A Policy Framework for Controlling Both Old and New Carbon Emissions

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Climate change is driven by the accumulation of years' and centuries' worth of carbon emissions. Yet economic solutions to climate change focus on controlling each year's new carbon emissions rather than the accumulated stock of recent and historical emissions. In particular, the standard prescription is to price new carbon emissions to reflect the damages they impose on societies and the planet. This price could be implemented through a tax or, nearly equivalently, through a cap-and-trade scheme such as the European Union has developed. Emitters would compare the true cost of emitting to the cost of eliminating each unit of emissions, choosing to eliminate emissions only when doing so creates value. A high enough price could even drive emissions to zero, as several major economies have recently proposed for the middle of the century.

However, the harm from accumulated carbon emissions in the atmosphere continues even once new emissions are zeroed out. And atmospheric carbon can actually be cleaned up directly: we can suck carbon out of the air through machines, we can capture emissions when generating power from biomass, we can crush rocks to absorb airborne carbon, we can modify oceanic environments to increase carbon uptake, and we can increase carbon uptake by soils and plants. In fact, many models show that meeting internationally agreed-upon climate targets will require large-scale cleanup of atmospheric carbon later this century. But a conventional emission price cannot incentivize such cleanup once emissions are zeroed out: raising the emission price does not incentivize carbon removal once there are no new emissions left to offset. If we are not going to rely on governments to directly fund carbon removal, then we are going to need new policy frameworks that incentivize cleaning up old emissions.

In a new working paper, I develop a new type of policy that incentivizes both limiting new emissions and cleaning up old emission. Instead of paying a conventional emission tax, an emitter posts a bond for each unit of emissions and receives a transferable asset, a "carbon share", in return. Each year, the government assesses the current cost of climate change (or discovers it by running a cap-and-trade program with an annually adjusted cap on cumulative emissions). It deducts those costs from all outstanding bonds and also pays shareholders a dividend from their bonds. If a carbon shareholder chooses to remove its underlying unit of carbon from the atmosphere, then it receives the remaining value of the bond in return. If it

chooses to leave its carbon in the atmosphere, then it receives the dividend and retains the option to remove its carbon at a later date.

Whereas a conventional emission price should be set equal to the expected future damage from carbon emissions, I show that the bond should be set equal to the worst possible damage from carbon emissions. The annual dividends are the difference between each year's worst-case damage and its realized damage. This new policy requires a policymaker to have less information than does a conventional emission price: a policymaker here needs to know only current damages and the worst case over all future damages, whereas optimally setting the conventional emission price requires developing a probability distribution over all future damages.

I show that the combination of the upfront bond and annual damage charges optimally incentivizes both reducing current emissions and cleaning up past emissions. The cost to emitters is the difference between the bond they post and the value of the carbon share they receive in return. I show that this difference is exactly equal to the optimal conventional emission price, so the incentive to reduce emissions is exactly the same as under conventional policy recommendations. Once emissions are already in the atmosphere, carbon shareholders compare the cost of removing carbon to the expected value of all future damage charges. They choose to remove the underlying unit of carbon if damage charges look to be severe or removal turns out to be cheap. This is exactly the calculation we would like them to do.

One might be concerned that the upfront bonds can challenge emitters' liquidity. In fact, the challenge is not so severe. First, I show that a reasonable bond may be around twice the conventionally recommended emission price. We do not usually think of this price as challenging emitters' liquidity. Second, emitters receive a valuable carbon share that they can sell on. Their net outlays are thus equal only to the conventional emission price, regardless of the magnitude of the bond.

One might also be concerned that carbon lasts a long time in the atmosphere but firms often vanish. What if emitters declare bankruptcy before removing their carbon from the atmosphere? The beauty of the proposed policy is that it is invulnerable to bankruptcy. The carbon shares are attractive assets that investors want to hold. They are not costs that creditors want to shed. Somebody will pick up a firm's carbon shares even if it declares bankruptcy.

This new policy improves on banking emission tax revenue to fund later carbon removal. We will most urgently need carbon removal precisely when damages turn out greater than expected. In this case, early emission taxes were smaller than required by the true scale of damages. There may not be enough emission tax revenue precisely when we need carbon removal most. In contrast, the carbon share policy's bonds should be large enough to fund any removal that turns out to be optimal.

The gains from transitioning to a carbon share policy are larger the sooner we start: the longer the timespan of emissions covered by the scheme, the more emissions that may eventually be removed. The gains are also larger when current policies are weaker than they should be, so that high current emissions make future carbon removal more likely. Given that much of the world is pricing emissions only slightly or not at all, it is important to begin designing today's policies to facilitate potential large-scale carbon removal in the decades to come.