Curbing emissions through (efficient) carbon liabilities: A note from a climate skeptic's perspective

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Curbing Emissions through (Efficient) Carbon Liabilities: A note from a climate skeptic's perspective*

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Abstract

We propose a new climate policy that is efficient, robust, and asks for payments proportional to realized climate damage. In each period, countries are made liable for their share of the responsibility in the current damage. Efficiency follows from countries' anticipations of climate change, hence of future payments. Robustness is achieved thanks to the introduction of a market for carbon liabilities. Rather than being based on the expected discounted sum of future marginal damage (as with a carbon tax or tradable emission permits) our proposal relies only on observed realized damage and on the well-documented emission history of countries.

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Climate policies that rely on economic instruments, such as emissions taxes or cap-and-trade programs, exact immediate payments on the basis that climate damage will occur in the future. In principle, an optimal carbon tax asks emitters to pay today the expected discounted marginal damage of emissions,

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according to some climate damage scenarios—over the next decades, sometimes centuries—that may or may not materialize. Likewise, the number of tradable permits issued in an efficient cap-and-trade programs is also contingent on said scenarios, effectively costing emitters the full expected consequences of their emissions flows upon emitting. Should these scenarios or mankind's responsibility in them prove inaccurate, such anticipatory schemes would cause needless disruptions to the economy.

Instead, we argue in favor of holding countries liable for climate damage arising from their greenhouse gas emissions through the creation of a market for liabilities. Concretely, emitting CO_2 in the atmosphere would be accompanied by the issuance of a *carbon liability*: a legal duty for the bearer to pay damages over time as climate damage occurs.[1] In other words, the bearers of carbon liabilities would be repaying their debt to the world in installments rather than upfront. Carbon liabilities would not expire, but would instead decay at the same rate as atmospheric CO_2, all the while holding its bearers accountable for paying *carbon damages* as climate damage occurs. Carbon liabilities could be sold to other countries, by *paying* them to honor their newly acquired responsibility in future climate damage. Free trade on the global market would ensure efficiency.

The idea of using liabilities as a means to controlling externalities traces back to Calabresi (1970) and was recently compared to corrective taxation in Shavell (2011). On the one hand, regulation (taxation) is costly even in the absence of damage, whereas a liability approach only kicks in when harm actually occurs. On the other hand, a liability approach is typically more informationally demanding because it requires establishing tort (Kolstad et al, 1990; Shavell, 2011). Hence, a liability approach is likely to be more appropriate in situations where damage is highly uncertain but where its source can be easily established. This is precisely the case of climate change, where the magnitude of damage is typically unknown but the responsibility of countries towards CO_2 concentration can be readily established thanks to available data on cumulated CO_2 emissions per country (CAIT, World Bank).[2]

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[1] For expositional purposes, we shall speak only in terms of CO_2.

[2] The liability approach is usually discussed in the context of tort law, involving private parties and legal costs attached to lawsuits, to establishing due care and negligence. By contrast, the liability approach we consider here is public, in the sense that it involves countries, and would consist in an automatic procedure where the negligence rule plays no role. Countries would be held responsible for climate damage according to their past emissions.

Even in absence of (environmental) externalities, some intervention may desirable in economies with uncertainty. There are several reasons for that, like imperfect insurance markets and misperception of risks. But even without these "market imperfections", the very existence of idiosyncratic risk generates ex-post inequality—*ex ante* equal agents, taking identical decisions, end up generally unequal *ex post*—to which it is very difficult *not* to object. We deal with the issue of environmental inequality as following from the arbitrary (geographical) distribution of damages in a separate paper. In practice, the revenues generated from carbon damages could accrue to an international climate fund and be redistributed in an efficiency-preserving fashion (Billette de Villemeur and Leroux, 2011).

Abstracting from redistributive concerns, we consider here the intertemporal optimal allocation problem as attached to climate change.[3]

1 Efficiency

Let $\{D_t\}_{t=0}^{+\infty}$ denote the flow of stochastic damage as attached to anthropogenic climate change. At any period, the occurrence and the magnitude of this damage is assumed to be an increasing function of Z_t, the current stock of anthropogenic CO_2 in the atmosphere. Our proposal consists in converting CO_2 emissions into financial debt. More precisely, in each period, all countries are required to contribute to an international climate fund to the tune of $\mu_t Z_t^j$ where $\mu_t = \frac{dD_t}{dZ_t}$[4] is the marginal climate damage due to anthropogenic emissions and where $Z_t^j = \sum_{s=-\infty}^{t} \gamma^s X_s^j$ is the contribution of country j to the stock Z_t (it is the discounted sum of its past emissions X_s^j, for all $s \leq t$, accounting for their natural decay at rate $1-\gamma$).

Proposition 1 *Such a carbon debt scheme yields first-best emission patterns.*

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[3] Hammond (1981) considers the problem of implementing optimal intertemporal allocations in the presence of risk. In a setting where the welfare theorems apply, with competitive contingent markets and in the absence of externalities, he argues that bonds may be able to correct the imperfections of an Arrow-Debreu market economy when individuals misperceive risk. We argue that carbon liabilites play a similar role to Hammond's bonds in the presence of an intertemporal climate externality. [Vérifier]

[4] Unlike in tort law, we do not aim for "full liability" because it is not optimal to cover all the costs. Rather, we require countries to pay for the marginal damage they induce, hence our use of the phrase "efficient carbon liabilities".

Proof. Under rational expectations, country i evaluates its present net benefit as:

$$B^i = \sum_{t=0}^{+\infty} \beta^t \left[B_t^i \left(X_t^i \right) - \mu_t Z_t^i \right], \tag{1}$$

Country i then chooses an emissions stream $\left(X_t^i \right)_{t=0}^{\infty}$ such that:

$$\frac{\partial B_t^i}{\partial X_t^i} = E_t \left[\sum_{s=t}^{+\infty} \beta^{s-t} \mu_s \frac{\partial Z_s^i}{\partial X_t^i} \right] = E_t \left[\sum_{s=t}^{+\infty} (\gamma\beta)^{s-t} \frac{\partial D_s}{\partial Z_s} \right] \tag{2}$$

under the usual Pigovian assumption that no single agent has an impact on marginal damage. Each country equalizes its marginal benefit with the expected discounted value of marginal climate damage, thus achieving first-best efficiency.■

Notice that the only information required of the planner to implement our scheme, on top of the well-documented emission history of countries, is $\mu_t = \frac{dD_t}{dZ_t}$: the marginal impact of current anthropogenic CO_2 concentration on the *current flow* of climate damage. While obtaining this information accurately may be no small task, it seems far less daunting to be working with observed data than with predictions over future decades or centuries. Indeed, the information required to implement an efficient carbon tax, τ, or the equivalent cap-and-trade program is the *expected*, *discounted* sum of the marginal impacts of current emissions on *future* climate damage:

$$\tau_t = E_t \left[\sum_{s=t}^{+\infty} \beta^{s-t} \frac{\partial Z_s^i}{\partial X_t^i} \frac{\partial D_s}{\partial Z_s} \right] = E_t \left[\sum_{s=t}^{+\infty} (\gamma\beta)^{s-t} \frac{\partial D_s}{\partial Z_s} \right].$$

From a policy standpoint, implementing our carbon debt policy is simpler than implementing a cap-and-trade program. Under our scheme, carbon debt is issued and allocated systematically based on each country's observed emissions. By contrast, cap-and-trade schemes require a planner to issue and allocate permits with the obvious risks of miscalculation and misallocation, respectively.

The upshot of requiring less of the planner is that much more freedom is left to the countries, thus allowing for more decentralization than, say, a carbon tax policy. Specifically, countries make their own predictions about future damage and work with their own discount factors. Section 2 addresses how trade can maintain efficiency in the case where countries have different discount factors and different expectations about future anthropogenic climate damage.

2 Robustness

If debt can traded, our approach is robust to heterogeneity in discount factors and to diverging forecasts. If discount factors and forecasts are country-specific Expression (2) becomes:

$$\frac{\partial B_t^i}{\partial X_t^i} = E_t^i \left[\sum_{s=t}^{+\infty} (\gamma \beta_i)^{s-t} \mu_s \right]$$

where β_i and E_t^i are the discount factor and the expectations of country i, respectively.

Country heterogeneity would yield trade opportunities: a market for debt would leave it to countries to determine how much debt they wish to hold based on their predictions of future climate change damage. Should opinions differ on the likelihood and magnitude of future damage, or on the discount rate, efficiency would be maintained through trade.

Specifically, given a competitive market price, p_t, countries may choose to buy carbon debt—and be *paid* to do so—or to sell them, by paying others to hold debt in their stead.

Proposition 2 *Consider a carbon debt scheme where installments are set to current marginal climate damage:* $\mu_t = \frac{\partial D_t}{\partial Z_t}$. *Allowing carbon debt to be traded maintains efficiency while decentralizing preferences and beliefs.*

Proof. We show that efficiency is robust to heterogeneity in countries' discount factors. The proof assuming countries formulate different expectations about future damage, E_t^i, proceeds similarly.

Suppose countries have heterogeneous discount factors. Assume country j sells Y_t^j units of the debt associated to its current emissons, $X_t^j + Y_t^j$. Its expected net present benefit writes as follows:

$$B^j = \sum_{t=0}^{+\infty} \beta_j^t E_0 \left[B_t^j \left(X_t^j + Y_t^j \right) - p_t Y_t^j - \left[\mu_t Z_t^j + c_t^j \left(p_t Z_t^j \right) \right] \right],$$

where c_t^j is the cost of holding financial debt for country j at date t and

$$Z_t^j = \gamma Z_{t-1}^j + X_t^j$$

is the amount of carbon debt held by country j at date t.The sole purpose of introducing a cost of holding financial debt is to ensure an interior solution. We interpret it as country default risk and therefore assume it to be negligible for usual levels of debt. We assume c_t^j to be increasing, strictly convex, and such that $c_t^j\left(0\right)=0$.

Similarly, assume country i purchases Y_t^i units of debt, as measured in carbon stock units. Its expected net present benefit writes as follows:

$$B^i=\sum_{t=0}^{+\infty}\beta_i^t E_0\left[B_t^i\left(X_t^i\right)+p_t Y_t^i-\left[\mu_t Z_t^i+c_t^i\left(p_t Z_t^i\right)\right]\right],$$

where the carbon stock for which country i is considered to be responsible now writes:

$$Z_t^i=\gamma Z_{t-1}^i+X_t^i+Y_t^i$$

From the point of view of a net seller of carbon debt, the first-order conditions write as follows:

$$\begin{aligned}\frac{\partial B_t^j}{\partial X_t^j} &= E_t\left[\sum_{s=t}^{+\infty}\beta_j^{s-t}\frac{\partial Z_s^j}{\partial X_t^j}\left[\mu_s+p_s c'^j\left(p_s Z_s^i\right)\right]\right]\\ &= E_t\left[\sum_{s=t}^{+\infty}\left(\gamma\beta_j\right)^{s-t}\left[\frac{\partial D_s}{\partial Z_s}+p_s c'^j\left(p_s Z_s^j\right)\right]\right]\\ \frac{\partial B_t^j}{\partial Y_t^j} &= p_t\end{aligned}$$

From the point of view of a net buyer of carbon debt, the first-order conditions are the following:

$$\begin{aligned}\frac{\partial B_t^i}{\partial X_t^i} &= E_t\left[\sum_{s=t}^{+\infty}\beta_i^{s-t}\frac{\partial Z_s^i}{\partial X_t^i}\left[\mu_s+p_s c'^i\left(p_s Z_s^i\right)\right]\right]\\ &= E_t\left[\sum_{s=t}^{+\infty}\left(\gamma\beta_i\right)^{s-t}\left[\frac{\partial D_s}{\partial Z_s}+p_s c'^i\left(p_s Z_s^i\right)\right]\right]\\ p_t &= E_t\left[\sum_{s=t}^{+\infty}\beta_i^{s-t}\frac{\partial Z_s^i}{\partial Y_t^i}\left[\mu_s+p_s c'^i\left(p_s Z_s^i\right)\right]\right]\\ &= E_t\left[\sum_{s=t}^{+\infty}\left(\gamma\beta_i\right)^{s-t}\left[\frac{\partial D_s}{\partial Z_s}+p_s c'^i\left(p_s Z_s^i\right)\right]\right]\end{aligned}$$

It follows that, for all i:

$$\frac{\partial B_t^i}{\partial X_t^i} = p_t,$$

and for all j

$$p_t = \frac{\partial B_t^j}{\partial Y_t^j} = \frac{\partial B_t^j}{\partial X_t^j},$$

yielding efficiency.■

A possible interpretation of Proposition 2 is that our scheme allows for diverging opinions regarding climate change.

It is noteworthy that our mechanism is also robust in the sense of being immune to manipulation both in the discount factor and in the expectations because the final allocation of debt is a competitive market outcome.

Remark 3 *Because our scheme financializes the carbon debt, failure to honor the latter is now no different than a default in the repayment of financial debt.*

Hence, the introduction of a market for carbon debt makes our mechanism deviation-proof and robust to misrepresentation.

3 Liability

Although there is some evidence that climate change already has an impact on economic outcomes, climate damage remains highly uncertain and volatile. It follows that ex ante approaches to climate policy exhibit the unappealing feature of possibly requiring high payments when realized damage is low. To avoid this disconnectedness we turn to a liability approach, which links payments to realized harm.[5]

Assume that payments are adjusted according to realized damage, $D(Z_t)$. More precisely, assume that countries are actually required to pay $\mu_t Z_t^i \mathbb{I}_{D_t}$, where

$$\mathbb{I}_{D_t} = \frac{D(Z_t)}{E_t[D(Z_t)]}$$

is the ratio of the realized over the expected damage.[6]

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[5] A similar debate already exists within tort law, comparing the regulatory approach with the liability approach. One of the main advantages of the latter is that payments reflect realized harm whereas the former is based on the possibility of harm. On this, see Shavell (1984, 2011) and Kolstad et al (1990).

[6] Expectation is assumed to be taken at the beginning of the period.

Proposition 4 *The liability rule* $\mu_t Z_t^i \mathbb{I}_{D_t}$ *is first-best efficient, robust and yields payments proportional to realized climate damage.*

Proof. By definition, $E_s\left[\mathbb{I}_{D_t}\right] = 1$ for all $s \leq t$, so that expected payments are unchanged. Hence, from Proposition 1, the liability rule is first-best efficient. For the same reason, from Proposition 2, it is robust to misrepresentation and deviations. Furthermore, $\mu_t Z_t^i \mathbb{I}_{D_t}$ is indeed proportional to realized harm:

$$\begin{aligned} \mu_t Z_t^i \mathbb{I}_{D_t} &= \frac{dD_t}{dZ_t} Z_t^i \frac{D_t\left(Z_t\right)}{E_t\left[D\left(Z_t\right)\right]} \\ &= \frac{Z_t^i}{Z_t} \frac{\left(dD_t/dZ_t\right)}{E_t\left[D_t\left(Z_t\right)/Z_t\right]} D_t\left(Z_t\right). \blacksquare \end{aligned}$$

If the damage function, D_t, were linear, payments would exactly cover total damage and countries would pay in proportion to their emission contributions: $\mu_t Z_t^i \mathbb{I}_{D_t} = \frac{Z_t^i}{Z_t} D_t\left(Z_t\right)$. If the damage function is convex, total payments add up to more than the realized damage because first-best efficiency requires going beyond full liability.[7]

Remark 5 *Full liability constitutes a conservative policy where payments rely only on realized damage, and not even on some estimate of the marginal damage function. In Europe and in the U.S., the field of environmental damage estimation is already well developed.*

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[7] The incompatibility between first-best efficiency and budget balance is well-known. See, e.g., Billette de Villemeur and Leroux (2011).

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