Smart Climate Change Mitigation

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[February 2022 - early draft, please do not cite; comments welcome]

Abstract

Current approaches to reducing carbon emissions rely on either voluntary reductions or government initiatives. Government action is hamstrung by compromises between those who see emissions reductions as important and others who see it as too costly or harmful to their personal interests. The result is under-investment in near-term carbon mitigation, which will lead in the long-term to greater overall costs. These costs will also be borne disproportionately by future generations who are underrepresented in the current political system.

I propose a new private investment vehicle which aims to bypass government deadlock and instead *leverage* differences in opinion to generate rapid investments in decarbonization. The trick is to create a mechanism whereby technological optimists (or climate skeptics), see an opportunity to benefit financially by participating on one side of a contract. Essentially, they can bet against the urgency of climate change adoption, while in the process financing mitigation.[1] Simultaneously, the mechanism allows those who believe early climate change mitigation is valuable to make investments with the expectation of financial payout at the end of the contract. Notably, the mechanism is *not* subject to veto by fossil fuel companies because they can only decide not to participate.

Specifically, I propose a futures contract whose value at maturity is determined by an independent body according to their scientific estimate of the value of CCM (the social cost of carbon). Investments in mitigation can then be financed on the basis of the discounted-present value of this contract security. Such a security could be introduced by an investment bank, or be hosted on a blockchain smart-contract platform such as Ethereum.

[1] Thus, in a sense it also provides them with a hedge: either they are right climate change is not urgent, in which case they profit financially, or they are wrong, in which case they can at least tell their children that they helped finance some efforts to reduce the problem.

1 Problem Definition

Preventing catastrophic climate change seems at once very simple and yet surprisingly difficult. There is a clear scientific consensus that climate change is a real problem. If the consequence of not doing more to reduce carbon emissions is massive economic and environmental damage, then it shouldn't be too hard to organize for real, immediate action on pure efficiency grounds. But of course there are a number of technical, political, and distributional reasons why this has not been possible over the last 50-70 years.

It helps to understand climate change as a series of inter-connected problems, among them:

- Uncertainty - Technological optimists believe that we will innovate our way out of the problem, in ways that we can't even currently foresee, while others see that as naive and simply an excuse for avoiding real change in the short-term.[2]
- The political impossibility of efficient approaches such as carbon taxes (Cullenward and Victor, 2020): While economically efficient, they concentrate costs among a few strong actors (carbon emitters), while dispersing benefits broadly among the population, such that even economically efficient reductions are not politically feasible.
- Intergenerational distributional conflict. The sooner we act the less costly action is. Yet the costs of climate change will fall more on future generations, who are politically under- or un-represented. (See, e.g. Stern (2007), chapter 2A.)

While these issues are complex, and this list is not exhaustive, I propose a private market-based mechanism that aims to sidestep these issues by instead leveraging peoples' divergent beliefs *towards action*, rather than setting up an arena in which these interests oppose each other and lead to deadlock in the public policy sphere.

Under the schema that I propose, environmentalists and the renewable energy industry buy into one side of a smart contract, and technological optimists buy into the other side of the contract. Fossil fuel companies do not have a (legal) way to oppose the participation of private parties in a contract.

2 Proposal

(Note: If you prefer a simple, concrete example, see Section 2.2 below).

We propose a financial instrument that would be introduced by an investment bank or hosted on a smart contract platform such as Ethereum, that would settle in the future

[2] I don't know of general survey results, but there are survey results about techno-optimism among farmers. See Gardezi and Arbuckle (2020).

(say 5, 10 years out) for a price that would be determined by some kind of neutral international body akin to the IPCC. The final value paid from one party to the other would be for amount of mitigation undertaken times the value of that mitigation, based on the institutions model of the social cost of carbon and the value of mitigation in different years.

Such a market would elicit people's best guess about the optimal path to climate change mitigation, and at the same time to allocate resources according to the most environmentally-conservative members. Thus, so long as there are *some* people who (correctly) believe that early action is less costly than later action, the mechanism will ensure near-optimal provision of carbon-emission reducing investments.

Consider 2 types of people:

- Person 1: Believes we need to act immediately to rapidly decarbonize, in order to prevent catastrophic effects and to reduce total costs of abatement.
- Person 2: Believes climate change is perhaps real, but thinks that our current path is roughly correct, because technological change[3] will make it easier to reduce emissions later (and without triggering massive a massive climate catastrophe). In theory they could also doubt climate change altogether, although these hard skeptics may be unlikely to trust the neutral international body.

The economically optimal approach is to reducing emissions is to continue to do more and more mitigation until the cost of each additional unit of mitigation is equal to the value of that mitigation, that is, to the social cost of carbon (See the Appendix for more details). Note that the social cost of carbon differs from the price of a carbon offset. The price of carbon offsets is determined by supply and demand, so if people do not take climate change seriously enough (or if those who take it seriously don't have sufficient cash) the price will be low. The social cost of carbon, however, is derived from an economic model of the impact of additional carbon emissions on the economy, such as through natural disasters that destroy property or cause agricultural failures.[4]

The mechanism we propose aims at achieving this optimal path and thus relies on the value of the social cost of carbon. While estimating this cost is difficult, as it depends on our understanding of climate change, technological innovation, etc., such estimates do exist, and indeed have been used by the US government for more than a decade to determine fuel economy standards and other policies. For an example of current estimates, a recent Brookings Institute working paper provides a scenario in which estimates range

[3] Such as viable carbon capture/ nuclear fusion/ modular fission/ agal fuels/ battery storage/ etc.

[4] Such an approach is in one way too narrow because we generally under-estimate the value of natural resources, since e.g. the true value of a rainforest goes beyond the lumber that could be harvested from it. But even relatively conservative models using this approach tend to price the value of carbon reductions higher than the market price for carbon offsets.

from \$56/ton to \$171/ton.[5]

The goal of creating our contracting mechanism is thus to align people's incentives around achieving economically optimal carbon mitigation, in a conservative way.[6] To do so, we define a smart contract for a given amount of emissions reductions in a given year whose value is only definitively established at expiration. Define the contract as based on $\$y$ worth of mitigation at time $t = 0$, with an expiration date, T, at which point the one who undertook the mitigation effort is rewarded with the social value of the emissions reductions they undertook ($v_{t=T}$).

Person 2, who thinks $v_{t=T}$ will be low, is willing to enter into this contract to receive an initial payment in $t = 0$, and accepts to pay at maturity whatever the independent research body determines is the social cost of carbon mitigation (at the time the mitigation was undertaken). Person 1, meanwhile, pays for mitigation upfront, and expects to be profit when their contract matures.[7] Note that they take on the risk that Person 2 defaults and isn't able to pay upon maturity. Thus, they might want to insurance against that risk, at some cost κ.)

Create a market in which parties can enter into these contracts, which thereby determines the price x that Person 1 pays to enter into the contract. For example, one approach would be that Person 1 pays $\$y$ for the mitigation in year t and wants a maturity in year T, and they set a ceiling for the contract price x and then sell it in an auction to the lowest bidder. (Person 1 wants the value to be low, Person 2 wants the value to be high).

Table 1: Summary of Payments and Receipts

	Person 1	Person 2
Pays	$y + x^* + \kappa$	$v_{t=T}$
Receives	$v_{t=T}$	x^*

So what are the basic calculus of the actors? Person 1 thinks that early mitigation is valuable, and thus that the ultimate payout ($v_{t=T}$) will be high. As a result they are willing to

[5]"Leading to central SCC estimates of \$56 and \$171/ton CO2 under 3 and 2 percent near-term stochastic discounting, respectively. (Errickson, 2021) p.38

[6]If Person 1 is wrong to invest early in mitigation, these early investments will be sub-optimal, but at least they will be the ones to bear the brunt of their error.

[7]One problem is that the contract could exist without Person 1 having to pay for mitigation at all, which would reduce it to just a futures contract on the value of the social cost of carbon. Those who want to actually do mitigation could still use this financial instrument, but financial speculators might buy up the contracts before them, thus driving down the mitigation actually achieved. One way to solve this would be for some entity to raise liquidity through issuing green bonds that they would use to underwrite the contracts (thus absorbing the cost κ) only for those entities who issue valid certificates of mitigation. This entity would thus (1) reduce financial risks and possibly financing costs, (2) oversee the mitigation work to ensure that, like carbon offsets, they are legitimately additional, verifiable, durable, etc.

engage the contract by paying for mitigation today in order to receive payout $v_{t=T}$ in, say, 10 years.

Person 2 thinks that the implied social cost of near-term reductions is too great, that is, either future mitigation will be cheap because of technology or the impacts of climate change are not actually that costly. So, they accept to pay, 10 years from now $v_{t=T}$ in exchange for receiving x^* at the start. If they are right, and mitigation gets easier over time, $v_{t=T}$ will not be that high (because, e.g. a lot of carbon mitigation will be done in future years at a lower cost).

2.1 When is a contract economically feasible?

We will do a simple analysis to identify the algebraic conditions under which a contract between the two parties is feasible. (If you prefer to explore the effect of different values I provide a python script to do so here). This is based on the assumption that Person 1 and 2 have different initial beliefs about the social cost of carbon (c_{true}) that is used to determine the value of the final payment ($v_{t=T}$).

Specifically, Person 1 believes that this will be high, while Person 2 believes it will be low, where for example c_1 is Person 1's belief about the social cost of carbon at the time of entering into the contract ($t = 0$). For concreteness, you could imagine that person 1 believes in the high estimate from the Brookings Report ($c_1 = \mathbb{E}(c_{true}|\text{P1 beliefs}) = \$171$) and Person 2 believes in the low estimate ($c_2 = \mathbb{E}(c_{true}|\text{P2 beliefs}) = \$56$).

Person 1 considers whether to make some investment $\$y$ in mitigation at the outset, during which the cost per ton of mitigation is $\$m$, yielding $\frac{y}{m}$ tons of CO2 reduction. They will make the investment if, given the cost of entering the contract x^*, and the financing cost κ, they nonetheless stand to profit when they receive the payment (from Person 2) when the contract matures in t years, above some expected rate of return r.

So Person 1 will participate if:

$$\frac{y}{m}c_1 > (y + x^* + \kappa)(1 + r)^t$$

We solve this in terms of x^*, to identify the maximum they are willing to pay for the contract:

$$x^* < \frac{\frac{y \cdot c_1}{m}}{(1 + r)^t} - y - k \tag{1}$$

Person 2 will participate if the initial payment they receive x^* is greater (assuming the same rate of return r) than their eventual payment at the end, based on their belief about the social cost of carbon. So they will participate if:

$$x^*(1+r)^t > \frac{y}{m}c_2$$

If we solve this in terms of x^*, we have a condition for the minimum they are willing to accept in the initial period to pay the maturity value:

$$x^* > \frac{\frac{y \cdot c_2}{m}}{(1+r)^t} \tag{2}$$

Combining (1) and (2), a contract is feasible if:

$$\left[\frac{\frac{y \cdot c_1}{m}}{(1+r)^t} - y - k\right] - \frac{\frac{y \cdot c_2}{m}}{(1+r)^t} > 0$$

Re-arranging, and substituting δ^t (a discount factor) for the expression $\frac{1}{(1+r)^t}$, we have:

$$\frac{y \cdot \delta^t}{m}\left(c_1 - c_2\right) - y - k > 0 \tag{3}$$

Implications

- Differences in beliefs about the social cost of carbon are necessary to drive the contract; to compensate for the investment in mitigation and insurance costs κ.
- The higher the cost of mitigation (m), the harder it is to have a contract.
- The higher the rate at which the two sides expect to profit (r), or equivalently, the higher the discount factor (δ), or the longer the time period; the more difficult it is to contract. [8]
- The greater the insurance cost (κ), the harder it is to contract.

2.2 Toy Model

To provide a sense of what this might look like, we can plug in some arbitrary values. Say Person 1 makes a \$1,000 investment in mitigation, the cost of mitigation is currently \$20/ ton, and they expect a 6% return on their investment over 5 years. Assume that Person 1 and 2 believe in the low- and high-estimates provided in the Brookings report, so $c_1 = \$171$, $c_2 = \$56$. Then Person 1 believes at the outset that they will receive \$8550 at the end of the contract and Player 2 believes they will pay \$2800.

Then ignoring the insurance cost, they can agree on a contract with x^* between \$2092.32 and \$5389. Alternatively, a contract is possible so long as the insurance cost is less than \$3296.

[8]However, under short time horizons, there might be little difference in their expectations, and/ or high uncertainty about the outcome of the determination of the social cost of carbon.

3 Conclusion

Make uncertainty a *lever*, rather than an obstacle: We argue that if parties are willing to trust an authority to estimate the social cost of carbon as well as the contracting platform, then it is possible to make use of their differences in opinion to finance early investments and elicit the market's belief about the optimal path to climate change mitigation. If so, this would bypass the veto of interest groups who oppose action. It would, we argue, generate higher investments than a system of green bonds and voluntary carbon offsets markets, and would also avoid transferring the full cost of these investments to future generations.

In the Appendix (currently incomplete) I consider the assumptions needed for the contract to be possible, such as (1) the viability of an independent, unbiased body to determine the social cost of carbon that is not susceptible to bribes.

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Appendix

4 Assumptions

Assumption 1. *The independent research body: Existence of a credible, neutral body to estimate the social cost of carbon, whose estimates improve over time.*

On the one hand, researchers have already provided estimates of the social cost of carbon. While these are not currently very precise, we could hope that this precision improves over time, and it is only necessary for it to be plausible at the end of the contract period. A second concern is their neutrality, as well as their *perceived* neutrality. If people see them as biased, one side or the other will be unwilling to engage in the contract. Could the institution be manipulated for financial gain? For example, a cabal of type (2) people could try to bribe the organization to under-state the social cost of carbon. That said, the type 1 people have a lot of money on the other side so they should be carefully monitoring this possibility. Regardless, doubts about the credibility and neutrality of this source lead to under-provision of carbon reductions.

Assumption 2. *Verifiable, additional climate mitigation*

The scheme requires climate reductions to be additional, permanent, etc, just like carbon offsets. While current offsets are a disaster, presumably it is a problem that can be overcome. Of course if mitigation is over-stated or there is doubt about the validity of carbon reductions, this will mean climate change mitigation will be under-provided.

Assumption 3. *Financial viability of contracts in a high-carbon-cost world*

If type (2) actors under-estimate the cost of warming, they could find themselves unable to pay the amount required at the end of the contract. One approach would be for the contract to require type 2 people put some capital in escrow to ensure the ability to pay or to buy insurance that ensures payment.