Cooperation to Reduce Developing Country Emissions

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Abstract

Without effective developing country participation in climate mitigation it will be impossible to meet global concentration and climate change targets. However, developing countries are unwilling and, in many cases, unable to bear the mitigation cost alone. They need huge transfers of resources – financial, knowledge, technology, and capability – from industrialised countries. In this paper, we evaluate instruments that can induce such resource transfers, including tradable credits, mitigation funds and results-based agreements. We identify key constraints that affect the efficiency and political potential of different instruments, including two-sided private information leading to adverse selection, moral hazard and challenging negotiations; incomplete contracts leading to under-investment; and high levels of uncertainty about emissions paths and mitigation potential. We consider evidence on the poor performance of current approaches to funding developing country mitigation – primarily purchasing offsets through the Clean Development Mechanism – and explore to what extent other approaches can address problems with offsets. We emphasise the wide spectrum of situations in developing countries and suggest that solutions also need to be differentiated and that no one policy will suffice: some policies will be complements, while others are substitutes. We conclude by identifying research needs and proposing a straw man to broaden the range of "contracting" options considered.

JEL codes

Q54, Q56, Q58, H87

Keywords

Climate, finance, cap and trade, CDM, clean development mechanism, developing countries, additionality, international agreements, Durban Platform

Contents

1. Introduction

Without effective developing country (DC) participation in climate mitigation it will be impossible to reduce global greenhouse gas emissions to a level that avoids most of the risks of "dangerous" anthropogenic climate change. China is now the largest net emitter; China and India alone emit nearly one-third of global emissions and their emissions are still growing fast. Although the more industrialised countries (ICs) are still significant emitters (and on a per-capita basis emit far more than DCs), the costs of mitigation are much higher than in DCs because the IC capital stock is growing more slowly. For any given target, the efficiency gains from getting effective mitigation in DCs are enormous.[1] But the cost of mitigation is high and DCs are unwilling and, in many cases, unable to bear this cost alone – they need huge transfers of resources, financial, knowledge, technology, and capability, from ICs.[2] This is quite apart from any ethical reasons for ICs to fund mitigation in DCs. Even though the Durban Platform agreed in December 2011 provides the start of a process to extend legally binding mitigation commitments to DCs, the strength of these DC commitments is likely to depend at least in part on the level of support from ICs.

Effectively transferring resources across countries for environmental gain is hard to do (Keohane, 1996). Applying his "three Cs" framework, it requires strong mutual commitment to the environmental goal (*concern*), well designed agreements (*contracting*) and strong *capacity* to implement change. In this paper we focus on the second but are mindful that the contracting instruments used must also support concern, by promoting rather than undermining trust-building; and capacity, by facilitating the flow of technology and skills. The key current instrument, the Clean Development Mechanism (CDM), is widely regarded as ineffective at all three.

Our key questions are "How are existing approaches working and why?" and "What are alternatives?" We need to find instruments that both DCs and ICs will agree to participate in, and that, through low transactions costs, high compliance and high levels of investment certainty, lead to efficient mitigation.

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1 Anger et al. (2007), using a computable general equilibrium (CGE) model, suggest that allowing CDM credits in the European Emissions Trading Scheme could reduce the permit price from US$12.62 to less than $3. Reilly et al (2006) estimate that continuing the Kyoto Protocol until 2100 (without the US) would cost around $6663bn and reduce global temperature by 0.3 degrees in 2090 – 2100 while a global agreement with all countries and all gases, could achieve a 0.65 degree reduction by 2090-2100 for only $96bn. This is suggestive of the enormous value of including developing countries.

2 Boyd et al. (2007) suggest that the CDM will be responsible for $27 billion to $34 billion in flows to developing countries by 2012, and this is probably a fraction of the amount needed.

In terms of current instruments, our focus in this paper is on offsets, as they are the only major policy instrument that has been instituted to date to promote mitigation in DCs.[3] However, many of the same challenges apply to other policy instruments, and we summarise and critically evaluate some of the main alternatives to offsets that have been put forward. We keep the discussion at a high enough level to be relevant to current United Nations discussions but also the wide range of potential, formal and informal future international architectures (Aldy and Stavins, 2007, Keohane and Raustiala, 2009).

In this paper, we also seek to address some of the terminological issues that have hampered discussions of climate policy, through relating observed problems discussed in the policy and academic literature to the underlying economic phenomena. For example, in the context of offsets, we show how baseline issues and additionality are used to describe the same phenomenon of adverse selection, and also how permanence (a concern with forestry offsets) can be treated as a form of leakage. There are several good reviews of the CDM, the largest offset program implemented to date (Paulsson, 2009; Grubb et al., 2011), and for a broader overview, the reader is referred to those. But these reviews do not relate the problems with the CDM to the underlying economic issues, as we do here.

We draw insights and evidence from the literature on international environmental instruments in the context of repeated game theory and contract theory. In the next section we establish the constraints and opportunities arising from the global repeated cooperation game in which any agreement and resource flows from ICs sit. We outline the basic nature of the principal agent contracting problem that we face, where, because of the global benefits of mitigation, either the DC or the IC could be seen as the principal.

In section three we discuss the instruments available and how they vary across four key dimensions. We then outline the common challenges they face: leakage, additionality, risk bearing and investment certainty, compliance and bargaining. Our review of the empirical evidence focuses on the performance of the CDM. In section four we suggest alternative instruments that could replace the CDM, and conclude with some thoughts on research directions.

[3] Hall et al. (2008) discuss a range of options for engaging developing countries.

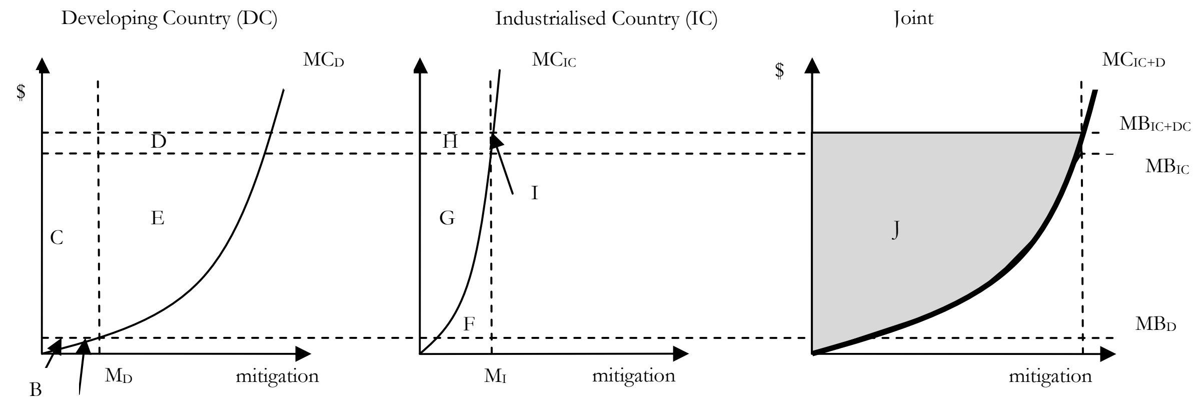
2. Relationships between Developing and Industrialised Countries within a Repeated Game

Efficient global mitigation requires that all countries act. Figure 1 shows the gains from cooperation both jointly and to each country. The marginal benefit (MB) from climate mitigation is essentially flat (does not change with the level of mitigation) in the short- to medium-term because of the accumulative nature of greenhouse gases. The short-run marginal mitigation cost curve (MC) is likely to be very steep after a certain point.

One can think of the relationship between ICs and DCs under the following framework. If "IC" represents an existing coalition of industrialised countries, persuading a DC to join the agreement will shift up the relevant MB curve (i.e., the marginal benefit to the coalition as a whole) as well as lowering costs for a given level of abatement. The DC raises its effort as it joins, in return for the countries already in the agreement raising their contributions (domestic reductions plus transfers to the DC). This is illustrated in a simple example in Figure 1.

Acting alone, the DC mitigates until its marginal benefit equals marginal cost (M_{DC}), gains benefits for itself of B and provides benefit of C to the IC. Alone, the IC chooses mitigation M_{IC}, gains G for itself and provides H to the DC. If they act together both mitigate more and they jointly gain J which exceeds B+C+G+H by the areas E+D as well as a small gain to the DC from extra IC action, I. The way this gain is distributed depends on the nature of the agreement between the DC and IC. If the international institutional form is such that transfers between countries are not facilitated, the gains from voluntary cooperation will likely be more limited and the costs determined only by relative marginal benefits and levels of mitigation.[4]

Figure 1 Mitigation with and without cooperation



[4] An example of this would be harmonised taxes as proposed by Richard Cooper and Warwick McKibben and discussed in Aldy and Stavins (2007). If a fund were implemented to complement the taxes, resources could be transferred.

With only two actors and the ability to make transfers from IC to DC, this cooperation seems relatively easy to achieve, particularly if they can make an enforceable agreement. However, a stable climate is a global public good and cooperation among many actors, in a world with weak international law, is hard to achieve and sustain. Barrett (1994) analyses this as a static Nash Equilibrium with self-interested actors and comes to a very negative conclusion, but when it is considered in a repeated game, which is the true context, the outcome becomes less certain and more positive. There are two key reasons for cautious optimism: experimental evidence has repeatedly shown that people (and countries?) are not purely self-interested; and repeated game theory shows that with good monitoring, low discount rates and a game of infinite or an indefinite length, punishments can lead to a cooperative outcome.[5]

On the other hand, such a repeated game will take place with many players and private information that hinders agreements. In this context, short-term levels of mitigation may also reflect strategic bargaining, which could lead to either higher mitigation (countries leading by example in the hope of generating trust and inducing more cooperation (Seabright, 1993; 1997)) or lower mitigation (countries understating their benefits to protect their bargaining position[6] or holding out for a better sharing deal[7]). Agreements are likely to be incomplete and policies to implement them may be ineffective or inefficient. How to structure agreements and design contracts to realise the potential for mitigation in DCs is the core theme of this paper.

This simple analysis could represent the operation of a number of international institutional forms that may be implemented within or outside the existing UNFCCC framework. The analysis in this paper can also loosely be applied to thinking about a more informal international cooperation such as "pledge and review" or a set of sub-global agreements that are only partially coordinated (Keohane and Raustiala, 2009).

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[5] Ostrom (1990) applies repeated game theory to governance of local commons and analyses several situations where communities were able to achieve high levels of cooperation without coercion by government; she also documents cases where cooperation failed. She and others emphasise that good information and trust building are critical to sustaining and building cooperation.

[6] This could be thought of as dynamic adverse selection – parties do not want to reveal their true levels of concern and marginal cost when negotiation is ongoing. See Bolton (1990); Aghion et al. (1990).

[7] With the risk of indefinite delay with two-sided asymmetric information (Myerson and Satterthwaite 1983). A similar model in the specific deforestation context is explored by Harstad (2011).

3. Policy Instruments

3.1. What Instruments?

What mitigation instruments exist that could allow developing countries to carry out low-cost mitigation actions funded by industrialised countries? Numerous mechanisms have been implemented, such as the Clean Development Mechanism (CDM) and the grant-based Global Environment Facility (GEF), or proposed in the context of international climate negotiations, such as sectoral crediting (Schmidt et al., 2006; Schneider and Cames, 2009). The differences among these mechanisms can be best understood on a four-dimensional continuum between tradable credits and grants/subsidised loans, as shown in Figure 2. [8]

Figure 2 Continuum of instruments for IC-DC resource transfer

Instrument	**Tradable credits**		**Grants and subsidised loans**
Examples	*CDM*		*Global Environment Facility*
	GHG reductions only	↔	**Broader development goals**
	Integrated into cap-and-trade	↔	**Not integrated into cap-and-trade**
	Focus on ex post monitoring	↔	**Focus on ex ante assessment**
	Results based	↔	**Effort based**

The first dimension relates to the goals of the instrument. Tradable credits focus exclusively on greenhouse gas emission reductions, despite the CDM's nominal promotion of sustainable development co-benefits (Ellis et al., 2007). Sustainable co-benefits were one of the early promises made for the CDM. In practice, there is little evidence that such co-benefits have been achieved, and there is no advantage conferred on projects that support broader economic development, public health or environmental goals (Ellis et al., 2007; Michaelowa and Michaelowa, 2007; Olsen, 2007; Sutter and Parreño, 2007). Grant programs like the Global Environment Facility, in contrast, may have local co-benefits as a central goal.

The second dimension – cap-and-trade integration – relates to how DC reductions affect IC levels of domestic mitigation effort. Tradable credits are almost always partly fungible with emission allowances in domestic or international (e.g. Kyoto) cap-and-trade programs, even if there are some quantitative limits on the number of credits that are accepted. Integration with cap-and-trade is more difficult with grant programs, as emission reductions may not be

[8] Recently, Nationally Appropriate Mitigation Actions (NAMAs) have been used as the framework to describe different instruments. NAMAs have been categorised as credit-generating (equivalent to our tradable credits category), supported (all our other categories), and unilateral (which we do not consider here). For a discussion of the NAMA terminology and framework, see Center for Clean Air Policy (2009); Wang-Helmreich et al. (2011).

quantified with sufficient provision to allow fungibility (while the GEF has an extensive monitoring program, it is not intended to be as precise as that of the CDM). On the third and fourth dimensions, a similar continuum can be observed on the dimensions of results vs. effort based, and ex post vs. ex ante monitoring. Tradable credit programs generally assign rewards based on results as measured ex post.

The advantage of viewing instruments to encourage and provide resources for DC mitigation on a continuum, rather than simply as a choice between offsets or grants, is that it highlights the potential for considerable flexibility in program design through adopting different positions on each of the four dimensions. Hybrid instruments, which blend characteristics that are normally attributed to either tradable credits or grants, emerge as possible options. For example, a tradable credit program could involve IC investment in joint ventures on the basis of an ex ante assessment of mitigation potential and reward the DC partly on the basis of effort. Similarly while grants and loans are generally provided in advance based on expected performance, they can be results based and award funding based at least in part on ex post performance.

Indeed, there are already examples of how offset programs have been implemented in flexible ways. While the CDM has been designed to issue offsets according to ex post emission reductions, in practice offset providers often sell the rights to the offsets up front, before emission reductions are realised. The risk of credit non-delivery is borne by a third party. There are also examples of non-greenhouse gas offsets that are credited according to different criteria. For example, in the case of offsets for nonpoint source water pollution in the U.S., credits are generated ex ante on the basis of effort, i.e. for activities that are expected to reduce pollution, rather than on actual, measured reductions (Hahn and Richards, 2010).

The forestry sector, meanwhile, has provided several recent examples of results-based agreements (RBAs), whereby payments from an IC to a DC are at least partly conditional on performance. Norway's REDD agreement with Brazil is a case in point (Nepstad et al. (2009) discuss the Brazilian case). The Copenhagen Green Climate Fund may take the form of a fund that seeks to maximise emission reductions within a budget constraint, in a similar way to the Multilateral Fund of the Montreal Protocol that Wara (2008) points to as an alternative to the CDM.

This continuum is certainly not exhaustive, and in this paper we do not discuss many potential instruments that fall outside it. Two are of particular note. First, technology transfer might be promoted through a tradable credit program such as the CDM (Popp, 2011). However aspects of technology transfer that go beyond financing, such as the transfer of intellectual property rights or market guarantees (Victor, 2011), can be a separate instrument to promote the spread of clean technology to DCs. Second, capacity building encompasses a variety of "soft" measures to improve a country's ability to implement policies and projects. These complement mechanisms that provide financial resources and create incentives.

Many of the inefficiencies and other challenges that have been identified with offsets are in fact common to all instruments on this continuum. For example, additionality, discussed in detail below, has long been identified as a problem with the CDM and other offset programs, but additionality can be just as serious a concern for grants. Therefore, in the following sections we first discuss the major common challenges – leakage, adverse selection, moral hazard, negotiation, and incomplete contracts – under a unified framework. We then discuss some of the implications of adopting different positions on the four dimensions in Figure 2, such as integration with cap-and-trade, focusing on the economic challenges.

3.2. Leakage

We define leakage as indirect effects that are not accounted for when assessing the environmental impact of a project.[9] For example, given a relatively inelastic global demand curve for tropical timber, ceasing deforestation in one region leads to reduced emissions and apparent success, but may displace much of the activity to another location. Thus, leakage can be minimised by expanding the sectors and geographic areas that are covered by accounting within international agreements. If engagement with DCs were at the national level, covered all gases and included all countries, there would be no leakage.

From an economic point of view, leakage might take several forms, all of which are identical regardless of which instrument is chosen:

- **Rebound effects.** Through reducing demand for fossil fuels, a mitigation project may reduce their price and thus lead to a rebound effect as consumption increases elsewhere. Vöhringer et al. (2006) estimate that this leakage amounts to about 14% of the emission reductions from CDM projects that reduce the demand for crude oil, while Rosendahl and Strand (2009) show that the amount of leakage can be even more sizeable, depending on the extent to which global fuel markets are unified. More generally, this type of rebound effect will lead to leakage from any project that reduces demand for "dirty" goods, such as timber extraction from forests.[10]

[9] In the CDM context, leakage is also used to refer to effects outside the project boundary that are accounted for when calculating emission reductions. For example, the CDM methodology for natural gas-fired power plants accounts for emissions from natural gas combustion as part of the project, but not for fugitive emissions during gas extraction or transportation as leakage.
[10] Meyfroidt et al. (2010) find that displacement of land use when countries move from net deforestation into net reforestation offsets 22 percent of the reforested areas, although this may have risen to 52 percent in the five years to 2010. Leakage can also occur through capital or labor markets.

- **Crowding out.** Through increasing demand for clean technology, for example wind turbines, the project may increase its price and thus lead to a crowding-out effect as investment falls elsewhere.
- **Outward-shifting supply curve.** In this instance, the subsidy provided by the mitigation instrument shifts the supply curve outward. Even if the product is cleaner than alternatives, an increase in supply may lead to leakage from higher consumption, and thus emissions, outside of the project boundary. An example from the CDM might be the production of coal bed methane gas, or any electricity generation project that alleviates brownouts rather than displaces higher-emission generating capacity. The outward-shifting supply curve phenomenon also applies in a broader set of circumstances where a particular technology is subsidised, such as low-carbon fuels. In the latter context, Holland et al. (2009) show that it is possible to have more than 100% leakage, i.e. emissions actually increase as the subsidy shifts the supply curve outward.

3.2.1. Forestry Permanence as Leakage

The (lack of) permanence of avoided deforestation or reforestation is often treated as a separate problem that is unrelated to leakage. However, lack of permanence is in fact a case of intertemporal leakage (Kerr, 2011). Reduced emissions today cause changes in economic conditions that can raise emissions relative to business-as-usual emissions (BAU) later if the project ends. Just as a decision to avoid deforestation (reducing the stock of carbon sequestered in forests) may be reversed in a subsequent period, a decision to avoid burning coal (reducing the stock of carbon sequestered in fossil fuels) is also reversible. The reason that intertemporal leakage is usually considered only in the forestry and agriculture context is because forestry is usually thought of in terms of the relatively easily measured stock of forest, rather than the flow of timber, other forest products, and sequestration/decay. In contrast, fossil fuels are usually thought of in terms of the flow of oil, gas or coal, rather than the stock remaining in the ground.

The amount of intertemporal leakage is determined by how the supply of timber and oil at a point in time depends on the stock, the availability of the stock for immediate extraction, and on how future demand and supply depend on current demand and supply. If, for example, a reduction in oil extraction in period one, arising from temporary protection of the stock or reduction in demand, lowers the cost of extraction in period two because the lower extraction cost oil is still available, the cost of oil will fall and consumption will rise in the next period. The short-term reduction in emissions in period one will be partly offset by increased emissions in period two – an identical rebound effect to that discussed above, except that the rebound is intertemporal rather than across sectors or space. If, in contrast, a reduction in supply or demand is costly to reverse, a short-term reduction could persist and even lead to permanent protection.[11] Examples of the latter case might include a relatively irreversible decision not to allow a previously planned well or power plant; a new low carbon technology gaining a foothold; or the strengthening of institutions to reduce deforestation during the temporary period of protection.

[11] This is often discussed in the context of the "forest transition". See Angelsen and Rudel (2011).

Whether forests are different from oil wells in this regard is an empirical question. In other words, permanence of emission reductions is not a special consideration for forestry and agriculture, but rather a more general problem of intertemporal leakage. [12]

3.2.2. Addressing Leakage

In principle, all of the sources of leakage discussed above can be taken into account when quantifying emission reductions. In practice, however, it is very difficult to do so, particularly on a project-by-project basis, and the present CDM accounts for very few sources of price-induced leakage (Millard-Ball and Ortolano, 2010). Indeed, leakage often only makes sense to consider on an economy-wide basis, and so attributing leakage to individual projects can be difficult (Vöhringer et al. 2006).

In some respects, leakage from the mitigation instruments discussed here is similar to leakage from a cap-and-trade program, which has been extensively analysed (Fischer and Fox, 2011). However, leakage outside of the cap-and-trade context is potentially a more serious problem for two reasons. First, many mitigation instruments for DCs may provide only partial coverage of emitting activities. Under cap-and-trade, by definition all leakage must occur outside the cap, but other mitigation instrument for DCs may be akin to a highly patchy cap, and so leakage can occur in local markets as well as overseas. Second, in contrast to cap-and-trade,[13] many other mitigation instruments discussed here involve voluntary participation by DC firms or sectors and hence represent a subsidy, which leads to the outward-shifting supply curve channel for leakage.

On the other hand, expanding mitigation programs to developing countries may reduce leakage from domestic cap-and-trade programs in industrialised countries. More broadly, providing a consistent carbon price across countries and sectors will reduce the benefits of relocating carbon-intensive industries to avoid the climate regulation. A broad climate mitigation effort is the best solution to leakage.

3.3. Adverse Selection

Emission reductions can never be measured, whether for purposes of tradable credits, a fund or other instruments. Rather, emission reductions are the difference between actual (measured) emissions and counterfactual business-as-usual emissions (BAU). Although the "true

[12] Thanks to Ruben Lubowski for helping to clarify this point.

[13] The exception is a cap-and-trade system where free allowances are allocated on the basis of output or according to a similar rule. Although the motivation for these is often to reduce international leakage, because the distribution of allowances also amounts to an output subsidy, the same issue of outward-shifting supply leakage may apply if they are poorly designed. For a discussion in the cap-and-trade context, see Fischer and Fox, 2011.

BAU" level of emissions for a country or project is uncertain for all parties, the DC, and particularly a firm within a DC, has private information about it that is not observable by the IC (or its regulatory agent). At a minimum, the private information includes a country or firm's planned (BAU) level of effort, but there will usually be other sources of private information – for example, about local market or political conditions. When participation by the DC is voluntary, which is inevitable in agreements across countries, this creates an adverse selection problem. In the context of offsets, the challenges presented by adverse selection were first formalised by Montero (1999; Montero, 2000), but recently there has been much more work on this issue (Millard-Ball, 2010; van Benthem and Kerr, 2010; Bushnell, 2011).

In the policy literature, adverse selection is normally considered under the rubrics of additionality and baselines. Offsets in general, and the CDM in particular, have attracted a slew of negative attention in academic and policy literature and in the media because of the lack of additionality, i.e., offsets are awarded to projects that would have happened anyway. In the CDM, additionality is understood as the binary case of adverse selection, i.e., would this *project* have happened in the without-CDM BAU baseline scenario. In other cases, additionality is often understood as a continuous phenomenon, e.g. *how much* deforestation has occurred relative to that which would have occurred in the BAU baseline scenario. An additional credit represents a real reduction in emissions from BAU. In the CDM, in contrast, the continuous case is understood as a baseline issue – even if the project is additional in the binary sense, what level of emissions would have occurred under BAU.

To avoid this terminological confusion, we call the binary case "project additionality," and the continuous case "credit additionality." Of course, if the project is non-additional, then none of the credits are additional, but the converse does not hold. A project may be additional, but generate some non-additional credits if awarded a baseline above BAU. While the economic logic of adverse selection is the same in both instances, we discuss "project additionality" first as it provides a more intuitive exposition.

Here, we use "baseline" to refer to the level of emissions below which a DC or other entity receives payment for emission reductions. It is important to emphasise that baseline emissions are not necessarily the same as BAU emissions. A baseline may be set at estimated BAU (which we call "BAU baseline"), but as discussed in this section, it may also be set above or below this level.

While the empirical examples are drawn from offsets, the principles apply equally to grant programs, RBAs and other instruments. However, the problem may be more severe in the case of offsets and other tradable credit programs that are linked to IC cap-and-trade markets. This is because (unless caps are adjusted accordingly) non-additionality of tradable credits will lead to "contamination" – an inefficient fall in the carbon price in all linked markets, and lead to under abatement in ICs as well.[14] The relative performance of different instruments will depend on the extent to which decision-makers anticipate the effects of adverse selection – and take them into account when setting the level of IC caps, any restrictions on the use of offsets, and the size of any fund or RBA purchases.

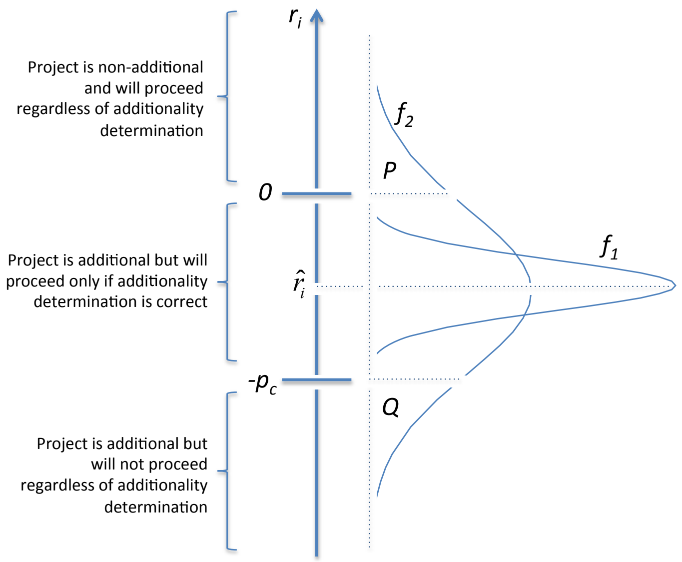
3.3.1. Project Additionality

To understand project additionality as a problem of adverse selection, consider the following setup. Let r_i be the return (excluding offset revenue) from potential project i, which could be protecting a plot of land from deforestation, building a wind energy facility, or destroying methane gas from a landfill. Assume each project i would reduce CO_2 emissions by one tonne. Consider the case where the project owner knows r_i with certainty, and also r_i^*, the minimum return in order for her to proceed with the project (which we normalise to zero), and the carbon price p_c, which may be thought of as the market price for offsets or the price offered by an RBA fund manager. Projects where $r_i < 0 < r_i + p_c$ are by definition additional. Projects with $r_i < -p_c$ will choose not to proceed. The regulator must then decide a cutoff level of $\hat{r}_i$. If $\hat{r}_i < \bar{r}$ the project will be accepted. In a deterministic world this would be set at $\bar{r}$=0.

The true value of r_i is private information. In order to make a determination of additionality, the regulator must estimate $\hat{r}_i$ as a function of observables or information that is provided by the developer. Suppose that $\hat{r}_i + \varepsilon_i = r_i$ where $E(\varepsilon_i) = 0$ so the estimate is unbiased. Figure 3 shows how the regulator's point estimate of $\hat{r}_i$ translates into the probability of non-additionality, depending on the distribution of ε_i. If $\hat{r}_i$ is very low and it is possible to estimate it with a high level of accuracy the regulator can be confident that the project is additional. If however, $\hat{r}_i$ is close to zero, or the estimation process is inaccurate, the regulator faces a tradeoff when deciding whether to accept the project.

[14] The reverse problem occurs if the decision-maker overestimates the problem of non-additionality and sets the cap too stringently – in this case, both ICs and DCs will overabate.

Figure 3 Additionality and efficiency tradeoff for one project



Assuming an unbiased estimate and a known distribution, two possible distributions of the error in the regulator's estimate are f_1 and f_2. For a given $\hat{r}_i$, in the first case (f_1), the regulator is certain that the project is additional. In the second case (f_2), the regulator trades off the risks of accepting a non-additional project (probability P) and rejecting an additional project that would go ahead with offset funding (probability 1 – P – Q); Q is the probability that a project does not proceed regardless. Adapted from Kerr and van Benthem (2011).

More generally, a decision rule will be set for a class of projects rather than for each one separately. By changing the cutoff $\bar{r}$, the regulator trades off between the efficiency loss from rejecting additional projects, and accepting non-additional projects. If $\bar{r}$=0 fewer than half the projects that proceed and are accepted will be additional. Making the decision rule more stringent (a lower cutoff $\bar{r}$) will improve the share of projects accepted that are additional and reduce the cost to the IC per unit of real reduction but lead to efficiency loss as mitigation opportunities are lost (van Benthem and Kerr, 2011). The converse is also true – the supply of both non-additional and additional projects is increasing in $\bar{r}$.

In practice, the type of investment analysis described above is a key way in which the United Nations Framework Convention on Climate Change makes additionality determinations (UNFCCC, 2008). Project developers are required to calculate r_i in the form of a financial indicator such as IRR, NPV or the unit cost of service. They may compare it to a benchmark r_i* or the return from an alternative option r_j (such as a coal power plant instead of a wind energy facility). However, alternative tests of additionality exist, and are used in the context of the CDM and other offset programs. Some of the most common are as follows (Trexler et al., 2006):

- Barrier analysis – identification of financial, technological or other barriers that would be alleviated by the offset program, and would otherwise prevent the project from proceeding.

- Common practice test – are similar projects widely observed in the same sector and region?
- Technological standard – does the project use a technology that is specified as being "not business as usual?"
- Regulatory standard – does the project reduce emissions below what is required by government regulations or other standards?

The fundamental problem of adverse selection inevitably means that these tests are imperfect. Moreover, it becomes no easier to determine ex post whether an individual project was additional. The counterfactual can never be observed, and additionality can never be verified or disproved. However, numerous studies do call into question the additionality of many classes of projects, using various methods:

- Admissions by project developers, who will sometimes explicitly state that a project would have happened anyway (Haya, 2009: 7).
- Prima facie evidence of manipulation of *r** by project developers. For example, power tariffs from wind energy in China, which are set by government regulators, vary considerably by project, raising suspicions that tariffs could be orchestrated in order to demonstrate additionality (He and Morse, 2010).[15]
- Assessment of the credibility of additionality claims in Project Design Documents, for example through examining how offset revenue affects a project's Internal Rate of Return (Sutter and Parreño, 2007). Schneider (2009) finds that: "43% of the analysed projects applying barrier analysis provide no explanation as to why the identified barriers would prevent the proposed project."
- Consideration of reasonable penetration rates in absence of CDM. This approach does not consider the additionality of a particular project, but rather aggregate additionality in an entire sector. On a project-by-project basis, additionality claims may be plausible, but not when (as with natural gas power plants in China) all projects in a sector claim to be additional (Wara, 2008).
- Simulation models which model participation in a mitigation program, and compare this to a business-as-usual scenario. Examples include Busch et al. (2009) and Millard-Ball (2010).
- Technology diffusion models that consider the timing of projects. Even if a project is not viable today without offset revenue, the CDM may simply bring its implementation forward by a few years (Popp, 2011).
- Econometric comparisons of rates of deforestation on land that opted into a program with land that did not using propensity score matching (Sanchez-Azofeifa et al., 2007).

3.3.2. Credit Additionality

Project additionality represents the binary case – a project is either additional or it is not. The adverse selection framework, however, applies to the more general problem of BAU baseline estimation which is relevant to a mitigation instrument with a wider scope than one discrete project: sectoral or regional or even over multiple years. In other words, even if a project is correctly deemed additional, emission reductions may be incorrectly estimated. Relax the assumption that each project reduces emissions by one tonne of CO_2. Suppose, for example,

[15] He and Morse do not take a stand regarding these fears of orchestration. Rather, they conclude (p. 3): "Because the NDRC [the regulator] determines power tariffs in a proprietary, non-market-based manner – as is their right in making sovereign decisions about energy policy – there is no real way to know what is business as usual and what constitutes gaming of the CDM. True verification of offsets is impossible in this context."

that a firm can choose from three levels of emissions – e_L, e_M and e_H. If the regulator determines that the counterfactual BAU baseline is e_H, when it is in fact e_M, then emission reductions will be overstated. However, if the regulator determines that the counterfactual BAU baseline is e_M, when it is in fact e_H , then the project may (inefficiently) not proceed if $r_i + p_c (e_M - e_L) < r_i^* < r_i + p_c (e_H - e_L)$.

3.3.3. Policy Options for Additionality and Adverse Selection

Reduce Private Information

If there is no private information, then the problem of adverse selection disappears. One option is to implement mechanisms that induce revelation of private information.[16] Alternatively, a good governance process can make additionality estimation more precise and at least unbiased.

In the case of the CDM, the additionality documentation and emission reductions estimates are prepared by the project developer, and audited by a third party (a Designated Operational Entity, or DOE) accredited by the CDM Executive Board. However, the project developer and the purchaser of offsets have a clear interest in inflating the volume of offsets that are claimed. While the DOE provides an independent check, it is contracted by the project developer – creating an incentive to gloss over any irregularities (Schneider, 2007; Wara and Victor, 2008; Dyck, 2011). The Executive Board has applied sanctions against some DOEs in recent years, but the problem of incentives remains. Moreover, to the extent that it increases transaction costs, a drive to gather more information and verify specific claims put forward by developers may exacerbate the problem of *project* additionality, through increasing transaction costs and reducing the net revenue that is obtained through the CDM.

Conservativeness and Discounting

Another approach to reducing the problem of additionality is to reduce the estimate of the likely impact of a grant program or the number of tradable credits that are issued in an offset program – either through setting a lower (conservative) baseline, or through discounting. While the precise impacts depend on the shape of the offset supply curve, in practice, this approach is unlikely to yield the desired benefit.

The challenge for the regulator is that project additionality and credit additionality are correlated, and thus measures that are taken to address one form of additionality may deleteriously affect the other. In the CDM, for example, considerable attention has been devoted to ensuring that baselines are "conservative," i.e. to ensuring credit additionality, and many

[16] Montero (2008), Hellerstein et al. (2011), Kerr (1995a) and Mason and Plantinga (2011) all offer potential instruments to induce revelation of private information but they have not been explicitly applied to this problem.

methodologies apply a "conservativeness factor" to this end. Reducing the number of credits that are issued to a particular project in this way, however, will exacerbate issues of project additionality. The conservativeness factor will not affect non-additional *projects* (which by definition will go forward anyway), but may cause the marginal additional project to not proceed. The extent of the trade off depends on the elasticity of the offset supply curve. The more inelastic the supply curve, the less the negative impact of discounting on the additional supply, and the greater the impact on reducing inframarginal rents.

One way to implement price discounting is to set a cap on the total number of units accepted (for example in the European Union system[17]), and hence lowering the price by constraining demand for units. Alternatively, a trading ratio can be used, so that one tradable credit is issued for (say) two tonnes of CO_2-e reduced, or equivalently, two tradable credits are required to substitute for one allowance in a cap-and-trade scheme. Discounting may reduce the average cost to ICs of real DC reductions and may protect the environmental integrity of the cap and trade program that accepts offsets, but by reducing the effective carbon price to DCs, will exacerbate adverse selection, reduce efficiency, and may even make problems of additionality worse (van Benthem and Kerr, 2011).[18]

Adjust the Cap or Fund Size

While adverse selection affects the cost to ICs of funding DC mitigation, it is not a bar to attaining the efficient solution, i.e. the implementation of all potential projects where $0 < r_i + p_c$. Efficiency is achieved by funding all projects that have nonzero probability of falling into this range. In the context of a tradable credits program, if the regulator can estimate the volume of non-additional offsets in aggregate, he can reduce the cap by an equivalent amount, leaving global emissions unchanged. In this case, the trade-off with efficiency is a transfer from ICs to DCs in the form of payment for non-additional offsets. A similar result was demonstrated by Montero (2000).

Exactly the same principles hold if an alternative instrument is used, for example if a fund is used to pay for adoption of a specific technology in DCs. In this case, rather than making the cap more stringent in anticipation of non-additional adoption and hence emission reductions,

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[17] For a critical discussion of some of the implications of the EU's system for imposing limits on tradable credits from the CDM, see Vasa (2012).

[18] In the extreme, discounting to compensate for non-additional credits could make additionality problems worse, and ultimately exclude all additional credits. To see this, suppose initially that 50% of projects are non-additional at price p_1. Then, the new carbon price is $p_1 / 2$, at which a higher proportion of projects will be non-additional (the lower price means fewer additional projects, while leaving non-additional projects unaffected). To compensate, the (discounted) carbon price must fall further. Depending on the shape of the supply curve, an unravelling process could occur and only non-additional projects remain in the supply, meaning the discounted carbon price falls to zero.

the size of the fund should be increased to fund the same amount of DC mitigation *plus* the payment for non-additional reductions.

Estimating the volume of non-additional offsets even in aggregate is, however a daunting challenge. Even ex post, there is no consensus in the literature on the extent of non-additionality in the CDM. A small "straw poll" of CDM experts found opinions of non-additionality ranging between 0% and 100% of projects in a given sector (Grubb et al., 2011). The solution of implementing more stringent caps above assumes that decision-makers in ICs can accurately predict both the total volume of offsets, and the proportion that are non-additional.

Scale Up

If the mitigation instrument were a national-level reward relative to a national-level BAU baseline for emissions in the DC, the challenge would be to get an acceptable prediction of BAU (and potential gains from selling credits) as a basis for negotiations. The law of large numbers suggests that this is an easier problem for national-level estimates compared to the project level. The uncertainty in terms of ex-post estimates of true BAU and the environmental gains resulting from efforts under the agreement is then similar to what we have observed during the implementation of the Kyoto Protocol which took this approach among ICs.

Van Benthem and Kerr (2011) show that increasing the scale at which baselines are set and monitoring is carried out will usually reduce adverse selection considerably. This requires engaging either with fewer countries and regions but at greater depth, or increasing total effort. While the share of funds that go to non-additional projects or credits may fall, a larger program may generate a larger volume (but a smaller share) of non-additional credits.

3.4. Risk Allocation and Moral Hazard

Real reductions in emissions are the difference between the BAU baseline and observed emissions. Risk arises in two key areas when trying to reward (or receive reward for) effort to reduce emissions. First, even if there were no private information and hence adverse selection, the BAU baseline is uncertain. This introduces significant uncertainty about the reward per unit of effort the DC will receive, and even raises the possibility that the DC could lose from participation or that the IC could transfer resources but induce no real emissions reductions. Second, effort to reduce emissions also leads to uncertain impacts. These uncertainties are often indistinguishable from variation in effort by the DC.

For example, if the BAU baseline is an overestimate, the DC will be unintentionally over-rewarded, and would be paid, even if they exert no effort. On the other side, if the BAU baseline is an underestimate of emissions, the DC could exert real effort (at some cost) but receive little or no reward. In the extreme they could face a liability. This will be exacerbated if the response of emissions to DC effort is less than anticipated. The DC will, however, face an efficient marginal expected reward for effort.

One proposed solution to the risk of liability is "no loss" baselines. While this approach avoids part of the extreme risk, though not the risk of bearing high costs of mitigation and receiving less reward than costs incurred, no-loss baselines reduce the marginal return to effort. If the probability of facing net liability is ρ, the expected return to effort with a no loss baseline is $(1-\rho)$ times the price of carbon.

If both countries were equally risk averse (or equally able to access insurance or other risk management tools), all risk could be imposed on the DC and its incentives to generate real reductions would be efficient. DCs, however, are often less able to manage risk and are unwilling to take on large amounts of risk, especially without compensation. The more risk the DC agrees to assume, the more costly the agreement will be to the IC. Where risks are outside the control of the DC (e.g. international commodity prices, international carbon prices, risks associated with new technologies, or risks associated with untested polices), and if the DC is more risk-averse than the IC, it may be efficient for the IC to bear these risks.

The CDM moderates risk in three main ways. First, it links rewards (the number of credits generated) to relatively controllable intermediate variables such as electricity generation.[19] Second, baselines are not set until the project is created and may be revised over time, in order to account for new policies, technologies, prevailing practices and other changes that affect baseline emissions. Third, private carbon markets allow some of the response risk to be passed to buyers who purchase units in advance.

While the CDM's approach helps to manage risks, particularly to the project developer, it introduces the potential for moral hazard. In contrast to the problem of adverse selection, which arises when DCs (or DC firms) have private *information* about BAU, moral hazard arises when *effort* cannot be observed, or is not adequately accounted for in the contract. The agent's incentives diverge from the interests of the principal. For example, if baselines are going to be revised, DCs may take hidden or simply non-contracted actions (change their level of effort) in

[19] For example, credits for wind energy are calculated as the amount (MWh) of electricity supplied to the grid, multiplied by a pre-determined emission factor that represents the carbon intensity of alternative generation sources. The developer bears the risk of lower-than-expected generation, but not of other uncertainties about the response to effort, such as electricity demand and changes in the dispatch order of other facilities.

order to secure a more favorable future baseline. These actions lead to later resource transfer from ICs to DCs, and also inefficiency.

For example, if future baselines depend on observed emissions, firms and governments may be deterred from adopting low-emissions technologies and policies in order to preserve their ability to gain offset revenue in the future.[20] A methodology for a hydroelectric project in Costa Rica was initially denied due to a new national policy requiring privately-generated power to rely on renewable energy sources, which in turn implied that the hydroelectric project was not additional. Subsequently, the CDM Executive Board, in recognition of the deterrent effect, ruled that national or sectoral policies that promote low-emission technologies, and had been adopted after 2001, should be ignored when setting the baseline (Bosi and Ellis, 2005). However, such a policy is clearly imperfect: while it removes a penalty from those who take desirable actions outside the agreement, it is likely to generate non-additional offsets as many countries would presumably have adopted low-emission policies even without the CDM.

At the extreme, firms may even increase their emissions in order to maximise potential offset revenue – so-called "baseline grabbing." Wara (2008) provides evidence that baseline grabbing has occurred in the context of HFCs, as firms increase their production of HFCs, a waste product, in order to gain CDM credits for destroying them. Incentives to distort project baselines through action at the national government level is modeled formally by Strand (2011). He shows that the CDM will distort national fossil fuel taxes downwards, as a government considers the effect of such a tax on offset revenue.

More generally, moral hazard arises wherever a contract is insufficiently precise so that what the parties explicitly agree to do in the contract is not exactly the intention of both parties. Suppose, for example, that a technology transfer program defines the specific technology to be provided to specific numbers of plants as a proxy for emissions reductions, desired by the IC, and for knowledge gains, desired by the DC. The program may be fully implemented, but lead to fewer emission reductions than expected by the IC if the DC encourages output growth using the new technology. Moreover, less knowledge may be transferred than the DC expected, if the IC chooses to use its own consultants.

Potential Solutions to Risk Sharing and Moral Hazard

Adverse selection creates a tradeoff between the value per dollar spent by the IC and efficiency; moral hazard creates a tradeoff between efficiency and reduction of DC risk. The

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[20] This is the problem of so called "low hanging fruit" and is discussed in the CDM context in Narain and Veld (2008).

choice between these objectives is one area where the different mitigation instruments in Figure 2 differ considerably. At one end of the spectrum, purely results-based instruments with ex-post monitoring minimise the potential for moral hazard. At the other end of the spectrum, purely effort-based instruments minimise risk to the developing country.

Other policies fall along the spectrum. Allowing the payment for a mitigation instrument to depend on proxies for performance is often desirable in terms of reducing risk, as proxies such as technology adoption or renewable electricity generation are more directly related to effort than are emissions. But the use of such proxies can lead to moral hazard, in the form of insufficient care to achieve the desired outcome of emission reduction.

A policy that rewards observable effort rather than results pays for specific investments or for policies rather than emission reductions. For example, suppose that a government can affect CO_2 from transport only through fuel economy standards for new cars. There is an (approximately) known relationship between fuel economy and CO_2 emissions, but there may also occur some exogenous shock that affects the parameters of this relationship (e.g. a change in the world oil price that affect the average distance that each vehicle is driven). Under these circumstances, it may preferable for the IC to pay for fuel economy improvements rather than for CO_2 reductions. Otherwise, the baseline will have to be higher to compensate the DC for taking on the risk of a changing relationship between fuel efficiency and CO_2.

However, this is a highly simplified example. First, fuel economy standards are not the only instrument for controlling CO_2 from transport, and limiting incentives to this one instrument will be inefficient. Second, the approach may lead to perverse behavior; the government may allow existing cars to stay on the roads longer or may use the fuel economy initiative funded by the IC to deflect political pressure to improve public transport, reduce fuel subsidies or implement other efficient policies. [21] Thus, shifting to effort- rather than results-based rewards may address the problem of risk but introduce the potential for moral hazard and other inefficiencies.

One approach to address the tradeoff between risk and moral hazard aims to simply reduce the risk – to all parties – by improving the BAU baseline and prediction of response through better research. The second approach is to reduce relative risk (risk per unit of real

[21] Another challenge is that history suggests that policy makers generally over-estimate the effectiveness of mitigation policies. Even at a project level within the CDM market, it was estimated in 2006 that the CERs that had been certified at that time represented 70 percent of the CERs that should have been generated over the same period according to the Project Design Documents (Fenhann (2006), cited in Lecocq and Ambrosi (2007)). Lecocq and Ambrosi also provide some interesting data on how CDM contracts are structured to reduce this risk to investors.

reduction). In a larger scale agreement, risks are pooled across sectors, projects and even time; this cancels out independent shocks. Increasing the level of emissions reductions within a given agreement through more effective domestic mitigation policies also reduces relative risk, as more real reductions are made relative to a fixed level of baseline risk.

The third approach focuses on moving risk away from the DC with as little moral hazard as possible. One way to reduce risk to the DC without exacerbating moral hazard would be to make the baseline an explicit function of uncontrollable factors that will affect, for example, the relationship between fuel efficiency and emissions, such as world oil prices and GDP. Fourth, if the IC were willing to be very generous, a partial solution, illustrated to some extent in the Costa Rican case discussed above, is to make baselines fixed for the long term; reward on the basis of observed emissions; and make the baseline sufficiently generous that the DC cannot lose. The downside of this fourth approach is the high and possibly unacceptable cost to the IC, and inefficient risk sharing between the DC and IC.

The deliberate manipulation of baselines occurs because negotiations over resource transfers for climate mitigation are ongoing. As long as negotiations cannot be concluded, strategic behavior will continue unless all ICs and DCs can commit to base all future negotiations on historical emissions or factors that are reasonably outside the ambit of domestic climate mitigation policy (such as regional or global GDP and population). Just as the ultimate solution to leakage is a broad agreement, the ultimate solution to moral hazard is a stable long-term agreement, on a national scale with appropriate risk management.

3.5. Negotiation over Cost Sharing

Both DCs and ICs must agree to participate in any mitigation instrument. Even though the total gains are probably large, by the time adverse selection problems, risks, capability issues and political constraints are taken into account, it may be difficult to find deals that are obviously mutually advantageous. Both DCs and ICs will have private information about their political willingness or ability to commit significant resources to mitigation in DCs. Even if there are obvious joint mitigation cost savings and other gains, parties may hold out for a greater share of the gains. The difficulties of negotiation are magnified in a multilateral context, but even bilateral agreements will be dependent on what other ICs and DCs are separately negotiating. Inefficient delay is the result.

Fund-based instruments have the most flexibility to make individual deals, tailor the risk bearing within projects, and price discriminate where the gap between mitigation cost and the marginal benefit is very high. For example, lower prices might be paid for reductions of HFCs and methane, where abatement costs tend to be lower compared to CO_2, in order to extract rents from offset providers and reduce the cost to ICs (Hepburn, 2007; see also Muller, 2007; Liu, 2008). Price discrimination might alternatively be used to give preferential treatment to low-income countries or particular sectors (Bakker et al., 2011). This discretion creates challenges, however, in a political environment with high stakes. Decisions will not be purely technical,[22] with the consequent risk of creating inequity and inefficiency.

In contrast, a simple tradable credit scheme will pay full price. For example, buyers will pay about €4.7 billion for CDM credits from HFC abatement projects in China, while estimated costs of abatement are likely less than €100 million (Wara and Victor, 2008). A tradable credit instrument's cost-sharing discretion comes through the setting of baselines, limits on purchase of units, or discounting/trading ratios. Differentiating tradable credit systems to suit individual DC and IC situations may be easier in an informal collection of agreements rather than one global agreement.

3.6. Incomplete Contracts and Under-Investment

Efficient, effective mitigation involves long-term investments, innovation, policy change and structural changes in economies. If these are worthwhile only if climate costs are internalised, they may not happen with international agreements with short time horizons and poor commitment. The risk to the DC and the investors in any projects is that the IC may not follow through with funding or may change the policy and hence the terms of the funding.

This can be thought of in terms of a policy as an incomplete contract that will be renegotiated. Investments in capital and infrastructure and changes in policy in the DC are relationship specific – they would not have done them without anticipating returns from the mitigation instrument and they cannot be used for any other purpose. Once the investments are made, they expose the DC and investors to "hold up". Their bargaining power will be poor when the agreement is, inevitably, renegotiated. This leads to underinvestment by the party who has to make the relationship-specific investment. Rodrik (1991) discusses this generically for developing country investment. Harstad (2009) explores the dynamics of climate agreements and how they generate hold up.[23]

[22] Even the outwardly technocratic decision-making process of the CDM is susceptible to political influence. CDM projects have a greater chance of being approved if the host country is represented on the CDM Executive Board (Flues et al. 2010).

[23] This problem, and other issues related to the design of instruments to fund DC mitigation were discussed in Kerr (1995b).

Solutions to hold up can lie in creating "hostages", in joint ventures, and more generally in shifting vested interests so that at the time of renegotiation the bargaining power is more balanced. To the extent that international mitigation instruments can be funded through private commercial contracts, created in response to binding domestic regulation rather than being dependent on current international policy, some of the political lack of commitment can be avoided.

One practical solution is for the IC to invest directly in necessary infrastructure and technology. Datta and Somanathan (2011) propose a focus on technology innovation in response to the commitment problem. This not only avoids underinvestment in innovation, but also reduces the difficulty of later agreeing on mitigation actions because their cost will be lowered if innovation is successful.

3.7. Integration into Cap-and-Trade

All of the common challenges discussed in the previous section apply to tradable credits (whether in the CDM or a sectoral crediting program), funds, results-based agreements and similar instruments. One key issue differentiates the instruments: the impact of tradable credits on uncertainty in IC cap-and-trade systems.

Linking DC mitigation to IC cap-and-trade systems through tradable credit instruments has the advantage that it allows mitigation effort to be more efficiently allocated between DCs and ICs. If there is a greater-than-expected supply of tradable credits, the carbon price will fall and less mitigation will take place in ICs – the efficient outcome if the cap is set at the right level. Conversely, if the volume of DC mitigation fails to meet expectations, prices will rise and more mitigation will take place in ICs. Under this framework, integration into cap-and-trade is to be desired. Tradable credit programs can also indirectly link domestic cap-and-trade markets in different ICs, which in some circumstances can equalise carbon prices and marginal abatement costs (Flachsland et al., 2009).

A further key advantage of using tradable credits to integrate DC mitigation with IC efforts is political. Victor (2011) argues that the attraction of offsets, rather than cash transfers among countries, is their invisibility. Assuming they are purchased by private actors, tradable credits are not a line item on any government's budget, and thus obscure the costs of transfers for climate mitigation. The resources also do not need to be raised through distortionary taxation.

The downside of integrating DC mitigation with IC cap-and-trade is the potential for contamination. Non-additional tradable credits generated by adverse selection – either at the project level in offsets, or through excessively generous baselines that are not completely offset with increases in IC targets – will affect prices and mitigation in IC cap and trade markets. In contrast, using RBAs or a fund can insulate IC cap-and-trade markets from problems with the DC mitigation instrument.

Offsets do have a potential benefit in terms of reducing the risk of unexpectedly high carbon prices in a domestic market, simply through broadening the market and reducing un-correlated shocks to price. Some cap-and-trade programs such as the U.S. Regional Greenhouse Gas Initiative (RGGI) make the link between offsets and price control explicit, through relaxing limits on the use of tradable credits as prices get high. However, supply constraints may make the RGGI approach difficult to implement universally, and the same role can be fulfilled by a safety valve or price collar.[24]

More broadly, it is unclear whether the CDM and other tradable credit programs do play any role in reducing carbon price volatility, or whether they exacerbate it. Although models suggest that mitigating climate change in developing countries is relatively cheap, the potential supply of mitigation from developing countries is highly uncertain. If tradable credits are generated and fully integrated into IC strategies to meet domestic targets, for example through integration in cap and trade markets, this uncertainty will be transmitted into the IC's effort also. This will lead to highly uncertain marginal costs of mitigation and carbon prices. An extensive literature examines the tradeoffs between taxes and tradable permits within domestic systems, focusing particularly on differences in price and environmental risk, but less work has explored this with respect to links with developing countries. Fell et al. (2010) begin to address these issues.

Over time, the differences between mitigation instruments that focus on price (or on the emission reductions achieved for a given financial transfer) and those that focus on quantities (emission reductions relative to a baseline) and generate tradable credits are likely to diminish. This convergence will come about if greater stability in policy and better information on marginal abatement costs reduces uncertainty, and if the adoption of national baselines and binding targets by developing countries reduces additionality concerns. Under these circumstances, international trading with capped systems might become the preferred option, given its advantages for transparent negotiations, confidence in environmental outcomes, devolution of responsibility for international transfers to the private sector, and a price that can

[24] The revenue raised from a safety price could also be spent on DC mitigation.

respond to technology and new information. Currently, however, the differences between price- and quantity based instruments for funding DC mitigation are stark.

4. Broader Context, a "Straw Man" and Research Directions

4.1. A Policy Proposal

Reducing global greenhouse gas emissions to a level that avoids most of the risks of "dangerous" anthropogenic climate change requires mitigation in developing countries. Because developing countries are growing rapidly and making key capital and infrastructure investments, they have the ability to move to lower emissions paths at relatively low cost. Estimates of the potential from DC mitigation always, however, ignore the difficulty of creating arrangements that give DCs incentives to mitigate and ICs incentives to fund that mitigation. Developing countries benefit from a stable climate, want the best available technology – which sometimes but not always involves low emissions – and, as they move toward the living standards of industrialised countries, will feel increasing pressure to control their own emissions. Thus, they have a long-term stake in making good investment decisions and short-term emission reductions. Because of domestic capability and priorities, and arguments around equity and justice, their willingness and ability to provide the resources to make low-carbon choices is, however, limited.

Industrialised countries are likewise keen to see mitigation in developing countries. It can increase the feasibility and lower the total cost associated with achieving a given target, and can allow targets to be more ambitious. Often DC mitigation is thought of as an add-on to domestic IC policy; it would ideally be considered jointly. In addition, DC mitigation efforts will reduce international leakage, with resulting benefits for the effectiveness of IC efforts and reduced domestic political cost, and move toward a broad long-term effort.

Here is a straw man proposal. First, develop reliable inventories of emissions for all countries. Currently, only some countries provide these regularly. Credible information is essential for developing cooperation in a repeated game. Although inventories do not reflect "effort", which is what we really want to observe, they provide a solid basis for assessment of effort.

Second, divide developing countries into "strong" and "weak" countries. The distinction between strong and weak states is based on domestic capacity and mandate to take actions that effectively control climate emissions, and does not necessarily correlate to the share of mitigation for which a DC can afford to pay.[25]

Third, for strong countries, negotiate a combination of a target which involves some DC contribution to global mitigation (i.e. below the predicted business-as-usual path) and a package of investment in policy, support for technological innovation, capital and infrastructure to lower emissions. Returns on the investment would depend on the number of credits generated and their value. The investment would share, between the DC and the IC, the risk that the country will bear higher than anticipated costs from participating in the agreement and would reduce hold-up problems.[26] The DC would not only get the investment, but also would receive payments on the basis of monitored emissions below the negotiated target or baseline. The advantage of this arrangement is that the investment package enables the target or baseline to be set more stringently than would otherwise be feasible, because of the reduction in risk to the DC. It does not pretend to eliminate the problem of adverse selection (there is no way to know how much of the investment package would be been implemented anyway), but it makes the transfer explicit and uses it as political leverage to entice DCs into a more stringent agreement.

International offsets from DCs should not be made fungible with IC domestic cap-and-trade allowances until additionality issues are addressed and the uncertainty in supply diminishes. Given a relatively flat marginal benefit curve, the availability of low-cost mitigation opportunities in DCs should have a minimal impact on the efficient level of IC mitigation, and so it makes most sense to set the cap based on expected mitigation costs in ICs and insulate the IC cap-and-trade market from problems with offsets. Allowing offsets introduces considerable complications about how to adjust the cap to account for the expected offset supply, and such adjustments may be politically difficult.

The strong DCs and ICs who provide funding would engage in mutual capability building to improve the effectiveness of mitigation policies and increase, in particular, the gains from their joint agreement. This would not be aid, but an agreement among equals. It could be negotiated between a DC and either an individual or a group of ICs. Guaranteeing sufficient demand and providing enough investment to create a mutually beneficial agreement would be easy for a small country – for example some of the Pacific Island nations could potentially make an agreement with New Zealand alone. However, making an agreement with China would probably require contributions from a group of ICs.

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[25] Karsenty and Ongolo (2011) discuss the inappropriateness of using price incentives in "fragile" states.
[26] In the extreme there is a risk that emissions will rise above the target level and they will need to themselves bear liability. However, even if this does not occur, they may have invested in extra mitigation in response to the incentives and not recoup their cost.

Fourth, for "weaker" countries, which may not be able to generate enough mitigation to make the potential gains worth the risks involved in a formal national agreement, a less formal, more flexible approach could be taken. Within nations, regions or sectors, results-based agreements (RBAs) may be possible (as has been done for deforestation in the Amazon through an agreement with Norway). This assumes that emissions data can be credibly separated (e.g. forests or process emissions from aluminium or cement) and that sectoral baselines are more certain and involve less private information than national-all-sector baselines. Where RBAs explicitly based on emissions are too difficult, a package of investment in policy, capital and infrastructure might be offered alone, which could also help the country transition toward being able to participate as a "strong" country. The support provided by the IC should not be so generous as to deter movement toward taking a stronger target over time. Capability building and access to capital and technology also have a role.

Weaker countries would be de-linked from IC cap and trade markets. Severing the link between IC cap-and-trade and DC mitigation allows a wider variety of instruments to be pursued to pay for mitigation. A fund could purchase sectoral credits, be used to back RBAs that focus on policies or infrastructure choices, or pay for emission reductions that are estimated ex ante. Such a fund can be designed to mimic the results of a fungible system of tradable credits, or be used in a more flexible way, including the potential to price discriminate. It could facilitate a transition toward being treated as a "strong" country. Where the country is poor, the support for domestic investment and policies could include an element of development aid as long as the policy's effectiveness at achieving the two goals – climate mitigation and poverty alleviation – are clearly analysed.

Finally, where countries (industrialised or developing) are unable or unwilling to engage in a meaningful way, it is also possible to internalise climate externalities to a certain extent from outside. Border carbon adjustments are one prominent and contentious approach. Strategic direction of investment and loans toward low-carbon investments, and consumer- or retailer-based movements to reward countries that mitigate are others. These, however, are always imperfect substitutes to directly engaging the country.

Post-Kyoto and under the framework provided by the Durban Platform, a wide range of international institutional structures is possible and different structures may coexist. Options to mitigate in DCs must be robust to this. We recognise that DCs are heterogeneous and that more than one instrument will be effective; some will be substitutes and some complements. However, the proposal that we put forward here takes account of the key criteria that are important to any approach: minimise the impact of private information and risk through including as many sectors as possible; keep the distinction between payments for climate mitigation (trade) and development aid clear, even where both are simultaneously addressed; respect the sovereignty of DCs; and be watchful that current policies facilitate rather than impede progress toward full and efficient DC participation in global mitigation.

4.2. Research Directions

The challenges discussed in this paper are not new, and there is a large literature on problems of additionality in particular. However, research to date has tended to be somewhat piecemeal, in two ways. First, many contributions focus on one particular challenge, such as additionality, and fail to recognise how proposed solutions (such as discounting) may interact with other features of the instrument. Second, research has understandably tended to focus on the primary existing instrument, the CDM, and not considered the extent to which challenges are unique to tradable credits or the particular design of the CDM, or common across all types of mitigation instruments.

With this in mind, we propose five areas where we suggest research will be fruitful. First, further work is needed to identify the potential bargaining space for IC-DC cooperation, particularly as the Durban Platform sets the stage for DCs to assume formal mitigation obligations. For example, what levels of domestic contribution are different DCs willing and able to make over what time frames? What level of risk are ICs and different DCs willing to bear, and how can risk be allocated? More research on purely DC-motivated climate mitigation policies and their relative effectiveness would also be useful.

Second, given the volume of theoretical and empirical evidence about problems of leakage (spatial and intertemporal), adverse selection and moral hazard, projections of future offset supply and DC mitigation potential need to account for their impacts. Currently, evidence for the volume of emission reductions that can be secured in DCs at a given carbon price usually comes from computable general equilibrium (CGE), integrated assessment or bottom-up technology penetration models, which often deal with an idealised version of the CDM with no adverse selection and (usually) no leakage or transaction costs.[27]

Third, the broader point is for research to focus on how mitigation instruments have actually been implemented, rather than an idealised version of the instrument. For example, how have limits imposed to CDM credits (for example, under the EU ETS) affected the mitigation achieved by the CDM? To what extent have well-intended policies such as standardised baselines

[27] For example, Heindl and Voigt (2011) use a CGE model to estimate the supply of offsets from developing countries, through imposing a carbon price in developing country sectors and assuming that all reductions can be converted into tradable credits.

and "conservativeness factors" affected the amount of mitigation that is secured? How do the predicted emission reductions from the CDM and other instruments such as the Global Environment Facility compare against those secured in practice, and what factors – such as risk aversion and additionality – can account for any discrepancy?

Fourth, a considerable amount of recent work has considered the implications of uncertainty for the design of cap-and-trade markets, and proposed instruments such as a safety valve or price collar in response. However, there has been very little parallel work that has considered uncertainties in offset markets, and how these uncertainties affect the design of DC mitigation instruments. This type of work is particularly important as the efficient cap in an IC depends on the volume of tradable credits that may be allowed from DCs, assuming that the markets are linked.

Finally, there is a need for more analytical work on the design of both tradable credit programs and alternative instruments, including mechanisms that can price discriminate. We have shown in this paper how many of the challenges, such as leakage, additionality and moral hazard, are not unique to the CDM or tradable credits, but are also faced by instruments such as fund-based mechanisms. Moreover, the focus of both research and policy on tradable credits, and specifically the CDM, has led to a neglect of alternative designs – for example, paying for effort rather than results, focusing on the national scale rather than the project level, or direct investment in technology, capital and infrastructure. The new framework for DC engagement presented by the Durban Platform may provide an opportunity to identify the potential of alternative instruments, without the constraint (for some countries) of Kyoto compliance.

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