5. As carbon trading expands, concerns about the commoditization of the atmosphere will intensify.
6. Voluntary carbon markets are growing rapidly but may falter if existing standards are not widely adopted.

DISCLOSURE STATEMENT

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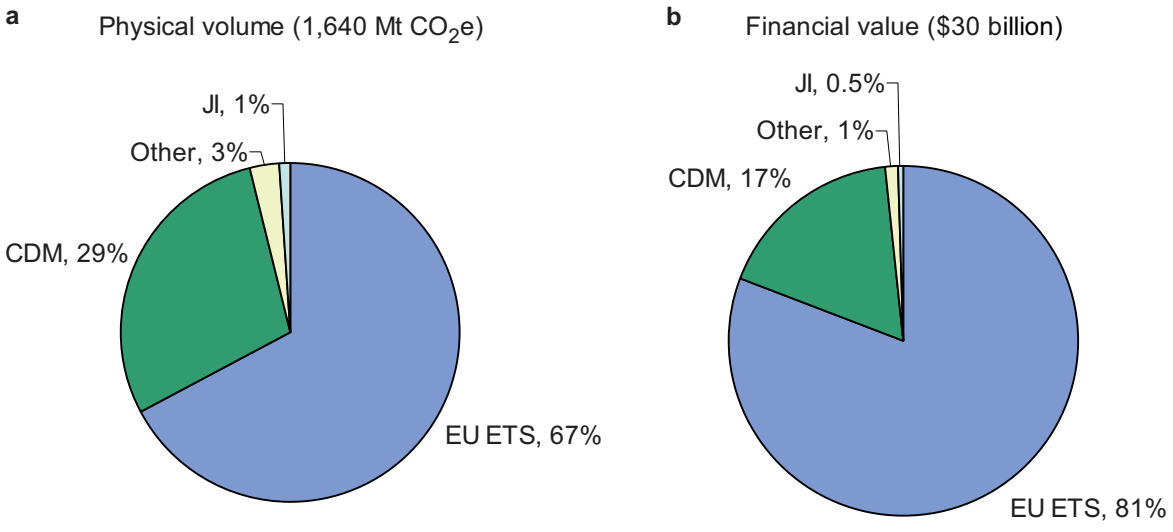

Figure 1

Carbon trading activity in different market segments in 2006. Abbreviations: CDM, clean development mechanism; EU ETS, a pan-European Emissions Trading Scheme; JI, Joint Implementation.

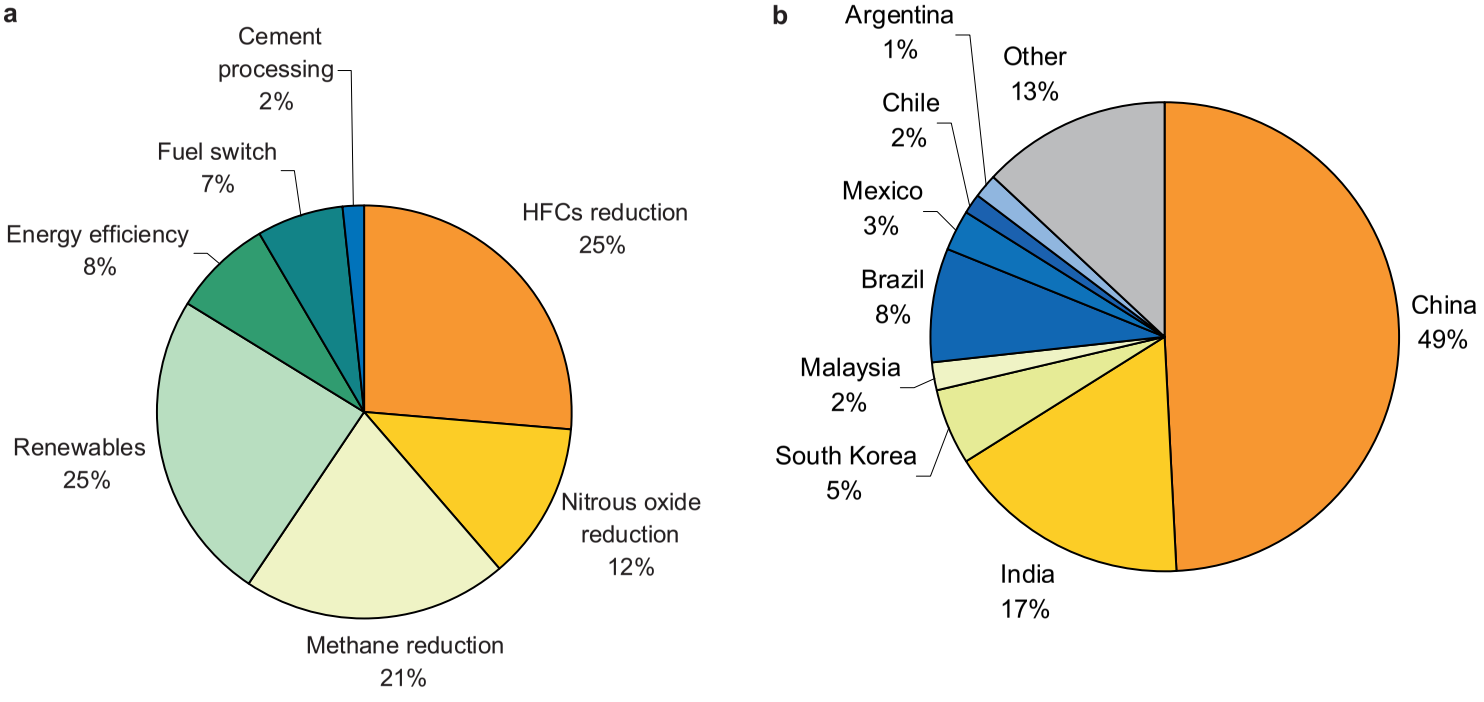

Figure 2

Concentration of clean development mechanism (CDM) projects by industry and country. (*a*) Expected certified emission reductions (CERs) issued to 2012 by sector. (*b*) Expected CERs issued to 2012 by country. Abbreviation: HFCs, hydrofluorocarbons.

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