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A “Stock-Flow-with Targets” Mechanism for Distributing Incentive Payments to Reduce Emissions from Deforestation

Introduction

Reducing greenhouse gas emissions from deforestation and forest degradation is increasingly recognized as an important option in the policy toolkit for mitigating climate change. In the process, the debate has shifted from *whether* to pursue the reduction of emissions from deforestation and forest degradation (REDD) to *how* to implement it, and the challenges involved. As part of a broader climate agreement, the Subsidiary Body for Scientific and Technical Advice (SBSTA) of the UNFCCC is focusing on methodological issues relating to reference levels of emissions from deforestation and degradation under REDD. The design of these reference levels will determine a REDD mechanism’s overall reductions in emissions from deforestation (“effectiveness”), reductions per dollar spent (“efficiency”), and distribution of REDD revenue across countries and regions (“equity”) (Stern, 2007; Angelsen, 2008).

This policy brief refines the stock-flow approach submitted jointly by the Woods Hole Research Center (WHRC) and by the Amazon Institute for Environmental Research (IPAM) to the UNFCCC in August 2008 on how to distribute across countries the potential incentive payments to reduce emissions from deforestation and forest degradation (REDD). We provide an overview of the stock-flow approach, extend it using targets, and then present simulation results on how it performs in terms of environmental effectiveness, economic efficiency, and equity of REDD payments relative to opportunity costs of participation. The evolution of the stock-flow approach presented here was inspired and made possible by the development of the *Open Source Impacts of REDD Incentives Spreadsheet* (OSIRIS; Busch *et al.*, 2009) as a powerful tool to improve our understanding of REDD mechanism design.¹

REDD design, reference levels, and the stock-flow approach

A central element of designing a system of positive incentives for REDD is determining a country’s reference level emissions. Most proposed REDD mechanisms award credits based on the difference between the reference level and a country’s actual emissions. These credits may be sold on the carbon market or be bought through a fund at a given price (PC). If the reference level for a country is set above its

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historical emissions, it allows an increase in emissions while still receiving incentives, whereas (if it is set below a country's historical emissions), the positive incentives are provided only after a reduction in emissions occurs without compensation. This can be problematic in international negotiations because some countries would have to accept not being compensated for a portion of their efforts.

The premise of the stock-flow approach is that the stream of revenues to provide positive incentives would come from the value at the going price of a country's carbon emission reductions relative to a reference level set equal to average historical emissions (either through a market or from an international fund, or a combination). A withholding from the revenue generated by emissions reductions is set aside to pay dividends to standing carbon stock. Therefore, in the stock-flow mechanism, countries receive compensation both for reducing emissions (avoiding physical depreciation of the carbon stock) and, through dividends, for maintaining existing stocks. If a country exceeds its historical emissions rate, the country's dividends will be reduced by the full cost at the international price for carbon (so as to avoid any reduction of dividends to other countries).

Since countries' participation in REDD will be voluntary, the design of the incentives has to take into consideration both the environmental target to be reached and how to distribute rents to encourage broad participation.² Trying to do both with just the reference level as a parameter can be difficult because there are implicitly two objectives: reaching an environmental target among participating countries and maximizing country participation.

The stock-flow approach can use two instruments (reference level and withholding level) to pursue these two objectives. Countries' baselines are set to historical emissions so that all emitting countries have an immediate positive incentive to lower emissions. The other parameter is the withholding rate relative to the price of carbon, which generates the funds to be distributed as dividends. In the standard stock-flow as presented in Cattaneo (2008), the withholding rate is assumed to be independent of the extent of the emissions reductions. However, this withholding rate could be made to vary with the level of emissions reductions so as to improve the incentives. So, for example, one can think of a target relative to historical emissions, and that reductions beyond this target are not subject to any withholding (Figure 3). The advantage of such an approach is that the marginal incentive to reduce emissions beyond the target is the full price and not the lower price after withholding. This variant of the stock-flow approach maximizes the amount of emissions reduction an individual country would be willing to provide while at the same time incentivizing broad country participation (through a stock payment).

How would the "Stock-Flow with Targets" approach perform?

A simulation was performed to examine how different levels of withholding and target levels would affect the outcome of a REDD program using the stock-flow mechanism with targets. The analytical framework used to model REDD incentives and deforestation emissions is based on the *Open Source Impacts of REDD Incentives Spreadsheet* (OSIRIS v2.4, 2009). It is a static one-year global partial equilibrium market for agricultural land cleared from tropical forest. Demand for frontier agricultural land is global, and each of

² If it were not voluntary, then a cap-and-trade system would be a straightforward approach, where the aggregate environmental objective is fixed and the allocation of environmental permits (equivalent to setting the baseline) would be simply a rent distribution issue with no environmental effect.

84 tropical or developing countries has a national supply curve for frontier agricultural land, based on returns from agriculture and returns from forest.

REDD design options differ in the manner in which countries' reference levels are established, which in turn leads to differing incentives for countries to participate in a REDD program. In the simplest design option, a country's reference level is equal to its average national rate of emissions from deforestation over a recent historical period, as in one variant of the original compensated reduction design proposal (Santilli *et al*, 2005). When positive incentives are extended only to countries with historically high rates of deforestation, there is exacerbated threat of shifting, or "leakage," of deforestation activities to countries with historically low deforestation rates. For this reason a variety of proposals have been developed to address the issue of leakage.

We follow Busch *et al.* to quantitatively model and compare the impact of REDD financial transfers for emissions reduction following the stock-flow approach relative to a national-scale REDD incentive-design options based on historical emissions and for a cap&trade approach under one set of illustrative conditions and a benchmark "cap-and-trade" approach³:

- "National historical" – Reference levels equal to a country's national historical rate (Santilli *et al*, 2005)
- "Standard Stock-flow" – A percentage of payment for emissions reductions is withheld to fund payment for forest stock (Cattaneo, 2008)
- "Stock-flow with targets" - A percentage of payment for emissions reductions is withheld, up to a target emission reduction being reached, to fund payment for forest stock
- "Cap-and-trade for REDD" - Countries required to purchase credits for emissions above their reference level (as a benchmark scenario only)

The formulae for calculating reference levels under each design option are presented in Busch *et al.* (2009).

³ Results reported here are outputs of OSIRIS v2.4SFwT using the following parameter values: carbon price = \$5/ton CO₂; permanence reduction scale = 1.00 (no permanence withholding); exponential demand with price elasticity = 2.00 (elasticity neither perfectly elastic nor perfectly inelastic); fraction of soil carbon eligible for REDD = 0.10; coefficient on slope of supply curve extensions = 0.10; Social preference for agricultural surplus parameter = 1.00; management and transaction cost = 2001 US\$3.50/Ha/yr; fraction of national average timber rent included = 1.00. Furthermore, the following design-specific parameters are assumed: reference level for countries with low deforestation rates = 0.003; weight on national historic rates = 0.40; fraction of forest and other terrestrial carbon land protected = 0.20; reference level as fraction of unprotected land = 0.01; flow withholding = 0.35 for standard stock-flow; for stock-flow with targets flow withholding = 0.75 and target=35% of national historical emissions.

Table 1. Comparison of effectiveness, efficiency and equity for different REDD proposals.

	Reduction in emissions	Efficiency	Inequality (in distribution of funds relative to opportunity cost)	Number of countries opting into REDD (out of 84)
		(effective CO2 reductions vs. credits)	Gini coefficient	
National historical	73%	98%	0.26	55
Standard stock-flow	72%	110%	0.24	84
Stock-flow with targets	80%	112%	0.24	84
Cap-and-trade (benchmark)	84%	100%	0.36	62

In table 1, results are presented for environmental effectiveness, economic efficiency, and a measure of inequality in the distribution of funds across countries. We adopt a measure of equity based on return relative to the opportunity cost, as specified in Cattaneo et al. (under review). Since countries reducing emissions from deforestation may face very different opportunity costs, a measure of equity based on equal compensation for equal effort is appealing. A Gini coefficient of the distribution of REDD payments relative to opportunity costs of participating in REDD is used as a metric. The Gini coefficient has an intuitive interpretation and it varies between 0, for perfect equality, and 1, which is the ultimate inequality.

Of the proposals analyzed here with default parameter values reduction in global emissions range from 72% to 84%, indicating that the different proposals lead potentially to different environmental outcomes. In this respect, the stock-flow with targets, with an 80% reduction in emissions, appears to be considerably more effective than other existing proposals as presented in Busch et al. (2009). In terms of efficiency, the stock-flow with targets performs very well (112%). Along similar lines, the stock-flow approach, with or without targets, emerges as the most equitable in terms of how REDD funds are distributed relative to opportunity costs (lowest Gini coefficient).

The 80% reduction in emissions, which comes close to matching the result for a cap-and-trade REDD system (84%) reported here as a benchmark, testifies to the effectiveness of the approach. The cap-and-trade is most likely not politically viable because tropical countries exceeding their historical emissions from deforestation would incur a loss since they would have to buy credits; however, it is a useful benchmark to determine the level emissions reductions that is economically attainable at a given carbon price. Therefore, the interpretation of the above result is that the stock-flow approach with targets attains nearly all economically attainable emissions reductions with a system that may prove to be politically viable and more equitable than a cap-and-trade.

Table 1 also reports the number of countries opting to participate in REDD under each mechanism. For such countries the financial return to deforestation is lower than what they would obtain by participating in REDD. This is therefore a measure of how broad participation would be in REDD depending on the REDD mechanism adopted. The stock-flow approach appears to be the only mechanism design where all REDD countries would profit from participation. A national historical reference level would be economically not

viable for 29 countries out of 84, while in a cap&trade mechanism with credits distributed according to national historical emissions 22 countries would be worse off from participating.

Conclusions

The stock-flow with targets approach proposed here differs from the previously proposed stock-flow approach (Cattaneo, 2008) in that: (i) there is no longer a global additionality constraint defining the distribution of dividends, and (ii) the withholding rate on flow payments to raise stock funds no longer applies to all reductions in emissions, but only up to a target reduction. The approach remains applicable independently of whether the adopted REDD system is market-based or fund-based, or a combination of the two.

For all countries, all emissions reductions relative to historical levels are compensated, which is not necessarily the case of other proposals attempting to reduce leakage exclusively through setting a reference level. The stock-flow approach introduces transparent, dynamic incentives to conserve forest by linking explicitly dividend payments to the carbon stock.

The incentives provided by the stock-flow approach are confirmed by simulation results indicating that the version of the stock-flow mechanism incorporating targets is environmentally effective leading to a potential 80% reduction in emissions from deforestation. This approaches the performance of a cap-and-trade system, which, however is not politically viable. The stock-flow with targets is also the most economically efficient (112%) and more equitable relative to distributing REDD revenues proportionately to opportunity costs (Gini coefficient of 0.24). More importantly, the stock-flow approach appears to be the proposal that would consistently encourage the broadest country participation (see also policy brief “On International Equity in REDD”) based on an economic rationale.

The refinement of the stock-flow approach presented here, improving its performance and political viability, is based on the knowledge acquired in the development of the OSIRIS model (Busch *et al.*, 2009). This is part of an evolving process of understanding REDD mechanism design and what will work best for countries. For example, preliminary OSIRIS simulation results of a REDD proposal being developed by The Nature Conservancy, based in part on the standard stock-flow approach, indicate that additional stock stabilization funds from Annex1 funding sources may also further improve performance.

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