Escaping the climate policy uncertainty trap: options contracts for REDD+

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Abstract. Climate policy uncertainty significantly hinders investments in low-carbon technologies, and the global community is behind schedule to curb carbon emissions. Strong actions will be necessary to limit the increase in global temperatures, and continued delays create risks of escalating climate change damages and future policy costs. These risks are system-wide, long-term and large-scale and thus hard to diversify across firms. Because of its unique scale, cost structure, and near-term availability, Reducing Emissions from Deforestation and Degradation (REDD+) has a significant

potential to help manage climate policy risks and facilitate the transition to lower greenhouse gas emissions. 'Call' options contracts in the form of the right but not the obligation to buy high-quality emissions reduction credits from jurisdictional REDD+ programs at a predetermined price per ton of CO_2 could help unlock this potential despite the current lack of carbon markets that accept REDD+ for compliance. This approach could provide a globally important cost-containment mechanism and insurance for firms against higher future carbon prices, while channeling finance to avoid deforestation until policy uncertainties decline and carbon markets scale up.

Key policy insights:

- Climate policy uncertainty discourages abatement investments and hampers demand for mitigation in general, exposing firms to an escalating systemic risk of future rapid increases in emission control expenditures;
- This situation poses a risk of an abatement 'short squeeze,' paralleling the case in financial markets when prices jump sharply as investors rush to square accounts on a widely 'shorted' investment, one they have bet against and promised to repay later in anticipation of falling prices.
- There is likely to be a willingness to pay for mechanisms that hedge the risks of abruptly rising carbon prices, in particular for 'call' options, the right but not the obligation to buy high-quality emissions reduction credits at a predetermined price, due to the significantly lower upfront capital expenditure compared to other hedging alternatives.
- Establishing rules as soon as possible for compliance market acceptance of high-quality emissions reductions credits from REDD+ would facilitate REDD+ transactions, including via options-based contracts, which could help fill the gap of uncertain climate policies and incipient carbon markets in the short and medium term.
- Options on emissions reductions from REDD+ could unlock private capital and create a sizable emissions reductions pool that could mitigate large future adjustment costs for

business and society while channeling investments for climate mitigation, forest conservation, and green growth in tropical developing countries.

Key words: Climate policy uncertainty; REDD+; options on REDD+; abatement short squeeze

1. Introduction

The move towards a more bottom-up global climate policy approach, based on voluntary contributions, as embodied in the Paris Agreement of 2015 carries both a threat and an opportunity. There is a threat because current emissions reduction pledges are not ambitious enough, and we are already late with mitigation (Fawcett et al. 2015, Millar et al 2017). There is an opportunity because the decentralized approach is spurring worldwide pledges and carbon pricing policy developments that could help increase ambition over time (World Bank, Ecofys and Vivid Economics 2016; EDF and IETA 2016). Moreover, the opportunity for Reducing Emissions from Deforestation and forest Degradation (REDD+), which was uniquely singled out within the Paris Agreement, could provide relatively low-cost emissions reductions on a large scale to help enhance mitigation ambition as countries work to achieve their pledges and tighten them over time.

REDD+ could provide three important contributions in shaping the global greenhouse gas emissions profile. First, it could reduce long-term emission reduction costs, providing about 10%-50% of required abatement by mid-century and offering a channel for emerging countries to participate in carbon trading, raising more finance to support their national strategies (Bosetti et al 2011; Lubowski and Rose 2013). Second, it could provide a "reserve" to accommodate future adjustments to lower emissions targets, thereby reducing the mid-term cost of switching abatement pathways (Golub et al. 2017; Houghton et al., 2015; Golub 2010). As the window of opportunity narrows to avoid dangerous increases in global temperatures, such a buffer is needed to keep the option open to meet more ambitious emissions reduction goals in the future. REDD+ could contribute to this buffer and at the same time generate additional co-benefits from forest conservation. Finally, well-structured market policies that allow access to low-cost near-term mitigation options such as REDD+ provide greater flexibility for longer-term investments into research and development (R&D) that can yield improved technologies in the future; this technological progress will be critical for ensuring a dynamically efficient pathway of decarbonization (Koch et al. 2017; Szolgayova et al. 2014).

The drivers of deforestation are complex and include economic incentives for land-use change (e.g., converting forests into agricultural land) weak institutions (e.g., lack of law enforcement, unsettled property rights, corruption) and scant economic incentives to protect and restore forests and the carbon they contain. Nevertheless, there is already evidence on the ground that large-scale deforestation can be stopped when the right conditions are in place. Improved satellite monitoring and remote sensing technologies, tougher law enforcement, and a suite of policies have already helped reduce average deforestation rates in the Brazilian Amazon by two thirds, relative to 1996-2005 levels, making Brazil the world leader in greenhouse gas reductions (INPE 2017; Nepstad et al. 2014).

Maintaining and extending the gains made so far will depend on durable policies that reward forest protection at a landscape scale. As a necessary but not sufficient condition to avert tropical deforestation, there must be a way for forest landowners, communities, and governments to realize at least some of the value of thriving forests. Including carbon credits for emissions reductions from jurisdictional (national or state-level) REDD+ within compliance carbon markets could play a central role in realizing this vision by unlocking private finance for a wide range of reforms, enforcement, and incentive programmes at the scale and durability needed for meaningful forest protection.

All of the necessary conditions for a large-scale international forest carbon market do not yet exist. However, there are signs that they are coming into place. In 2013, Parties to the United Nations Framework for Climate Change (UNFCCC) adopted the Warsaw Framework for REDD+, which addressed technical issues for national REDD+ programmes. Furthermore, the Paris Agreement explicitly affirmed the central role of REDD+ as a mitigation tool and called on countries to sacle up results-based payments. In addition, the Paris Agreement broadly recongized the role for international cooperation in increasing mitigation ambition. Although REDD+ is not included in any compliance carbon markets at the moment, REDD+ is the most popular credit type in the voluntary carbon market (Hamrick and Gallant 2017), and several compliance markets have the potential to accept jurisdiciotnal REDD+ over the next 3-5 yuears. These markets include California and South Korea, which allow for the limitied use of international credits for compliance, though the necessary

regulations are still pending, and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) under the International Civil Aviation Organization (ICAO). Under current levels of participation, this aviation market is estimated to require, on a cumulative basis, at least 110 million tons of offset credits through 2020, 350 million tons through 2025, and 2.5 billion tons of carbon-dioxide equivalent (CO_2e) through 2035 to fulfill its mandate of capping global aviation emissions at 2020 levels (EDF 2016). On the supply side, the pipeline of jurisdictional-scale REDD+ credits is estimated to be 157-167 million tons of CO_2e over 2016-2020 and about 1.3 to 1.5 billion tons over the following 5 years, depending on the participation of Brazil (Grillo et al. 2016). While conditions are thus potentially ripe for a REDD+ market, there remain significant institutional and policy barriers to implementing REDD+ at large scales and for emerging carbon markets to help tap this potential (see, for example, Brockhaus et al. 2017; see Lubowski and Rose 2013 for a review).

In this paper, we pull together insights from recent literature on the economics of climate change that highlights the impact of regulatory uncertainties and identifies financial tools and approaches to help manage these risks. We build our policy analysis upon a macroeconomic analysis of the potential role of REDD+ in emerging carbon markets presented in Golub et al. (2017). Starting from this broader economic perspective, we analyze the significant financial risks facing greenhouse-gas-emitting firms and the potential financial and policy solutions for private companies to use REDD+ to manage these risks. In particular, we argue that enabling options-based transactions could minimize risks for both REDD+ buyers and sellers, help smooth the transition to future climate policies, and unlock important emissions reductions that can accelerate climate action in the context of significant policy uncertainties.

In the next section, we discuss how regulatory uncertainty currently suppresses the demand for emissions reductions, including REDD+. In section 3, we introduce a new concept of an “abatement short squeeze” and explain how using ‘call’ option contracts--granting the right but not the obligation to buy--on demonstrated emissions reductions from REDD+ offers a promising strategy to mitigate the

cost of policy uncertainty for business and society. The last section summarizes and offers policy recommendations.

2. Regulatory uncertainty suppresses demand for abatement

Parties considering a potential carbon market transaction need to make irreversible decisions in an uncertain economic and policy environment. Golub et al. (2017) explain how regulatory uncertainty discourages the accumulation ('banking') of emission allowances for use in future periods and therefore suppresses the current price. Empirical analysis supports this theoretical conclusion. The low carbon prices persisting under the European Union's Emissions Trading System (EU ETS) have been widely attributed to an oversupply of allowances due to the economic recession and overlapping policies supporting renewables, together with large availability of low-cost international credits. Through an econometric analysis, Koch et al. (2014) show that negative price changes in the EU-ETS are indeed been associated with economic activity, renewables policies and costs of fuel switching. However, the explanatory power of these factors is just 10%, and the balance can be attributed to regulatory uncertainty, particularly related to policy efforts to strengthen the EU ETS.[1] Market participants learned about the difficulty of policy reform processes, translating into decreased confidence in the future stringency of the cap and in the associated price of allowances (Koch et al., 2016).

Furthermore, investments in REDD+ are subject to specific regulatory uncertainty since its recognition within compliance carbon markets is not certain (Goldstein and Ruef 2016). This uncertainty over the future "fungibility" of REDD+ is a key reason why private sector actors are discounting the value of REDD+. A survey and set of interviews with private sector stakeholders conducted by Laing et al. (2015; 2016) confirms that uncertainty about future compliance market eligibility is the major factor holding back further demand for REDD+ credits (Goldstein and Ruef 2016. Lee et al. 2017).

[1] In a subsequent study, Koch et al. (2016) examine the response of allowance prices to regulatory news regarding the supply of allowances in the EU ETS. Based on an event study method, they quantify the price response to news announcements about the time profile of EU ETS supply schedules between 2008 and 2014.

Regulatory uncertainty thus discourages banking of emissions allowances as well as of REDD+ and other emissions reduction credits. In the short run, with limited banking, emerging carbon markets will experience so-called "oversupply" and low spot prices for carbon. However, over the long term, society will end up caught short on abatement opportunities as myopic extrapolation of those low prices discourages both banking of emission units and deployment of new abatement technologies. In the next section, we demonstrate how such behaviour can lead to an eventual 'short squeeze' on abatement at a system-wide level and how call options on REDD+ credits could help mitigate the shortcomings of current climate policy.

3. Call options on REDD+ and other cost-effective emissions reductions could help manage policy risks

While uncertainty over long-term climate policies discourages near-term investments to reduce emissions, if firms leave it at that, future policy risks will be unhedged. If a jurisdiction or sector eventually implements stringent climate policy, regulated emitters that have deferred investments will have limited abatement possibilities, leading to a potential spike in expenditures on emission controls. Using financial terminology, we call this situation an abatement 'short squeeze,' as it parallels the case in financial markets when prices jump sharply as investors rush to square accounts on a widely 'shorted' investment, one they have bet against and promised to repay later in anticipation of falling prices.

As an example, Table 1 presents a simplified event tree, which depicts a two-period decision problem for an emissions-intensive firm. In period 1, the firm can choose to make an investment to abate a certain amount of emissions and at least delay their possibility until period 2. The three columns to the right in Table 1 describe the different outcomes depending on society's selection in period 2 of a policy to stabilize atmospheric concentrations of greenhouse gases at either 450 or 550 parts per million (ppm) of CO_2e. (This global-scale target is shown for illustration only but, in reality, relevant policies

for firms will likely be selected at the level of national or subnational governments.) Accelerated abatement in the first period provides a reserve or buffer of emissions reductions that could be fully or partially used to reduce the future cost of climate policy if the more stringent 450 ppm target is selected or, alternatively, simply abandoned in the case of a weaker target.

Table 1: Reserve accumulation and policy adjustment

Selection in the first period	Selection of policy in the second period	Reduction of abatement cost as a result of innovations	Cost of permanent deferral of emissions	Use of reserve
Abatement and deferred emissions	450 ppm	Modest learning (high cost)	High	High
			Low	Maximum
		Significant learning (low cost)	High	Medium
			Low	High
	550 ppm	Modest learning (high cost)	High	Medium
			Low	High
		Significant learning (low cost)	High	Low
			Low	Medium

Our analysis suggests that a firm with a potential abatement liability should consider managing its risks of sudden cost shocks in response to future climate policies. There are several ways to reduce such risk exposure: (I) avoiding new high-carbon investments, (ii) investing into abatement to decarbonize production, (iii) banking allowances or emission reduction credits, and (iv) buying a call option on carbon allowances or credits. The first alternative is relatively no-regret, since the investment could potentially be initiated later, while the second and third alternatives require upfront capital investment whose value could be at risk if the returns rely on future carbon prices being above a certain level. In contrast, a call option would give the buyer the right but not the obligation to buy an allowance or credit at a pre-determined purchase ('strike') price at a future date. Call options would of course also

lose value with low prices, but the losses would be limited to the value of the upfront ('premium') payment to purchase the option.

All firms in a given climate policy jurisdiction essentially face the same climate policy risk, and risks are likely to be correlated globally to some extent. This makes it difficult to diversify this policy risk across the potentially exposed firms. Similarly, policy risks are typically hard to insure directly through typical financial and insurance markets. Long-dated carbon price insurance products are not currently available at large scale and low cost. As a result, firms have limited tools to hedge long-term carbon emission prices via existing carbon markets and associated futures or other derivatives.

Golub et al. (2017) estimate that over the next fifteen years, reduced deforestation and forest degradation has the potential to contribute up to 20 gigatons (Gt) CO_2e of tradable emissions reductions, about half of which could be cost-effectively financed via options-based contracts. Even if this potential is only realized partially, such contracts could equip industry with a vitally important abatement reserve that can help avoid an abatement short squeeze.

Within a carbon market system, simple direct purchases and banking of allowances and credits could be a solution for firms to manage their policy risks, if these units were available at a large discount to the future market price. An attractive price for buyers would equal the marginal expected value of emissions units (i.e. forward price) adjusted for the investment risk, but suppliers may not be willing to accept such a low price. A potential solution for both buyers and sellers is to structure call option contracts with a strike price high enough to cover the expected opportunity cost of avoided deforestation or other near-term, cost-effective abatement options. Call options on REDD+ and call options on reductions of industrial emissions (emission allowances) are critically different in terms of their potential costs and scale.

Entering into a call options contract, a seller should have a plan on how to deliver emission reductions in case the buyer chooses to exercise the contract. Options backed up ('covered') by actual emissions reductions, already achieved and demonstrated via rigorous emissions reduction monitoring,

reporting, and verification protocols, would have the most credibility and help manage risks associated with the delivery and potential non-performance of abatement efforts. In providing a call option backed up by actual reductions in energy or industrial emissions, the seller should simultaneously invest into abatement, which may be capital intensive, essentially making the irreversible decision to abate. On the other hand, the cost of reducing deforestation to keep open an option on the associated reductions is based on the initial incremental costs of instituting forest protection and rural development programs (relative to the costs of investment in deforestation-based development), along with the recurring costs of managing these programs. Society also likely faces the potential of foregone net revenues from agriculture or other alternative land uses over the time that the option to delay deforestation is preserved. Compared to investments in abatement in fossil-energy and industrial sectors, this cost structure of avoiding deforestation is likely to be less frontloaded, with fewer and smaller initial investments and more recurring investments (e.g. to pay for ongoing law enforcement and monitoring efforts and compensate landowners and communities for forest conservation). This makes REDD+ programs a promising source of call options.

Based on the estimated cost-effectiveness and scale of REDD+, there is potential for a significant economic surplus in transactions to hedge a possible shortfall on energy and industrial abatement with an investment in demonstrated REDD+ outcomes. Form the suppliers' perspective, in order to sell an option backed up by actual forest protection, tropical forest regions will need to refrain from ideforesting at least until the option contract expires. This decision potentially has limited irreversible upfront costs, as described above. Forested regions also have an option value related to their potential future carbon value. Accounting for the value of this option, in addition to all the other local benefits that forest ecosystems provide, the economic value of immediate deforestation could be negative in most cases (e.g. Engel et al. 2015). If this decision could be made financially viable, it would thus be rational for the land manager or policy maker to defer deforestation until major uncertainties regarding carbon markets and relative returns in the agricultural sector are resolved.

From the perspective of potential call options buyers, different firms may have different preferences regarding both strike price and level of upfront payment for an option on future abatement from REDD+ or other sources. The Foster-Hart (2009) risk metric is a useful tool to understand the preferences of heterogeneous firms over potential strike prices, upfront payments and exposure to regulatory risk in the climate policy context. This metric links the choice over a risky decision ('gamble') to the level of "critical wealth," defined as a bottom line a company may not afford to go below. If such a decision creates the risk of a result that could potentially reduce wealth below this threshold, then the decision-maker should reject this choice. For a firm, Foster and Hart (2009) define this threshold as the point of bankruptcy, but it could also be a critical level of debt-to-equity, earnings per share or other indicator of the firm's financial performance. The concept of critical wealth establishes an objective criterion for evaluating decisions based on their potential outcomes. The Forest-Hart metric thus helps understand why different firms, even with identical preferences, may tolerate different levels of risk and choose different hedging strategies according to their financial status.

Consider an example where a firm has a critical wealth threshold W_0 and faces the choice to invest in a reserve of emissions allowances R_0, paying a price of \$40/tCO$_2$, in anticipation of a future carbon market liability. However, the future price could drop to \$20/tCO$_2$ or rise to \$70/tCO$_2$. As a result, by building a reserve of allowances, the firm could suffer losses of $\$20R_0$ (the over-payment in the case the price falls to \$20/tCO$_2$), ignoring for simplicity any cost of capital. Alternatively, by deferring this investment, the firm could face a potential cost increase of $\$30R_0$ if it misses the opportunity to pay \$40/tCO$_2$ and the price then rises to \$70/tCO$_2$. If the firm can tolerate losses up to $W_0 > \$30R_0$, then either gamble -- banking allowances or deferring abatement- - is in minimally acceptable. However, if $W_0 < \$20R_0$, then neither gamble is acceptable under the Foster-Hard criterion.

Options on REDD+ or other cost-effective sources of high quality abatement provide a tool for engineering the firm's risk-return prospects in such a situation. In the example above, if the firm can buy a 'call' option that locks in the right to buy credits at the current price of \$40/tCO$_2$ (i.e. an 'at-the-money' call option) and this costs \$5/tCO$_2$, then the firm's maximum losses are capped at $\$5R_0$, what

it paid for the insurance provided by the options. As long as $W_0 > \$5R_0$, the firm can afford this modified gamble. Given values for W_0 and R_0, the firm could be willing to pay up to $(\hat{P} + p^{call})\, R_0 = W_0$ to cover its future liability, where p^{call} is the upfront cost (premium) to buy the call option and $\hat{P}$ is the maximum acceptable level of the 'strike' price associated with that premium (the pre-determined price the firm would need to pay to buy the credit if the option were exercised). Rearranging this equality equation, the maximum acceptable strike price can be defined as $\hat{P} = \frac{W_0}{R_0} - p^{call}$.

This application of the Foster-Hart risk metric provides a structure for evaluating the potential for firms to demand call options on REDD+ credits and other cost-effective types of abatement. The upfront price needed to cover the costs of REDD+ in the near term may be low. However, given unknown future agricultural opportunity costs, as well as the need of tropical countries to achieve and use some of their emissions reductions for meeting their own domestic emission reduction pledges, notably their Nationally Determined Contributions (NDCs) under the Paris Agreement, the negotiated strike price may need to be relatively high. With a relatively high future purchase price, sellers also retain the ability to sell credits on the market directly if a REDD+ market materializes but actual carbon prices turn out below the strike price. A benefit-sharing arrangement based on the ultimate market price (Krasovskii et al., 2016a, 2016b) or an indexed annual payment (Engel et al. 2015) could also provide more attractive alternatives to a fixed strike price.

4. Discussion and conclusions

How are companies hedging climate policy uncertainties? Intuitively, they would try to avoid long-term irreversible investment decisions in carbon-intensive assets, assigning an indicative price to associated carbon emissions. Internal carbon prices used by companies already enable the assessment of important decisions that could lock companies into a particular carbon emissions trajectory. Over 400 companies worldwide reported using an internal price on carbon in 2015, up from 150 in 2014

(CDP 2016). This is at least consistent with firms' anticipation of the potential for stricter climate policy. Internal carbon prices that vary across entities can also be interpreted as a subjective valuation of the foregone option value associated with carbon-intensive decisions. Nevertheless, simply avoiding locking into new high-carbon investments may not provide sufficient flexibility in case of a sharp future adjustment of climate policy.

Options on REDD+ credits provide an added way to enhance flexibility. Policy risk is a system-wide risk, which is hard to diversify across firms such that firms underinvest on abatement in the aggregate, relative to an ideal case without uncertainty. On the other hand, the optionality of deferring investments to convert tropical forests to agriculture works in the opposite direction, creating a value to delaying emissions in anticipation of potential future carbon values. Because of its unique scale, cost structure, and potential near-term availability, REDD+ has a significant potential to facilitate the transition to a low-carbon emissions pathway and enable the adjustment to more ambitious future global climate policies.

The rationale put forth in this paper is that there is likely to be a willingness to pay (and accept) to keep open the option of accessing low-cost REDD+ credits that could be valid for compliance. Even if business is sceptical about carbon markets and unsure about the recognition of REDD+, a modest upfront payment for an option that might or might not be exercised against a certain strike price at a later point in time could be an attractive hedge against the risk of tighter future emission limits. Delaying deforestation and selling options on emissions reductions achieved via REDD+ could also make sense from the perspective of the seller countries, if the strike price is sufficiently high.

Given the potential costs and volumes, options on REDD+ could make an important contribution to firms' risk management portfolios. Such options could provide firms with a hedge against uncertain costs due to both policy and technological uncertainties (Fuss et al., 2011). Modeling by Szolgayova et al. (2014) suggests that if firms have the ability to invest into REDD+ options alongside uncertain R&D of low-carbon technologies, their benefits are increased. This is because the hedge provided by

the options creates additional flexibility for making R&D investments that could pay off over the longer term while still ensuring compliance with emissions limits over the nearer term.

If climate policy tightens, REDD+ will be increasingly likely to form part of compliance market systems, given pressure for cost-effectiveness. This will increase the potential that call options on REDD+ will have hedging value for emitting industries. Nevertheless, given the nascent stage of international carbon markets and regulatory uncertainties about future market rules, REDD+ credits remain an imperfect hedge against future climate policies for individual firms.

Stronger signals of long-term climate policy ambition would help build confidence for low-carbon investments across all sectors. In parallel, policy makers can help unlock the potential value of REDD+ as a cost-effective mitigation option and hedge against policy risks by providing certainty over recognition of high-quality REDD+ credits within existing and emerging compliance markets. Careful policy designs in terms of use of REDD+ options and quotas and price floors also merit consideration to minimize the potential "crowding out" of clean energy investments (Koch et al. 2017).

A critical start would be for policy makers and stakeholders to support efforts to codify and build consensus around market standards for high-quality jurisdictional REDD+ credits, consistent with the Warsaw Framework for REDD+ and the Paris Agreement. Additional efforts should focus on establishing registries and other market infrastructure for high-integrity REDD+ transactions, with robust benefit-sharing arrangements. Furthermore, companies and governments could support pilot transactions of call options on verified REDD+ credits using a blend of public and private capital to provide proof-of-concept and catalyze larger efforts. For example, a blended-finance vehicle to aggregate and channel potential buyers and sellers could help facilitate the development of a compliance carbon market for REDD+ credits and options (EDF and CFC 2018). Public and philanthropic donors could catalyze such structures with price guarantees ('put' options) to tropical countries and potential investors to ensure a minimum price for REDD+. These efforts could unleash the potential of well-structured REDD+ contracts to reduce policy risks for both the private sector and

tropical nations, while mobilizing finance to significantly address climate change and protect forests as policy uncertainties decline and carbon markets scale up.

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