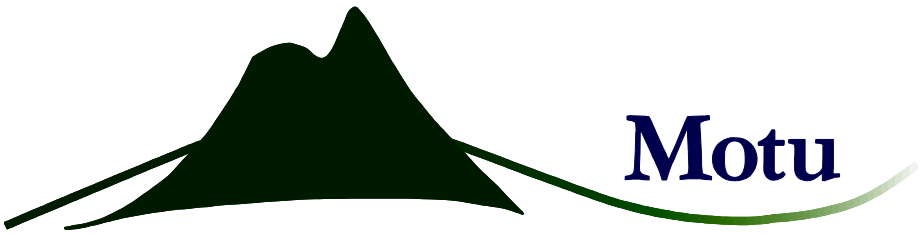

The Economics of International Policy Agreements to Reduce Emissions from Deforestation and Degradation

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Abstract
This paper provides a synthesis of the key conceptual insights from economics that can contribute to the design of effective, efficient, and fair international policy that creates incentives and strengthens capability to reduce deforestation and forest degradation and promote reforestation (REDD+ in United Nations terminology) as part of the international climate change mitigation effort. Most of the emphasis is on the contribution of economics to effective design of results-based policies that introduce a price incentive for strong states to address deforestation, degradation, and reforestation. The paper emphasizes the value of large-scale agreements to minimize leakage and adverse selection, the importance of allocating uncertainty with care, and the need to differentiate clearly among potentially conflicting objectives. It explores the conflicts between cost sharing and efficiency that arise because of private information and the inability of states to make long-term commitments. It also canvasses policies that complement price incentives, and, for weak states only, substitutes for results-based agreements.

JEL codes
Q54, Q58

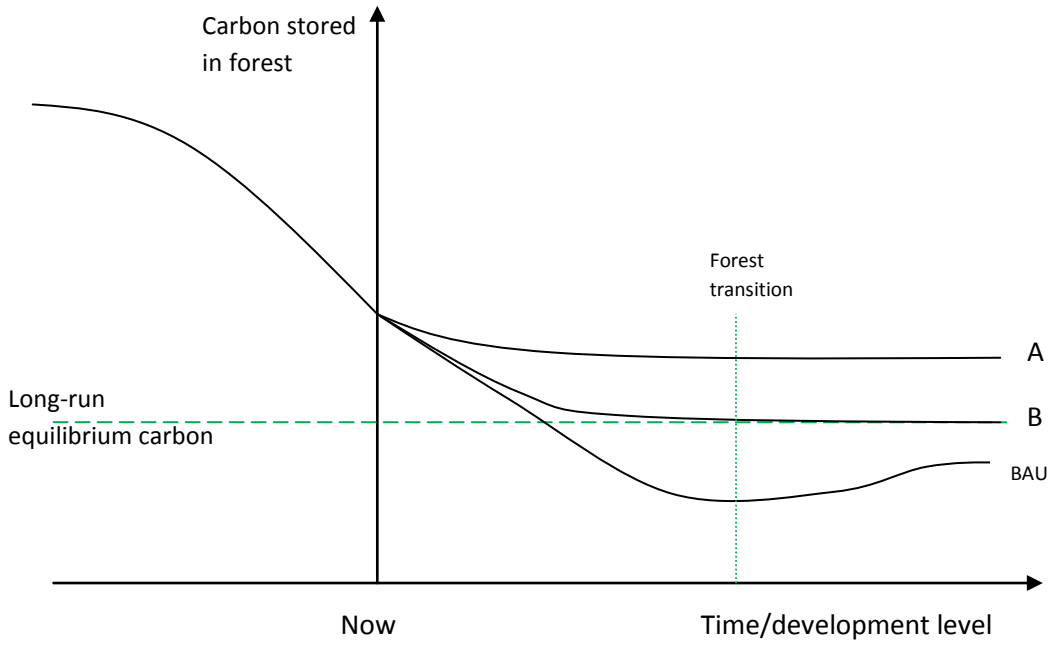
Keywords
Greenhouse gas emissions, climate change, deforestation, developing countries, REDD, reducing emissions from deforestation and degradation

INTRODUCTION

Deforestation accounts for 12–15 percent of global anthropogenic greenhouse gas emissions and is largely carried out in developing countries, particularly in the tropics (van der Werf et al. 2009; Pan et al. 2011). REDD refers to efforts within developing countries to mitigate climate change by Reducing greenhouse gas Emissions from Deforestation and forest Degradation, but also protecting and enhancing forest carbon stores and managing forests sustainably (sometimes referred to as REDD+). It was included in the text agreed by the Conference of the Parties in Cancun (2010) and expanded in Durban (2011). Some countries and states, for example Norway and California, are already developing REDD agreements with DCs to meet their own climate mitigation goals.

The basic idea is to reward those who control forests for not deforesting or degrading forest; estimate a reference level (or baseline) level of carbon in forest and pay for any carbon stored above this level. Figure shows three possible paths of carbon storage. BAU indicates continuing high levels of loss that overshoot the long-run equilibrium carbon level and lower carbon stocks even when forest increases (and recovers) again to the long-run equilibrium. Path B would provide international carbon protection payments only until the country reached a development level where the remaining forest was protected by domestic institutions. BAU and path B may lead to the same level of carbon in forests, but because the forest was never cleared or degraded in path B, it has higher levels of medium-term carbon storage. Path A attempts to protect more forest than the domestic government would choose alone, even in the long term.

Figure 1 Paths of carbon storage



A significant portion of the funds for REDD is assumed to come from developed countries. The exact form is still evolving and highly contentious and in the meantime, many different approaches are being tried ranging from local projects to an Amazon-wide initiative.

Many studies have suggested that reducing deforestation is a potential low-cost way to mitigate climate change significantly in the short term (e.g. Richards and Stokes 2004; Stern 2007); others are more skeptical (Blackman 2010). This paper considers one aspect of research to address the challenge of REDD: the design of international bi- or multi-lateral agreements. It provides a synthesis of the key conceptual insights from economics that can contribute to the design of effective, efficient, and fair international policy that creates incentives to reduce deforestation and forest degradation (REDD) and increase reforestation as part of the international climate change mitigation effort.[1] Like current efforts, it focuses largely on avoided deforestation though many arguments are also applicable to reforestation and avoided degradation. The paper focuses on relationships among countries, with an emphasis on the importance of uncertainty.

When considering international policy agreements, I divide developing countries into "strong" and "weak" states or subnational jurisdictions, and suggest a differentiated international approach to address REDD in each. I frame the issues at a more theoretical level than current policies processes within the United Nations and individual countries. The analysis in this paper can be applied to a multilateral agreement or a set of subglobal agreements that are loosely coordinated (Keohane and Raustiala 2009).

The distinction between strong and weak states is based on domestic capacity and mandate to take actions that effectively control deforestation and degradation.[2] A strong state is one with institutions that provide good access to local information needed to implement effective policy, and strong legal and other governance structures that enable policies to be enforced. Strong states will be able to respond strongly to a reward for not deforesting, so the reductions in emissions from the agreement will be relatively large. This will increase the total economic gain from the agreement, making it more likely that, despite two-sided private information about true gains, a way to share the expected gains and risks can be found so that both the buyer country (BC) funder and the developing country (DC) receiver benefit. For strong countries, the paper explores design options for results-based agreements.

[1] Several excellent reports summarize the key policy issues in REDD and REDD+ (which includes reforestation) design, e.g. Angelsen (2008), Angelsen et al. (2009) and Emmer et al. (2009).

[2] Karsenty and Ongolo 2011 discuss the inappropriateness of using price incentives in "fragile" states.

Some weak countries will be in transition to results based agreements while others will be unlikely to have the capacity to engage in them in the near future. In transitional states, some policies may focus on strengthening governance to facilitate this transition. [3]

The paper explores policies that could be used with both strong and weak states to either complement results-based policies or transition towards them, and follows with policies that would be used to support REDD only in weaker states. Many of the issues discussed here in an international context will also make policies within DCs difficult. A key difference is that a domestic government is less constrained in its policy choices. For example, it can pass and enforce laws that compel local actors to protect forest and can make strategic infrastructure choices.

The paper begins by defining results-based agreements and framing them within a principal agent framework. It then explores compliance issues, covering monitoring, rewards and sanctions; and then within the constraints of these, explores the specific definition of obligations, covering 'permanence', baseline, scope, scale and leakage. It then considers how results-based agreements can be complemented by other policies and what can be done in weak states to substitute for the clear national-level signals that a results-based agreement can bring while facilitating a longer term transition to more efficient policy. Finally it concludes.

RESULTS-BASED AGREEMENTS FOR DEVELOPING COUNTRIES WITH STRONG INSTITUTIONS

By "results-based" agreements, I refer to agreements whereby a BC (or delegated public or private actors) agrees to pay a DC jurisdiction per unit of monitored carbon stock relative to an agreed baseline or reference level. Conceptually this is very similar to how land use, land-use change, and forestry are dealt with in Annex 1 countries under Articles 3.3 and 3.4 of the Kyoto Protocol. The "reference level" in the Annex 1 case is not a business-as-usual forecast but is based on land use in 1990, a definition of forest, and measurement protocols. Countries can claim credit for sequestration above this, and are liable for net losses relative to it.

In DCs, the two closest existing examples of results-based agreements both involve Norway. In 2010, Guyana and Norway established an agreement whereby payments are based on performance in limiting greenhouse gas emissions and also on progress on governance

[3] This loosely mirrors the approach proposed by Angelsen et al. (2009), where countries graduate through three phases as their institutions develop. Their third phase is my "strong" countries. Countries that are in transition toward being strong would be in phases one and two. I am considering a wider group of policies than REDD as envisaged by the UN. Some of my "weak" states are countries that I do not anticipate evolving through the stages any time soon and that require quite different approaches in the short to medium term. The policy approaches to transitional and longer-term weak states would be the same in some ways but also have some critical differences.

indicators. The first payment based on externally verified performance has recently been made. Nepstad et al. (2009) suggest that Brazil has been motivated by the international climate mitigation effort to set targets to control deforestation in the Amazon and that these will be strengthened by Norway's offer of U.S.$1 billion in funding, conditional on continued success. Brazil's recent successful control has largely relied on command and control approaches, which may not be sustainable in the face of economic incentives to deforest. Soares-Filho et al. (2010) find that 44 percent of the recent decline in deforestation is due to market forces, 37 percent due to the establishment of protected areas, and 18 percent due to other factors, including better enforcement of restrictions against illegal logging. However, the forest code has recently come under attack and anticipation of a change in the law may be driving an upswing in deforestation (though it is still likely that Brazil will meet its targets).

To reduce deforestation and degradation effectively, agreements need to pass global incentives on to those who control forests.[4] A perfectly efficient results-based agreement would be a fully enforced agreement that will never be renegotiated, with baselines and payments that vary only with factors outside of human control, and where the set of agreements covers the globe. Because this is not possible, at least in the medium term, any real policy will involve compromise.

Framing agreement design within a principal-agent model

A principal-agent framework provides a formal conceptual approach to results-based agreement design. I briefly outline the issues as presented in this framework and discuss some existing models that use this approach. Because of the complexity of the issues, no existing theoretical model provides a complete analysis, so later sections explore the key issues in a more policy-oriented structure: compliance, permanence, baselines—reference levels, and scope, scale, and leakage.

The principal designs an agreement to maximize its expected utility subject to a participation constraint (the agent's expected utility must exceed its reservation utility) and an incentive compatibility constraint (the agent must choose to comply *ex post*). Either the BC or the DC could be the principal: the total net gains and the minimum utility to induce participation by each define the bargaining space. The BC's utility comes from the additional climate mitigation benefit (valued within their coalition), net of the cost to it of the agreement. The DC's utility is the value of the payments it receives plus its valuation of the extra climate mitigation benefit

[4] These "agreements" could be deals among countries in the context of bilateral or multilateral agreements, or they could be legally binding contracts.

created by the agreement, net of the cost of mitigation. Private information about effort and about marginal costs and benefits creates moral hazard and adverse selection and negotiation problems, respectively, and the inability of both states to commit creates inefficiency.

Perfect internalization of the carbon benefits to DCs from forests would involve marginal rewards for observed forest (carbon), relative to a baseline, paid at the marginal cost of climate mitigation in the BC (or the current carbon price). It also requires a long-term complete contract (i.e. a contract that specifies each party's rights and duties for every possible future state of the world) so that future options are valued appropriately and investments are efficient.

The risks this would entail make the agreement less attractive to DCs and requires a more generous baseline to induce them to participate.[5] Where risks are outside the control of the DC (e.g. international commodity prices, international carbon prices, large-scale fires, or pest invasions), and if the DC is more risk-averse than the BC, it may be efficient for the BC to bear these risks. Changes in forest emissions in response to exogenous factors could, in theory, be excluded from the definition of observed effort that will be rewarded.

The DC has private information about its true baseline; this creates an adverse selection problem, which leads to nonadditionality (payments for protecting forest that was not at risk). The baseline errors that result can be minimized through research and through increasing scale (van Benthem and Kerr 2011). They could also be reduced through mechanisms that induce revelation of private information.

Kerr (1995) and, more recently, Mason and Plantinga (2011) show how offering a series of contracts can implement a separating equilibrium for forest sequestration.[6] Effectively, those who accept more stringent baselines (higher transfers back to the funder) are rewarded with a higher price for the protection they achieve relative to that. For the U.S., Mason and Plantinga simulate reductions in cost to funders of 70–80 percent with only small efficiency losses (an order of magnitude lower). This is an empirical result that occurs in this specific application because those with higher levels of baseline sequestration also have very low costs of additional sequestration so benefit disproportionately from the higher price offered in exchange for a more stringent baseline. This correlation combined with considerable heterogeneity in marginal costs makes it relatively easy to vary baselines and reduce cost considerably. It may not be generalisable. This solution requires knowledge of distributions of marginal cost of forestation

[5] DC participation must also be induced in future years as uncertainty is revealed, because DCs can opt out at any point. "No-loss baselines," where there are no liabilities if countries fall below their baseline level of forest, aim to avoid complete opt-out if baseline realizations are negative.

[6] Kerr (1995) shows how offering a set of contracts can induce DCs to reveal their perception of risk about the amount of abatement they could achieve. This could be relevant to reducing the price risk created by introducing REDD in a cap and trade system, and avoiding costly negotiations for agreements that may yield little benefit.

by observed characteristics (e.g. state and land-quality class), and depends on an empirical relationship between the marginal cost slope and the baseline forest level. It also assumes that it is politically feasible to offer different contracts to different countries and that the contract set is offered only once. These conditions may not hold internationally.

Montero (2008) proposes an elegant implementation of a Vickrey-Clark-Groves mechanism that offers a set of rebates that make truthful revelation a dominant strategy. However, prices are determined only through the tender process, whereas REDD will be influenced by the international carbon markets/price, and it is a one-shot game that is unrealistic internationally. Hellerstein et al. (2011) propose yet another promising approach by using competition for quota within the tender process, but again this is probably better suited to domestic policy.

States find it difficult to make binding long-term commitments, and in any case an agreement is likely to be an incomplete contract. Because efficient protection and enhancement of forests involves long-term specific investments, problems of agreement enforcement, hold-up, and inefficient underinvestment will occur. Harstad (2011) models conservation as a hostage and predicts that there will be difficulties in reaching agreements, leading to inefficiently low levels of protection. He argues that international agreements will be in the form of rental agreements while the price of carbon is low, there is strong pressure to deforest, and enforcement in DCs is difficult for the BC. If the agreement does require permanent protection or ongoing funding, problems of DC incentive compatibility must also be addressed. MacKenzie et al. (2010) model a situation with both moral hazard and the need to enforce sequestration.

The ability to negotiate an agreement will depend, among other things, on the total potential gains from trade, taking into account the level of risk and ability to manage it, and the remaining private information about the DC's baseline and mitigation cost and the BC's willingness to pay.

If through research and negotiations we are unable to develop credible baselines so that BCs believe they are largely paying for additional protection, funding REDD will be less attractive to them, and agreement may not be reached, particularly if BCs also have private information about their willingness to contribute (Myerson and Satterthwaite 1983). Prices (rewards) may need to be discounted below the carbon market price (marginal benefit) to induce BCs to participate, possibly through trading ratios that require more than one REDD unit to offset one unit of emissions. This has a cost in terms of efficiency. Each of these theoretical issues is reflected in a practical policy debate relating to REDD, which I discuss under the broad

headings of compliance (covering monitoring and rewards and sanctions) and definition of obligations (covering permanence, baselines, and scope, scale, and leakage).

Compliance

Because REDD entails costs, in terms of funds transferred from BCs, and loss of economic opportunities, costs of forest management, and direct administrative costs in DCs, both parties have incentives to avoid cost by not complying. Both the BC and the DC could choose not to comply if rewards and penalties of negotiated REDD agreements are weak. The DC may not provide the promised protection if it is paid in advance; the BC may not sustain payments or may unilaterally require a renegotiation of the baseline after the DC has begun to change its behavior. Anticipation of DC noncompliance makes BCs unwilling to make agreements, while anticipation that BCs will sustain payments for only a short period deters investment in DCs and induces strategic behavior in anticipation of renegotiation of the agreement.

Monitoring

Advances in remote sensing have made monitoring of forest cover reasonably accurate, low cost, and timely in most areas. The technology does require initial ground-truthing so still has a considerable set-up cost. Several projects are now automating satellite interpretation, which will allow rapid replicable forest-cover data. For example, Google, in collaboration with Stanford University, are working to make enormous quantities of satellite images available for real-time interpretation (Regalado 2010). These data may not be accurate enough for regulation of small properties, because the errors may be large, which would impose unfair risk of perceived noncompliance on landowners. At a regional scale, however, the law of large numbers will tend to reduce variance, resulting in sufficient accuracy. For international agreements, a critical feature is that the technology can now be automated and replicated in both buyer and seller countries, so monitoring is transparent and incorruptible. Reforestation can be observed by satellite but only with a lag.

Increasingly, forest degradation, and even (to a lesser extent) carbon, can be sensed remotely. This requires LiDAR from airplanes, or RADAR, and must be ground-truthed, so is costly. It is most likely to be feasible for large regions with high levels of threat, where the cost relative to potential gain per hectare falls dramatically. However, estimating changes in forest carbon stocks still mainly relies on converting forest cover changes to carbon values using carbon tables (derived from fieldwork supplemented with LiDAR) for different ecological conditions that can be identified with Geographic Information System data. The quality of the

estimates depends on the underlying data and on the extent to which this measurement method induces bias. If the threat to forest is positively correlated with the unobservable errors in carbon measurement, incentives will be poorly targeted and will protect lower-than-average carbon stocks. Kerr et al. (2004) modelled this effect in Costa Rica and found that it was small.

The ability to monitor without bias and potential for manipulation should fundamentally drive the scope of agreement in different places. Deforestation and reforestation are easiest to measure so can be included everywhere. If degradation cannot be monitored or if there appear to be risks that countries have incentives to protect lower-than-average-carbon forest, discounting the value of carbon to account for the uncertainty in measurement could be appropriate in order to encourage improved monitoring. If the bias is not sensitive to the strength of the incentive, discounting will also reduce the potential to overreward forest protection. Practical analysis of monitoring in relation to United Nations processes is given succinctly in Emmer et al. (2009) and, in more depth, in chapter 4 of Angelsen et al. (2009).

Rewards and sanctions

Forest mitigation rewards can come in three forms: domestic benefits that will be recognized by a stable government, such as more efficient use of forest resources (both timber and non-timber forest products), preservation of livelihoods and cultures, improved water quality, flood prevention, local biodiversity protection, improved air quality, and protection of aesthetic values for local or tourism benefits; payments on the basis of net forest emissions reduced (relative to a baseline); and the less tangible benefits of international affirmation—increased external cooperation, trade access, and stronger national pride. The most effective programs will combine all three.

If domestic benefits alone justify protection and if the government represents the interests of its people, the government's incentives are already aligned with social benefits and the country should require assistance only with access to capability, knowledge, risk sharing and capital. Once policies in response to these benefits are established, domestic pressures should sustain them. In many countries, however, this will not be sufficient to protect large areas of forest; this is where payments and international pressure are key.

The key risks for a DC from responding to payments are first, that the BCs will not follow through on payments after the DC gives up future development options, and, second, that current protection will weaken the DC's bargaining position when it negotiates for forest protection support in the future. These add to the risks associated with accepting a baseline. With the acute uncertainties that surround international climate cooperation, it is understandable

that DCs will be concerned that investments that depend on long-term payments are worthwhile. If payments are not all given at the time of the agreement, and the international agreement or domestic regulation that motivated the industrialized party (country or private entity) comes to an end, the DC may be left with a partly irreversible investment—a different pattern of land use than it would otherwise have chosen. For example, it may have redirected roads, redirected available capital toward other sectors, or established parks that are hard to disestablish.

The second risk is sometimes expressed as a concern that BCs will claim all the "low-hanging fruit," with the implied disadvantage to the DC when it later faces reduction targets of its own. DCs may also fear regret if they make a commitment at a fixed price now when future prices may be much higher. This may lead to a preference for temporary rather than permanent forest commitments.

The sanctions that can be applied at an international level if a DC is paid to protect its forest and then fails, or conversely if an BC promises to provide resources for climate mitigation in DCs and then does not follow through, are limited even for highly developed countries. Even when agreements are expressed as private contracts, countries sometimes default on loans or expropriate resources. In theory, trade cooperation can be used as a carrot and stick, but in reality trade negotiations are complex and it is hard to link them explicitly to noncompliance.

Definition of obligations

Given the challenge of risky rewards and weak potential penalties, defining what the contracting parties are committing to when they engage in REDD is critical because it affects the costs of compliance and the risk of noncompliance. These factors must be matched to the available sanctions to achieve an acceptable level of compliance.

A REDD agreement has (at least) three dimensions: time (permanence); baseline (reference level); and scope (deforestation, degradation, and reforestation) and scale (the area covered—potentially accounting for leakage outside). Each is addressed here in turn.

Permanence

Reductions in emissions achieved by protecting forest carbon stocks can be reversed easily either through deliberate clearing or unintentional loss through fire, wind-throw, or extreme events such as war (e.g. Chomitz 1998; Marland et al. 2001; Gumpenberger et al. 2010). When additional storage of carbon in a forest is compared to a reduction in emissions from fossil fuels, it is important to consider whether the storage, and the reduction, will have an equivalent effect on the atmosphere in the long term; is it equivalently *permanent*? The problem of unintentional

clearing is a standard question of risk management and can be thought of in an insurance framework where, after precaution has been taken, the net value of storage is reduced by the actuarially correct premium, assuming an insurer exists to cover unintentional losses.[7] If the government faces considerable risk from natural causes and is unable to self-insure, access international insurance markets at fair costs, or otherwise diversify the risk, there may be a role for a complementary insurance policy. Deliberate clearing, either authorized by a domestic government or by private domestic actors outside of the government's control, requires careful agreement design that balances restrictions on what will be required under the agreement and the liability that will be applied for noncompliance.[8]

Protecting a store of carbon in forest is analogous to protecting the store of fossil fuels.[9] Reduced coal use in one period leaves more carbon stored, but this can be reversed in a later period if coal use rises above what it would have been without the temporary reduction. This could happen if coal prices fall because the stock of high-quality, easily extracted coal is higher than it would have been. A temporary reduction in coal use could have value in terms of delaying emissions but will be 100 percent effective in reducing long-term concentrations only if it is part of a long-term commitment to reduce emissions (equivalent to accepting a liability for future reversal of forest emissions reductions), or if it leads to an irreversible technology, capital, and infrastructure switch away from fossil fuel. The only difference in permanence between protecting fossil fuel and forest stock is the potential speed of reversal if efforts to protect stocks stop.[10] This is an empirical question. The key practical difference between forests and fossil fuel reserves is that current international agreements reward reductions in flows of fossil fuels at the point of consumption, while avoiding the flow of emissions from deforestation or degradation requires direct protection of the stock in the country where it is found.

Where protecting carbon is not in the self-interest of the country in which the forest is located, but valuable only in response to international rewards, a prudent government will be more reluctant to make long-term commitments to land use (either contractual or through

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[7] It is already possible to buy private insurance against loss of carbon credits.

[8] Shavell (1984) explores ways to combine safety regulation (equivalent in our case to reducing the risks of noncompliance created in a forest-protection contract) with liability for accidents (clearing after permanent or long-term protection payments are received) when liability is limited.

[9] The Yasuní project in Ecuador is a vivid example of this. The Ecuadorean government is offering to refrain from opening up a new oil field if other countries agree to compensate it for its loss.

[10] Nonpermanence can also be thought of as "leakage" through time. A reduction in emissions now causes greater pressure at a later time (instead of in another place), leading to increased emissions that at least partly offset the initial reduction. In the case of fossil fuels, this is because higher remaining stocks will lower prices. In the case of forests, temporary protection will mean that attractive land will still be available for clearing in future, thus potentially leading to higher deforestation at a later time. Protection of fossil fuel stocks may face higher leakage because they are traded in a more highly integrated international market than the food and timber markets associated with deforestation.

irreversible actions) as these may turn out to be against its long-term interests.[11] This argues for agreements that commit DCs to only temporary protection of carbon in forest, even if the funders might hope that this protection will have long-term effects.

The risks to DCs from long-term commitments, the weakness of penalties, and the potential for rapid reversal of gains suggest that careful agreement design is critical to making REDD agreements work. Agreements can be structured in two fundamentally different ways: as a temporary payment for storage; or as a permanent commitment to store carbon that imposes liability if the carbon is released.

Temporary "rental" units (t-CERs and l-CERs) for reforestation have been created within the Clean Development Mechanism of the Kyoto Protocol. While these units temporarily fulfill obligations, they have to be replaced with a permanent unit (or a sequence of temporary units) at a later date. These units are not accepted in the context of compliance markets (in particular, the E.U. and New Zealand emission trading systems) and will continue to have limited acceptability without a long-term futures market (or debt market) for carbon, because if a government accepted them—within an emissions trading system, for example—it would have to regulate transfer of the liability when they expire.[12]

If either party agrees, and can credibly commit, to accept the liability, a system that provides credit when emissions are reduced as though they are permanent reductions but imposes liability if they are later increased is the most flexible. Thus, if strong penalties for DCs are possible, policy can be highly efficient. Private agreements can translate this credit/liability agreement into temporary or "rental" contracts where desired (e.g. Esuola and Weersink 2005; Coleman 2011). The difficulty is that the liabilities accrued by DCs would rapidly become large and compliance could be noncredible. With weak sanctions on DCs, either a permanent agreement that also cedes long-term control over land use or a temporary one that avoids liability may be the only possibilities.

Two contrasting examples make this clear. New Zealand, within Kyoto rules, has created a system with credits for sequestration which are fungible with Assigned Amount Units, and liability for removals (Karpas and Kerr 2011). Under Kyoto rules, these units can be used for compliance in any Kyoto country. This is possible within New Zealand because New Zealand law is strong and liabilities occur at harvest, when the forest owner has considerable cash. International sales of credits for which New Zealand accepts liability are relatively credible

[11] Harstad (2011) suggests that temporary rental contracts will be easier to negotiate efficiently because they avoid strategic behavior with regard to long-term outcomes.

[12] If, for example, there were a futures market, the government could accept a current t-CER and a matching carbon credit futures contract for the delivery of a permanent unit valid in the year the CER expires. This would, however, still expose the government to the risk that the futures contract is not honored.

because New Zealand, as a small country dependent on international cooperation and with a long history of stable democracy, has the ability and strong incentives to uphold its international commitments. Many of the poorer DCs, in contrast, have less consistency in national government and hence cannot be held externally liable. This means that any agreement between countries would most likely assume temporary protection.

Limited sanctions on DCs, the value of retaining options, and a desire by the DC to benefit from upside price risk argue for rental agreements; avoiding downside price risk and limited sanctions on BCs, which mean the BC may not continue payments once partly irreversible efforts to control deforestation are underway, argues for permanent protection agreements that protect DC interests. In cases where control of deforestation is largely irreversible (for example Path B in Figure 1), the risk of DC default is lower so the balance shifts away from rental agreements.

An agreement would optimally provide a marginal incentive that reflects the global value of carbon, net of local value. The size of the optimal incentive would vary depending on who retains the future options and on how risk is shared (these push prices in opposite directions). A permanent agreement, especially one that does not explicitly allow for reversal by paying back previous credits, takes options away from the DC, so it will require a higher price (in net present value terms). However, it also removes the uncertainty about future carbon prices, whether baselines will be renegotiated, and whether payments will, in fact, continue in the future, which allows a lower price.

Baselines—reference levels

The simplest way to apply an efficient incentive to protect carbon stocks on the margin is to subsidize all forest carbon. When most forest is not under threat in any given year, however, this is extremely expensive for the BC. Thus, all proposals suggest assessing protection efforts by comparing observed carbon to a baseline level of carbon—countries are rewarded for "avoided" deforestation.[13] If the baseline were an accurate estimate of the counterfactual—the level of carbon that would have been stored in a business-as-usual case—all carbon would be additional. In reality, baselines are negotiated and may simply be an historical benchmark: they may bear only a loose relationship with a counterfactual.

The business-as-usual, counterfactual level of deforestation depends on the relative economic returns of forested and deforested land (driven by international prices, the quality of timber and of land under remaining forest, and accessibility), local cultural values for forest, and

[13] I use the term baseline to be synonymous with reference level or compensation baseline. It is intended to be applicable in either a market or non-market context for agreements.

the local institutions that affect land use. Recent deforestation rates may be good short-term predictors but are unlikely to continue in the long term. A low recent deforestation rate may be driven by poor accessibility, which may alter with a new road or with peace after a period of conflict, or a lack of institutions, which hinders rural development; a high recent deforestation rate may not continue when high-quality forest and high-quality agricultural land is all cleared. Pfaff (2003) and Kerr et al. (2004) use spatial data collected since the 1960s in Costa Rica to separate the causes of deforestation into economic pressures and developmental level, and suggest that deforestation rates fall close to zero when good-quality land has been cleared so that further deforestation is not economic. However, the precise timing of that transition, and the extent to which a country may temporarily overshoot the long-term level of forest, is very hard to predict (Angelsen and Rudel 2011). It may be easier to predict the long-term equilibrium level of forest, limited by legal and biophysical limitations on use, than short-term deforestation rates (Terrestrial Carbon Group 2008).

Short-term deforestation rates will depend on relevant commodity prices, local economic conditions, short-term political commitment to conservation, and many other factors. The baseline could be made a function of factors that are exogenous but it would be hard to agree on a formula.[14] If baselines were made a function of commodity prices, one implication would be that effective REDD policy will itself affect commodity prices and hence reduce baseline forest levels. While this would move baselines away from a no-REDD business-as-usual status, it would reduce the risk of DCs finding that the agreement they initially entered into is no longer in their interests over time.

Various baseline approaches have been proposed.[15] These have focused almost exclusively on baselines for deforestation. The approach chosen has implications for strategic behavior, participation and, hence, efficiency, and the distribution of costs and benefits from REDD. One critical lesson that economists have always stressed, and that policymakers have struggled with, is that any perception that baselines (or, equivalently, permit allocations) will depend on levels of forest or recent deforestation at the time of regulation leads to a perverse rise in deforestation in anticipation of regulation in order to gain a favorable baseline.[16] In the case of DCs and REDD, this would have particularly perverse effects because deforestation has large carbon effects and is almost irreversible, and the period of uncertainty before all countries enter a REDD agreement

[14] This was proposed and modelled for Costa Rica in Pfaff (2003). It provides a form of insurance for the DC, for which it would pay with a more stringent average baseline (its premium).

[15] Busch et al. (2009) explore the effects of several proposed baseline approaches in a one-period model.

[16] This has been visible in the case of the New Zealand Emissions Trading Scheme, where deforestation rates spiked in 2007 in anticipation of a liability for deforestation of pre-1990 forests from 1 January 2008 (Karpas and Kerr 2011).

may be long. This argues for clear communication that baselines will, as far as possible, be based on forest data at an historical date. This can be facilitated through the effort to create high-quality datasets on the state of forests now. To the extent that baselines need to be updated to make agreements possible, those countries with lower-than-expected deforestation between now and when agreements are finalized should expect to receive more generous baselines. Once established, baselines should never be renegotiated except to account for events that are truly outside of the state's control.

Because participation in REDD will be voluntary (for both sides), baselines will have an efficiency impact—DCs will participate and face an incentive to protect forest only if they expect to gain. DCs that do not participate will not only lack efficient incentives to protect forest, but may deforest more as a result of leakage, leading to a double loss of efficiency.

Setting a baseline in a REDD agreement implicitly defines a new property right, because payments can be claimed relative to the baseline. Baselines could have significant implications for wealth distribution both between BCs and DCs, and among DCs.[17] Once agreements are created, the scale of wealth effects depends on the generosity of baselines and on how long REDD payments are expected to persist. REDD payments could be temporary for two reasons: as a bridge toward DCs deciding to protect their own forests for domestic reasons or as their contribution to the global climate mitigation effort; or as a bridge until technologies and policies develop and capital and infrastructure are replaced, such that fossil fuel mitigation costs fall.

Because of the high stakes, baselines are likely to be the key driver of transaction costs, expressed here primarily as delay in reaching an agreement. This makes them a critical efficiency issue as well as a distributional issue.

Scope, scale, and leakage

The potential scope (deforestation, degradation, and reforestation) of the agreement with each country largely depends on the ability to create an acceptable baseline and to monitor. The wider the scope, the greater the efficiency and the less leakage will occur.

There are more options for scale. It is possible to create an agreement with any legal entity: individual, private legal persons, community (if legally constituted), region, or nation. Sovereignty and local control increase with scale because local groups can decide where, how, and how much to respond. Payments for ecosystem services programs have generally dealt with small-scale

[17] Cattaneo et al. (2010) use a one-period model to explore the equity implications of various baseline approaches and suggest that, if equity is "evaluated as the financial incentive relative to the opportunity costs of participating in REDD," then compensating emission reductions (short term) and also providing some compensation for existing carbon stocks (which may be at risk in the long term) is most equitable.

actors (Pattanayak et al. 2010) but that is not necessarily appropriate here (Plantinga and Richards 2008). Bias in measurement, adverse selection, which systematically leads to inefficiency and rewards for inframarginal (nonadditional) protection, and leakage generally go down with scale. At low carbon prices, landowner-scale projects will be extremely vulnerable to adverse selection. This is likely why Sanchez-Azofeifa et al. (2007) find no identifiable effect from the Costa Rican Payments for Ecosystem Services program before 2000 and Robalino et al. (2008) find little effect after 2000. The challenges of nonadditionality are confirmed by case study evidence from the Clean Development Mechanism (Millard-Ball and Ortolano 2010; Morse and He 2010).[18] Van Benthem and Kerr (2011) show how the law of large numbers reduces the role of private information in creating errors in estimates of BAU, and hence adverse selection leading to inefficiency and rewards for nonadditional protection.[19] The value of a national-scale accounting framework has been recognized by the UNFCCC Conference of the Parties in Cancún, but in the interim many project-based activities continue to develop and many authors do not appear to understand the severity of the private information problem with small-scale projects.

These presumed benefits of scale for reducing private information about BAU depend, however, on whether international actors can as easily or more easily deal with larger-scale entities and whether the larger-scale entity can pass down incentives as well as, or better than, an international actor. It assumes that regions that would be aggregated in a larger project do not have significantly different levels of private information; if they did, combining them would make adverse selection worse relative to the international actor dealing only with regions with little private information.

Once the scope and scale and the approach to permanence have been chosen, some leakage will remain both within and outside the country.[20] What other policies could address it and are they worthwhile?[21] The most obvious policy is to increase spatial and temporal coverage of results-based REDD agreements. This is the same as in any other sector. It can be achieved by more generous agreements—e.g. generous baselines and higher credit prices—but comes at a cost.

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[18] This is also consistent with evidence from domestic programs such as the U.S. Acid Rain Program (Montero 1999).

[19] Private information here refers to information that landowners have about their probability of clearing that regulators cannot observe (or cannot use).

[20] Murray (2008) discusses leakage in detail in the context of avoided deforestation. Gan and McCarl (2007) using a CGE model find leakage as high as 42-95% in the forest products industry. Rose and Sohngen (2011) estimate leakage from deforestation to degradation. 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, and that this may have risen to 52 percent in the five years to 2010.

[21] Wunder (2008) presents the issues and discusses possible solutions.

If the agreement is on a large scale, the key leakage concern is international. Any policy that reduces demand for timber or land-intensive agricultural products, or raises the productivity of land used for timber or agriculture anywhere in the world, will tend to reduce leakage pressure on natural forests at risk of deforestation and degradation. In contrast, for commercial forests, raising demand for timber will encourage reforestation. Packaging REDD payments with support for local productivity improvements and policies that reduce local demand for timber and land-intensive agriculture could be useful.

A complementary approach would be to estimate leakage directly and adjust the price paid—discounting credits—according to monitored levels of leakage. It is extremely hard, however, to estimate leakage reliably, even without incentives to distort the data that would be used in making such estimates, so it is unlikely that doing this formally within an international system is possible or effective.

A mechanism that is increasingly being used within emissions trading systems to address leakage is output-based free allocation of units (Fischer and Fox 2007). The aim is to reduce the incentive to cut output in order to reduce emissions, and to focus on reductions in emission intensity that are not subject to leakage and will tend to lead to irreversible technological and management advances, and hence are unlikely to be reversed over time. In REDD, the equivalent approach would be to make payments based on a combination of forest levels and agricultural and timber consumption, net of production. There is, however, no international reward for avoiding leakage in the Kyoto Protocol and nor is it foreseen in REDD decisions adopted at COP16.

The expected level of leakage should be taken into account when considering the value of entering a REDD agreement. The best solution, however, is to create attractive agreements so that most DCs choose to participate.

INTERNATIONAL EFFORTS THAT COMPLEMENT OR SUBSTITUTE FOR RESULTS-BASED AGREEMENTS

Results based agreements are only one of several possible international policies. Here I briefly outline others that can complement them or act as substitutes.

Complementary Policies

Complementary policies could be used for any country but will be most effective in the presence of the country-level price signal provided by an results-based agreement. The basic justifications

for these policies are: weak policy infrastructure; and poorly functioning markets, other than the market for climate externalities.

Recent efforts have focused heavily on building the monitoring infrastructure, policy institutions and local capability critical to creating effective results-based agreements. These concentrate on building a credible regional- or national-scale carbon-monitoring system and predicting credible reference levels as a basis for negotiation over baselines. Building monitoring capability, developing effective domestic policies, and developing the legal and governance institutions required to implement them—e.g. effective forest management institutions, land tenure reform, and land titling—may all benefit from some external human capability and efforts to develop local capability. These skills may be provided most effectively by ICs if DCs find it difficult to access them.

There is a shortage of high-quality evaluation of policies to address deforestation; these are critical to avoiding misdirection of limited resources (Pfaff et al. 2011). Much of the evaluation effort to date relates to assessment of process and attempts to measure the carbon impact of individual projects (Wertz-Kanounnikoff and Kongphan-apirak 2009). These measurements do not, however, constitute formal statistical evaluations of effectiveness.[22]

From here on, I will focus on the rationale of poorly functioning markets and, for explicitness, will assume that the DC in question also has, or will soon have, an RBA. Assistance to address the rationale of poorly functioning markets should clearly differentiate between poverty alleviation and climate mitigation objectives even where both are pursued in one policy to avoid poor antipoverty policy combined with ineffective climate mitigation efforts. Where complementary policies bring resources to reduce deforestation, these could lead to reductions in the generosity of a later results-based agreement (through, for example, adjustments to the baseline) or, more transparently, the BC could have the right to some future credits once the agreement is established. This would ensure that the DC accepts assistance only if it believes it will lead to effective mitigation.

Both parties should try to avoid strategic behavior within the DC that slows the transition to a more efficient relationship and even leads to perverse behaviour. In particular, the policy should not be so generous that it is more attractive than an RBA to specific interests within the country or to the country as a whole; if baselines are not yet set, current actions should not be allowed to affect them, as this could either deter action to avoid deforestation or even encourage high deforestation rates to justify a more generous baseline ('baseline grabbing'). Interactions between DCs and BC relating to complementary policies will reveal information about local

[22] Where *ex-post* evaluation of the carbon impacts has been carried out, such projects have often been found to be ineffective (Pfaff et al. 2008).

costs of control and local preferences. This will make it easier to reach a mutually beneficial results-based agreement but could also slant bargaining power away from the DC.

Ensuring flow of financial, human, and knowledge capital, and addressing missing risk markets

Kanowski et al. (2011) argue that most DCs have strong formal forest management requirements but may need help to implement them. Four key markets – financial, human capital, knowledge and risk (including food security and risk associated with the results-based agreement) - could operate poorly; each leads to potential complementary policies. Where the problem is access to financial capital for forest protection projects, BCs could provide resources to buy out concessions, establish national parks, fund ecosystem service payments programs, or pay the incremental cost of a redirected road that lowers deforestation risk (Pfaff et al. 2011).

A debt-for-nature swap is one mechanism to provide capital.[23] A creditor government, or a conservation organization that has purchased debt on the secondary market (at low cost because of perceived risk), and renegotiates the terms with the debtor government(relieving them of the pressure to service the debt, possibly by exploiting natural resources) in exchange for a conservation agreement.[24] Criticisms of such schemes are that the value to the debtor of the debt reduction is smaller than claimed, particularly given that creditors did not expect this difference to be repaid, and that the funds are not always used effectively.

Anti-leakage policies could complement results-based agreements by either increasing food (Angelsen, 2010) and timber supply (Meyfroidt and Lambin, 2009) within the country with the agreement or reducing domestic or external demand for them. If a critical anti-deforestation and anti-leakage policy is improved agricultural productivity, agricultural extension support provided by ICs might be valuable. Similarly, knowledge capital such as new crop varieties or animal breeds, agricultural technologies, or pest- and drought-resistant forest species may not be directly accessible to some DCs because of intellectual property protection. In these cases BC governments may be able to facilitate access. Private sector "roundtables," such as the Roundtable on Sustainable Palm Oil, can also transmit knowledge. They could also attempt to prevent the movement of timber extraction capital to more vulnerable countries.

[23] Sheikh (2010) estimates these have generated over US140m but Cassimon et al. (2009) says their use has been declining since the mid 1990s. A recent example was the Italian contribution to the Yasuní project (McAvoy 2011).

[24] A positive correlation exists between country indebtedness and rates of deforestation (Kahn and McDonald 1995), although it is difficult to establish a causal link since deforestation has many drivers. Relatedly, debt repayment can sap revenue from other areas such as conservation budgets, making enforcement and central oversight of, for example, remote protected areas nearly impossible, and opens the door to illegal logging and corruption (Amacher et al. 2011).

Access to risk markets is also likely to be an issue. As discussed above, entering into an RBA brings risk. This can partly be managed within the agreement but external insurance could make agreements more attractive. Some private companies are beginning to provide insurance against natural losses (from fire, wind, and pests) and even policy risk, and a limited futures market offers some insurance against carbon price risk, but all these are in development and DCs may not have access to them on actuarially reasonable terms. Other risks could contribute directly to deforestation pressure. Food price volatility could lead to high reliance on domestic food production and development of otherwise marginal land. Better management of international food trade and distribution, international food reserves that can be used to regulate extreme prices, and provision of insurance against local shocks to food production (e.g. droughts) could, by reducing food risk, facilitate more efficient global food production, and hence reduce deforestation pressure and allow for more reforestation of marginal land.

Policies that Substitute for RBAs

Some countries will not be able or willing to engage in a results-based agreement for a long time. In the absence of a price signal within these countries, it is appropriate to provide external rewards to reduce deforestation and degradation or encourage reforestation, or to impose costs on activities that damage forests. The BC actor could mimic the activities that would occur if a price signal were imposed, by directly supporting carefully targeted investments and institutional developments. These could be the nationally appropriate mitigation actions (NAMAs) identified by DC governments. BCs can also reduce deforestation pressures by internalizing climate and other environmental externalities at their end. Possible approaches include adjusting prices and demand within the BC through either government policies or consumer-based movements (e.g. for timber or biofuels, Blackman and Rivera, 2010), and making trade or investment conditional on sustainability. This also can provide an incentive to the DC to enter an agreement.

Where carbon implications of forest management cannot be internalized within DCs, an alternative is to mimic the effect they would have had on the IC and DC by adjusting import/export prices and demand where possible. This may result in a move towards the globally efficient outcome and also provide an incentive to the DC to enter an RBA. This occurs not because these actions are designed to be punitive to those outside an RBA, but because even if the global emissions outcome were similar to that under an RBA, where the costs are internalized affects the distribution of costs and benefits between the DC and ICs.

The most direct approach is through border carbon adjustments, but these are controversial and risk increasing protectionism (Frankel 2008). In any case, setting appropriate

adjustments for forest-related products is particularly difficult because in some cases increased demand for timber increases deforestation pressure, while in others it may encourage reforestation.

A key example of domestic internalization of international effects is in relation to first-generation biofuels. California has begun to implement a low-carbon fuel standard, but the carbon implications of biofuels, particularly through indirect impacts on tropical deforestation, have been controversial and the implications of the program for net carbon emissions is unclear (Holland et al. 2009).[25] The E.U. sustainability standards and the U.S. Federal Renewable Fuel Standard also try to account for indirect land-use change.

Consumer and retailer pressure leads to eco-certification initiatives that certify that products are produced under conditions that meet predefined environmental (and social welfare) standards. They may have carbon protection benefits, though climate mitigation is not their primary objective. Blackman and Rivera (2010) identify "four main threats to eco-certification effectiveness: (i) weak certification standards; (ii) noncompliance with certification standards; (iii) limited participation, which can stem from supply-side or demand-side factors; and (iv) adverse self-selection, whereby actors already engaged in, or intending to engage in, innovative or environmentally-friendly practices disproportionately participate in the program." They find that "the threat of adverse self-selection, which has been shown to limit impacts in a wide range of voluntary programs, is typically ignored in project designs." They also find that only four studies of the effectiveness of certification programs have examined environmental impacts and also made a serious attempt to elucidate the causal impact of certification by eliminating rival explanations of the observed outcomes that have nothing to do with certification. Only one of these four detected any environmental impact. They conclude that "The evidence base provides, at best, weak evidence for the hypothesis that certification has positive socioeconomic or environmental impacts."

In a more direct approach, the U.S. Lacey Act 1900 has been amended to ban imports of products from illegal timber. In the E.U., the Forest Law Enforcement Governance and Trade (FLEGT) assists DCs in preventing illegal logging and benefiting from greater access to the E.U. timber markets through bilateral trade agreements and by creating a roadmap for E.U. financing. It aims to create enabling conditions for scaled-up investments and to provide a transparent and inclusive national process for policymaking in the land-use sector.

[25] Gurgel et al. (2007) provide estimates of the global implications of not including the externalities on forests when regulating fossil fuel emissions.

In the 1990s, conditional loans were seen as partial alternatives to binding treaties that were difficult to establish and enforce (Keohane and Levy 1996). However, an internal International Monetary Fund review on macroeconomic policy adjustment found that "tightly budgeted conditional assistance programs never bring about reforms" due to asymmetries in information and the influence of special interest groups (e.g. policies are chosen to placate the timber industry lobby at the expense of the general population and environment) (Mayer and Mourmouras 2005). For example, in the late 1980s the World Bank failed to decrease deforestation in Indonesia through the use of conditional loans because the powerful timber industry was able to persuade the Indonesian government to reject the loan terms (Ross 1996).

CONCLUSION AND POLICY IMPLICATIONS

REDD could contribute significantly and cost-effectively to climate mitigation. Significant challenges arise, as with all international climate policy. Economic modeling can estimate the value, the intertemporal dynamics of REDD, the risks and uncertainties, and how it depends on specific policy designs (Lubowski and Rose 2011). Economic theory can also contribute to international policy design.

Results-based agreements are essentially a form of contract within a repeated game and hence amenable to the tools of contract and game theory. Although a price incentive is a critical tool to induce cost-effective mitigation, other policies can complement a results-based agreement by addressing problems in capital, labor, knowledge, or risk markets, or problems of governance. In addition, not all states have institutions capable of supporting a results-based agreement, and the need to avoid missing low-cost opportunities and the danger of leakage across national boundaries makes it important to enable participation of all countries. Policies that can be used in relation to these countries will act as partial substitutes for results-based agreements.

Within results-based agreements, the most difficult economic issue is negotiating a baseline against which rewards will be given. Cost-sharing objectives conflict with efficiency objectives in an environment with private information. Renegotiation of baselines over time that is motivated by cost-sharing considerations creates a similar conflict with efficiency because it induces inefficient strategic behavior.

Compliance issues, or equivalently the inability of states to make long-term binding commitments, also create efficiency issues. Risk that a DC will reverse protection after it is paid for, as well as concerns about loss of DC options, creates pressure for short-term or rental agreements. However, these will not induce efficient investment in forest protection activities if there is a risk that the BC will not continue rental payments over time. This risk, combined with

uncertain carbon prices, creates pressure for higher payments in the short term. Similar issues arise in private contracts, and economics may be therefore able to contribute more from lessons learned in private contexts.

Several results-based agreements have been initiated, each with distinct design features. Evaluating these rigorously could facilitate evolution of more effective and efficient international agreements (bi- or multilateral) with enough flexibility in cost sharing to create a package attractive to a broad set of DCs and BCs. Clarity of thought about the complementary and substitutability between results-based agreements and other policies will maximise positive interactions among policy efforts and avoid inefficient and costly double payments. Without a well-designed package of policies, the enormous mitigation potential of REDD will be unrealized.

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