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DRAFT

Abstract

Funding a response to climate change after Kyoto will require another look at both burden sharing and funding mechanisms. After reviewing the risks of cap-and-trade with carbon offsets and the advantages of a harmonized carbon tax, a method is proposed to utilize a harmonized carbon tax to finance a global climate fund. A common carbon tax rate is assessed across all nations and collected internally for internal investments in climate change. Financing for the global climate fund is generated from transferring a percentage of the collected carbon tax based on historical responsibility for carbon emissions and national wealth. Collected revenue is disbursed for climate aid based on a set of national climate need factors for adaptation, preserving strategic carbon sinks, low-carbon infrastructures and population management. In the interest of distributive justice, nations themselves determine the need factors of each other. Unlike cap-and-trade, this method does not explicitly require emissions caps. Formulas are presented for collection and disbursement, which require parameters for a globally harmonized carbon tax rate, a climate fund contribution rate, a national wealth threshold for fund contributions and need factors for each nation. Published economic and emissions data are used with the formulas to demonstrate an example of how the financing can work. This presents an equitable way to address climate needs across all nations on both a global and regional level.

JEL: E01, F18, F35, F51, F53, Q54, Q56

Keywords: climate change; global warming; climate fund; carbon tax; cap-and-trade; climate finance; Kyoto protocol

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1. Introduction

Efforts to develop a truly effective global carbon emissions treaty have proven to be very difficult, as was evident at the Copenhagen climate summit. Key challenges are not only how to limit carbon emissions, but also how to fund this process globally. Unfortunately, the climate is not a linear system where differences can be split down the middle like a budget might be. Rather, the climate is more like a dynamical system, which accelerates between stable states. A large body of growing evidence suggests that the global climate is being pushed out of equilibrium, and at some point global warming will accelerate to the point of being unstoppable until a much warmer stable condition is reached. Current best estimates indicate present atmospheric CO_2 concentrations are already enough to cause a 2 °C rise in global temperatures (Schwartz et al. 2010). Global warming is likely to accelerate given positive feedback and as natural global heat and CO_2 absorbers shrink. Temperatures are rising faster at the poles, triggering the release of methane from the permafrost. Between 2003 and 2007, methane emissions from the Arctic increased by 31% (Bloom et. al. 2010). CO_2 levels have not been as high as current levels since 15 million years ago, when the climate was very different and global average temperatures were 3-6 degrees Celsius higher than they are today (Tripati et. al. 2009). Additionally, the global climate sensitivity to atmospheric CO_2 levels as estimated in the 2007 Intergovernmental Panel on Climate Change (IPCC) report are now considered to be on the low end. Each year, human beings burn carbon that took nature hundreds of thousands if not millions of years to sequester, thus there really is no way to sequester our way out of this with carbon offsets. Carbon emissions have to drop substantially. Carbon offsets purchased from developing nations are not likely to significantly reduce global emissions, because offsets can be used by purchasers to continue polluting at the same levels (Den Elzen & Höhne 2010). While equilibrium emissions of nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride may be attainable in the foreseeable future, equilibrium emissions of CO_2 and methane are much more difficult. However, it is necessary to get CO_2 and methane emissions down as quickly as possible.

Among other things, the Kyoto protocol (United Nations 1998) established some rules for sharing the burden of climate change impacts, as well as mechanisms to begin limiting carbon emissions. While Kyoto has made valuable contributions, the burden sharing rules have not been acceptable to the US, the only of 192 countries to sign but not ratify the treaty. The main issue from the US perspective is that emerging and developing nations are not required to limit emissions, even though this is where most of the emissions growth is occurring. It also puts the US at a competitive disadvantage with emerging economies such as China. Kyoto's description of burden sharing is discussed in article 10 and 11 of the protocol. Article 10 starts with:

"All parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, without including any new commitments for Parties not included in Annex I…"

This effectively means that all treaty nations are responsible for carbon emissions, but only 40 developed countries (Annex I) are required to make commitments. Article 11 states:

"The implementation of these existing commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among developed country Parties" and "The developed country Parties and other developed Parties in

Annex II to the Convention may also provide, and developing country Parties avail themselves of, financial resources for the implementation of Article 10, through bilateral, regional and other multilateral channels."

Thus, the 23 richest countries (Annex II) may provide financing to developing nations to reduce emissions. Although "differentiated responsibilities" leaves much to interpretation, it can be decomposed into responsibility for cumulative historical emissions (polluter pays) and national wealth (ability to pay). This is because when historical emissions and GDP per capita are highly correlated, the likelihood is greater that national wealth is a resulting benefit from fossil fuel consumption. Fossil fuel consumption also produces climate damage liabilities from carbon emissions, so nations that benefit more from burning higher amounts of fossil fuels should have higher burdens on these liabilities. Each emitted ton of CO_2 raises the social cost and damages of subsequent emissions, because it accumulates in the atmosphere with a half-life of about 31 years, further increasing temperatures. The higher the temperatures, the higher the damages. If the global climate was a linear system and each quantity of CO_2 caused a fixed incremental change in temperature, damages from these emissions would increase exponentially, since current emissions are much higher than decay. But considering that the global climate system is highly non-linear and is already becoming less stable, damages from emissions are likely to increase faster than exponentially.

Several studies by UNFCCC, World Bank, Stern, Oxfam, UNDP and others have sought to assess the total global costs of damages from climate change over time, using integrated assessment models (IAMs) and other economic models (Parry et al. 2009). The differences between damages with and without adaptation expenditures can be used to estimate the net present value of adaptation investments, with an appropriate discount factor. But these estimates are over a wide range and have serious limitations since some damages can be very difficult if not impossible to monetize. A changing average temperature can require an ecosystem or habitat to migrate to survive. But, when boundaries exist such as a sea or desert, a habitat can be driven to extinction or experience major losses in biodiversity. As another example, severe flooding in the Ganges river delta would likely have a catastrophic impact. Adaptation assumptions and discount factors are largely speculative, but can have large effects on outcomes (Ackerman et al. 2009). However, for the sake of discussion, let's assume the UNFCCC (2007) study is in the right range, estimating that $49-171 billion is needed globally per annum by 2030 for adaptation alone. That's a mean of $110 billion annually, which will continue to increase over time without mitigation funding to also reduce emissions and stabilize atmospheric concentrations. And without adaptation funding, climate damages are estimated to be 10x higher by 2060 (Parry et al. 2009). Consider that if the de facto liability for climate change damage is based on historical emissions, then the proportion of national liabilities from the total global climate damage could intuitively be based on a national percentage of cumulative global emissions. This means the US would likely have the highest burden in funding a climate change response, because it presently has the highest historical responsibility. So, why would the US participate in a global climate treaty when it might appear to be less costly to avoid it? Just considering the accumulating global liabilities from a US contribution of 26% of total historical emissions (1950-2007) from fossil fuels, these liabilities might be reduced by contributing roughly a factor of 10 less into a global climate fund. In addition, as a minimum, to not engage in a treaty would result in a loss of good will, less political influence, a weak internal market for green technologies, loss of trade exports, higher dependence on fossil fuels from both national and international sources and higher internal damages from climate change.

Still, there is a serious problem if emerging or developing economies do not have to establish emissions limits or set a price on carbon. Not only is it fundamentally unsustainable, but emerging and developing economies will soon be contributing over half of global emissions. Establishing a new treaty may come down to negotiating acceptable burden sharing rules, with each region asserting rules which favor them most. Emerging economies often discuss burden sharing based on emissions per capita. But this will not work, because key factors in emissions growth are fossil fuel driven development and population growth. If those cannot be controlled, then climate change cannot be controlled at all. If the entire world had European 2003 level emissions per capita, the planet only has a sustainable level of 2-3 Billion people (Desvaux 2007), which is about the world population size in 1950. Using emissions per capita can also actually encourage population growth, because a higher population size can translate into a lower emissions per capita. Because of higher productivity, the US may favor emissions by unit of GDP. Russia favors emissions by land area. (Ringius et al. 2002) But, the real issue is the carbon emissions itself, wherever it occurs.
The approach considered in this paper is to adjust burdens based on carbon emissions, taking into account historical responsibility and national wealth.

Basing burden sharing at least partly on carbon emissions requires setting a carbon price either directly or by imposing limits. IAMs and other methods try to establish the economic impact or social cost of carbon (SCC). Estimates of SCC have a large variance and high uncertainty. Some consider the economic models to provide weaker estimates than the more robust climate science models which they partly depend on (Ackerman & Stanton, 2010). Curiously, over the last several years, SCC estimates have been dropping, even as warming predictions get worse. Since these economic models are highly sensitive to initial conditions, it is likely possible to tune them for political acceptability by plausibly adjusting damage assumptions and discount factors. While this might appease policy makers, nature cannot be appeased. Even if these estimates of the SCC are correct, much of the damage is not actually adaptable. Further, the SCC estimates do not price in a remedy, considering that the SCC will continue to climb over time. And any carbon revenue based on the SCC may disappear into another public good or the private sector and not address climate change at all. Thus, the proposal presented here takes a different approach to pricing carbon. The only way to truly reverse the damages is not emit the carbon in the first place. While this is not possible, carbon removed in one location can compensate for carbon emitted elsewhere, both now and in the future. Thus, the cost of carbon equals the cost of simultaneous removal, but increases with a time delay of removal and rising temperatures. The price of simultaneous removal can be approached gradually, until an atmospheric equilibrium has been reached. At that point, carbon revenues should be fully utilized to maintain that equilibrium.

The Kyoto mechanisms, including cap-and-trade and CDM, have largely failed to limit global emissions growth. Kyoto also has not been effective in reducing carbon emissions within the developed and industrialized countries that have ratified it. Recent drops in emissions from some countries during the global recession are only temporary (Friedlingstein 2010). Estimates are that the European Union (EU) Emissions Trading Scheme (ETS) phase II (2008-12) caps will only constrain emissions on covered emitters by a mere 0.3%, with this difference and additional emissions growth allowable by purchasing cheap carbon offset credits from within the EU or elsewhere (Morris & Worthington 2010). Only a couple of countries such as Sweden have been truly successful reducing emissions under Kyoto and have done so largely because of a carbon tax, without the need of ETS. For example, Sweden adopted a carbon tax in 1991 and reduced emissions 9% between 1990 and 2006. The current Swedish carbon tax rate in industry is approximately \$75 per metric ton of CO_2 (MtCO2), although electricity producers are exempt. The general carbon tax rate outside of industry is \$150 MtCO2 and applies to fossil fuels such as petrol. Indications are that emissions would have been 20% higher without this (Global Utmaning 2009). Carbon taxes are often criticized with the claim that they will hurt economic recovery and growth. So, it is worth mentioning that the comparatively high carbon taxes in Sweden do not appear to be negatively affecting economic growth and competitiveness, considering that the Swedish GDP growth rate is estimated to be 4.3% for 2010 (NIER 2010) and Sweden is ranked 2nd globally by The World Economic Forum global competitive index for 2010.

2. The risks of cap-and-trade with offsets

Cap-and-trade was first used in the United States to reduce sulfur dioxide released into the atmosphere in order to combat acid rain. For this, cap-and-trade has been somewhat successful, but since sulfur emissions are much smaller than greenhouse gas emissions, confined to coal-related industries and not required for energy production when burning coal, it has been much easier to achieve a level of equilibrium in the atmosphere. Much was achieved by adding scrubbers to coal-fired plants and switching to coal with lower sulfur content. Greenhouse gas emissions are a very different problem because energy production is a product of burning fossil fuels, not from impurities in the fuels.

The risks of using cap-and-trade for CO_2 equivalent emissions are substantial and the failure of this approach is not likely to provide time for a second chance. Some of these risks have been described earlier by Nordhaus (2009) and others. In theory, capping emissions and trading the rights to pollute within the cap seems like a plausible approach. With auctions of emissions permits and a secondary market, working capital can be utilized to fund the most efficient ways to reduce carbon emissions in exchange for carbon credits, which can then be sold to industrial polluters where emissions reductions are more expensive. In practice, cap-and-trade becomes very complex as key assumptions are tested and real risks come to light. Cap-and-trade for CO_2 emissions has yet to be validated as effective within the ETS and cannot be truly validated until after caps are planned to shrink starting in 2013. In the US, a cap-and-trade system promising a 17% reduction from 2005 emissions levels by 2020 was included in a passed US house bill (H.R.2454) and three recently proposed US senate bills (S.1733; American Power Act; The CLEAR Act), but proposals have caps which are too high (Stanton & Ackerman 2010) and the number of emissions allowances do not drop below 2012 or 2013 levels until 2022 or 2023. This proposed legislation implies that any emissions reductions in the near term would be based on offsets. This also suggests that a truly global cap-and-trade system as envisioned by the Kyoto protocol cannot be validated until the mid 2020’s, which is too late.

While defining a cap can be an important tool, it is almost meaningless without verification, integrity and enforcement. The weakest link in a cap-and-trade system with offsets is carbon offset integrity both inside and outside the Clean Development Mechanism (CDM). The basic assumption is that participants in offset exchanges will act with self interest, but follow rules which will indirectly aid the global interest. However, human behavior does not typically follow this assumption. While the rule of law affects behavior, law in this domain is currently primitive. Even with laws in place, they must be enforced, but still will not prevent pathways around those laws which are not in the global interest. Offset projects in developing countries may be difficult to verify, because they may not be easily accessible. Carbon offsets are supposed to be eligible for credits if a project would not have been done anyway. However, this is difficult to validate. Suppose a company may or may not cut down their forest for timber. If the company is paid not to cut down a forest, the demand can just shift elsewhere. Money would be paid for offsets, even though there were no real offsets. There is also a significant measurement risk. Gold can be easily weighed, so it makes an excellent commodity. Measuring the amount of carbon sequestered from a forest, landfill or farm is quite a different matter. Planting and counting trees is not enough, because trees can die and rot from disease or forest fires can occur. In the case of the Noel Kempff forest preservation project for creating carbon offsets, estimated CO_2 emissions reductions dropped 90% from original estimates (Densham et al. 2009). Although forest preservation is critical, funding does not have to be based on a carbon market. The CDM has already resulted in multi-billion euro offset frauds, including the case of deliberate overproduction of refrigerant in China, in order to sell destruction of the HFC-23 byproduct for carbon credits (Wara 2007), which for a time was almost 30% of the entire market. Carbon credit carousel fraud in the EU ETS resulted in losses of about 5 billion euros in 2008-2009 and is estimated to account for 90% of the carbon trading volume in some countries (Europol 2009). In auction markets for carbon allowances, blocks of allowances are auctioned for future emissions, so a secondary market is usually necessary for trading excess supply and demand. Auction allowances can be awarded over long fixed time periods, adding additional legal, business and environmental constraints that can take years to unwind. These allowances can lock in business decisions on deploying low-carbon infrastructure and are not adaptable to changing environmental conditions. There is also the possibility that global financial firms could buy emitters to access the auction market, buy up auction rights by outbidding other emitters and then sell emissions securities back to them at a higher cost. In addition, a corruption risk exists when permits and allowances are allocated by politicians to special interests, particularly in their jurisdictions.

Financial corporations and traders act with self interest, sometimes regardless of the consequences. Ceding control of carbon emissions to very large financial firms with an appetite for risk and profits would have substantial risks. Some of these firms have manipulated the energy, oil, mortgage and currency markets in the past, at the expense of the common good. Not long ago Enron was heavily manipulating the electricity and energy market to cause price spikes and the world is still reeling from the mortgage crisis. Although these markets are different in some respects to carbon market, manipulation was driven by the same common human behavior which would be active in carbon markets. Similar foreseeable and unforeseeable things can happen with derivatives on offsets, allowances and permits. Some of what is likely to happen is predictable, because it has happened before. Carbon allowances and offsets can be pooled and securitized. This gives financial firms the power to buy the offsets and offset projects they like and directly control the offset market, forcing most companies to buy emissions securities from them. Financial firms would charge transaction and management fees on the pools, buy the cheapest carbon allowances and offsets, and may hide the source, effectiveness and compliance or use a rating firm they hire to assert the carbon instruments are effective. This is similar to what happened in the mortgage market and caused the current global financial crisis. Even in the mature mortgage industry, many home owners cannot find out who owns their mortgage or what mortgage-backed securities pool their mortgage went into. And the financial firms paid ratings agencies to provide high ratings on their sub-prime and other mortgage pools, which ultimately failed. In a new carbon market, this kind of behavior is very likely to occur with carbon instruments. Consider carbon offset origination companies that go into the business of creating domestic and international offsets. Companies selling offsets at a profit would be encouraged to exaggerate their offsets and cut corners to increase profits, forcing other companies to either do the same or go out of business. Offset originators could also create and flip an offset project without considerations of the affected communities, which may lead to inefficient community offset strategies. The risk is huge transfers of capital to financial firms and ineffective carbon reductions. Carbon traders can make profits with arbitrage and momentum trades, which they would be able execute before the intended users of a carbon market could, such as the energy intensive businesses and governments. Linking cap-and-trade markets around the world would enable global high-speed arbitrage trades which carbon trading firms would have privileged access to. Global carbon trading firms would effectively have their own tax on carbon, draining resources which could have been used more directly to reduce carbon emissions. Secondary carbon markets also have price volatility, adding risk to companies who might need to buy emissions credits. Speculation in carbon instruments do not increase capital for carbon investments, they just increase price volatility, and this volatility can also provide poor price signals for investments in carbon emissions reduction, discouraging investment. Cap-and-trade with offsets can also create perverse effects, such as the movement of manufacturing to poorer countries with low emissions and higher caps, effectively reducing manufacturing costs and then forcing competitors to do the same. However, this would result in increased transport of parts and finished products between manufacturing sites and markets across the world, actually increasing total CO_2 emissions. Global shipping now accounts for about 5% of the total carbon emissions and is already expected to grow substantially.

The global financial system is highly complex, having evolved over much of the 20^{th} century, often during economic crises. Yet, it still needs a lot of work. Cap-and-trade with offsets essentially establishes a whole new monetary system of huge complexity in a short period of time. ETS thus far is still experimental with questionable results. The real risk is that even with a huge effort it still may not work due to complexity, and irreplaceable time will have been lost. Some have argued that the complexity of the climate problem requires a market based approach, therefore carbon trading is necessary. However, there are several markets involved, including for renewable energy, low-emissions products, technologies and services for carbon sequestration. Climate financing can be a based on lending, rather than carbon markets and trading. There is nothing inherently inefficient about a tax based on a stable carbon price of a global commodity common in the atmosphere, particularly with increasing climate change costs for the foreseeable future. In addition, due to high complexity, carbon trading adds substantial regulatory risks and high overhead.

3. A harmonized carbon tax

Many of the risks of cap-and-trade are substantially reduced or eliminated if a carbon tax is used instead and harmonized across the world. This has been suggested previously in a Swiss proposal during the COP13 Bali Climate Conference (UVEK 2008), (Nordhaus 2009) and by others. The approach detailed here suggests that the global price for carbon emissions per metric ton of $C0_2$ equivalent (MtCO2e) be based on a percentage of the actual cost to remove carbon from the atmosphere. Over time, the harmonized carbon tax can incrementally increase over 40 years until 2050 to reach the true cost of removing the carbon from the atmosphere, adjusting down as the cost of removal drops. By some estimates, the current cost of CO_2 removal by air capture is estimated to be near $360 per metric ton in 2007 dollars, but may not drop below $100 before 2050 (Pielke

2009). If the cost of CO_2 removal is initially estimated to be $360 in 2050, then a harmonized carbon tax can incrementally increase by $9 each year, starting at $9 in 2011. This tax would start low, but provide predictability and incentives for industries and other emitters to become more carbon efficient.

The tax would be assessed on whatever party emits the CO_2. For example, when coal is burned for electricity, the utilities would pay the tax on carbon emissions. For oil products, emissions taxes from extraction and refinement would be paid by the producers, but the taxes on CO_2 released from burning the fuel would be paid by consumers, such as an added petrol tax. Methane emissions in non-farm sectors could also be taxed at higher levels than CO_2, since it causes 21 times more heat retention. This would encourage collecting and burning Methane to produce energy whenever possible, even though a byproduct is CO_2. Countries would collect carbon taxes internally and invest those funds internally strictly in climate change adaptation, low-carbon infrastructure, protecting natural carbon absorbers, climate research and monitoring. This would create economic growth and fuel the right kind of carbon market, one for creating and implementing solutions. Companies might also deduct investments in carbon emissions reduction from the carbon tax. A harmonized carbon tax would be much easier to implement and adds badly needed elements of certainty and predictability. It is also more adaptable to changing environmental conditions, unlike national cap-and-trade plans with fixed targets. Further, Carbon taxes do not require a secondary market since taxes can be paid based on actual emissions.

4. A global climate fund

A global climate fund has been proposed in the past by Switzerland (Multilateral Adaptation Fund), Japan (Cool Earth Partnership Fund), Mexico (World Climate Change Fund), Mexico-Norway (Green Fund) and most recently at the Copenhagen climate summit (Copenhagen Green Climate Fund). The global climate fund detailed here is perhaps most similar to the Swiss proposal, but with different funding and disbursement strategies. The global climate fund would aid developing nations in climate adaptation, mitigation such as development of cleaner infrastructures, protecting carbon absorbers such as the rain forests and for managing population growth. In addition it would provide funding for R&D, climate monitoring and compliance on a global scale. Developed and industrialized countries have emitted much more CO_2 over time and have some historical responsibility. To compensate for this, each country would contribute a percentage of the internally collected carbon tax into a global climate fund, based on the total amount of CO_2 emissions from fossil fuel consumption by that country since 1950 and the country's national wealth. The contribution percentages can be scaled up or down, depending on the needs of the global climate fund. If a country is not party to the harmonized carbon tax agreement, a tariff equivalent to the carbon tax could be assessed on imported goods and services into compliant countries, with the entire proceeds going into the global climate fund. A country is encouraged to participate in the harmonized carbon tax agreement because that country can instead invest carbon tax collections internally on carbon emissions reduction projects. The harmonized carbon tax can also be applied to international shipping, with the entire proceeds going into the global climate fund.

Combined, the harmonized carbon tax and global climate fund would result in an inflow of capital into poorer countries to combat climate change. Global R&D funding can accelerate development of renewable energy and promising technologies such as Thorium nuclear reactors, which have a lower proliferation risk, are safer to operate and have less radioactive waste (IAEA 2005). When a viable technology is developed to remove CO_2 from the atmosphere directly, the global climate fund can purchase carbon removal as well. All this would require carbon accounting, monitoring and audits on the country and corporate levels. However, this accounting would be very similar to what is already done with government, corporate and personal monies around the world and is compatible with what has already been achieved by Kyoto protocol participants.

More formally, funding for the global climate fund can be based on a harmonized carbon tax T on MtCO2e emissions, current carbon emissions E_n of each nation, cumulative historical carbon emissions since 1950 nationally H_n and globally H_g national wealth W_n and a contribution rate G_r into the global climate fund of nationally collected carbon taxes. Equations will be presented using these values.

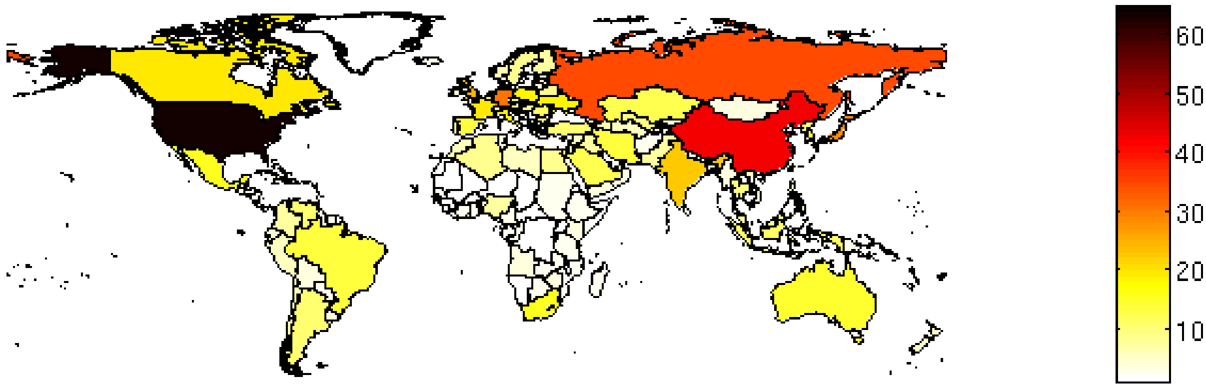

Figure 1. Historical emissions from burning fossil fuels 1950-2007 in billions of metric tons of carbon. Source data from T.A. Boden, G. Marland and R.J. Andres at CDIAC, Oak Ridge National Laboratory, 2009. Modifications were make to extend emissions in some countries backwards to 1950 by combining retroactively in cases such as the former East/West Germany or by using post-breakup ratios in cases such as the former Soviet Union countries.

Based on the cumulative emissions as seen in figure 1, national historical responsibility, R_n, can be represented as a ratio of national historical emissions H_n to global historical emissions H_g.,

$$R_n \triangleq \frac{H_n}{H_g} \qquad (1)$$

For determining national wealth, consider the following:

$$g_n \stackrel{\text{def}}{=} national\ GDP\ per\ capita$$
$$\sigma_g \stackrel{\text{def}}{=} standard\ deviation\ of\ the\ national\ GDP\ per\ capita\ across\ all\ nations$$

National wealth W_n is determined by subtracting the global mean of GDP per capita and an offset Z from the national GDP per capita g_n and dividing this by the standard deviation of the GDP per capita across all countries σ_g. Countries that have a GDP per capita below the global mean have a negative wealth factor, when the offset adjustment Z is zero. A positive Z pushes the zero cutoff towards richer nations and a negative Z pushes it towards poorer nations.

$$W_n = \frac{g_n - \langle g_n \rangle - z}{\sigma_g} \qquad (2)$$

If W_n for a nation is above zero, the country is considered rich enough to contribute to the global climate fund. In figure 2, this would be countries above the threshold, where $W_n = 0$ and Z = 0 in this example. Calculations for national wealth could be expanded to include sovereign debt and foreign currency reserves, with appropriate discount factors.

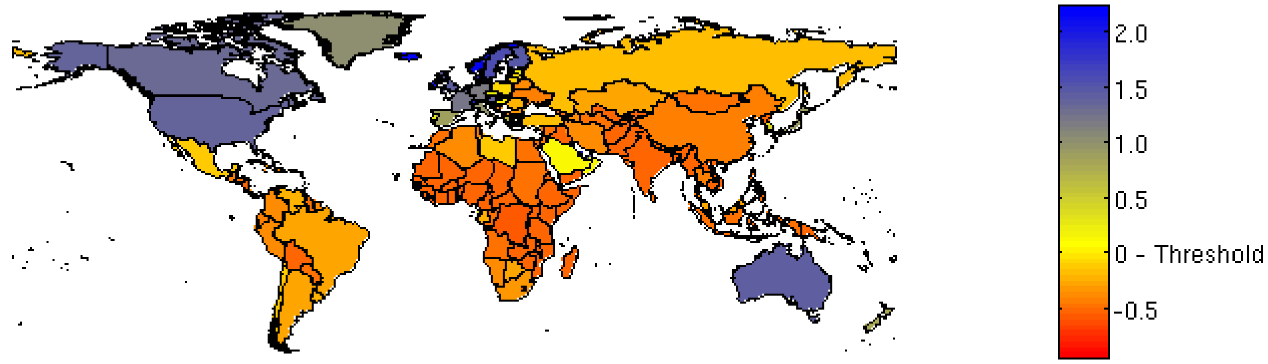

Figure 2. Wealth W_n of all nations in 2007 with potential fund contributors above the threshold. Calculations are based on equation 2 with $Z = 0$.

Given national emissions E_n of greenhouse gases, a carbon tax rate T, a global contribution rate G_r, and the total contribution F^{in} into the global climate fund for a total of N countries,

$$F^{in} = G_r T \sum_{n=1}^{N} R_n W_n E_n \quad when \;\; W_n \geq 0 \qquad (3)$$

The global contribution rate G_r can be calculated to start initial funding for climate aid at $10 billion in 2011. After this, funding will increase as the carbon tax T increases. As an alternative, historical responsibility and national wealth alone can be used to determine the percentage of contribution C_n from each nation into the global climate fund. In this case, funding does not scale up with an increasing carbon tax and would likely be insufficient over the long term. In (4), V equals the sum across all nations of the product of factors for historical responsibility and wealth. V is used in (5) for normalization to obtain a contribution percentage C_n for each nation. Equation (6) sums all contributions into the global climate fund. This approach requires agreeing on the fund size explicitly from the top down and will not take into account national emissions growth except that higher cumulative growth will increase historical responsibility. However, the effects of increasing emissions or potential emissions reductions failures could be compensated for somewhat by additionally multiplying E_n in (6) with a ratio of the current national emissions with respect to 1990 levels.

$$V = \sum_{n=1}^{N} R_n W_n \quad when \;\; W_n \geq 0 \tag{4}$$

$$C_n = \frac{1}{V} R_n W_n \;\; when \;\; W_n \geq 0 \tag{5}$$

$$F^{in} = G_r \sum_{n=1}^{N} C_n E_n \tag{6}$$

All revenue from the harmonized carbon tax entering into the global climate fund can be disbursed as F^{out} in (7) to fund several global climate initiatives as well as climate aid, where:

$F_g^{ca} \stackrel{\text{def}}{=}$ $total\ global\ climate\ aid$
$F^{rd} \stackrel{\text{def}}{=}$ $climate\ related\ research\ and\ development\ at\ the\ global\ level$
$F^{cm} \stackrel{\text{def}}{=}$ $global\ climate\ monitoring$
$F^{gc} \stackrel{\text{def}}{=}$ $global\ emissions\ compliance$

$$F^{out} = F_g^{ca} + F^{rd} + F^{gm} + F^{gc} \tag{7}$$

The total disbursement of climate aid F_n^{ca} to each nation is based on the following need factors:

$A_n \stackrel{\text{def}}{=}$ $relative\ adaptation\ needs, for\ each\ nation$
$S_n \stackrel{\text{def}}{=}$ $relative\ needs\ for\ preserving\ carbon\ sinks\ (such\ as\ rain\ forests), for\ each\ nation$
$M_n \stackrel{\text{def}}{=}$ $relative\ needs\ for\ mitigation\ and\ low\ carbon\ infrastructure, for\ each\ nation$
$L_n \stackrel{\text{def}}{=}$ $relative\ needs\ for\ limiting\ population\ growth, for\ each\ nation$

National climate need factors A_n, S_n, M_n, L_n can be defined as within a range from zero to a maximum such as 0-100. Additional need factors can be easily added to this formula. Needs for limiting population growth is included because this is a key driver of emissions growth. Each participating country could be asked to rate the need factors of all other participating countries. However, there is a risk countries could assign maximum needs to themselves and their allies, but to no one else. Alternatively, each country can be given an allocation a fixed set of credits, 10,000 for example, and be asked to assign all of them across all countries. All assignments can be averaged for each need factor to compute A_n, S_n, M_n, L_n for each nation. Assignments might also be weighted by a number of factors, such as compliance. This method can provide a transparent and democratic method to solve the distributive justice problem of fairly allocating the limited resources of the global climate fund.

In (8), the relative need factors are summed for each nation and divided by the maximum need factors to determine the total relative need. This is multiplied by the national population P_n in 2010 to scale national needs appropriately and then divided by national wealth $W_n + 1$. W_n is always greater than -1, so the denominator is always positive, approaching 1 when W_n is negative and approaching 0. The poorer the nation is, the more the total needs are increased. The total population size is fixed at 2010 levels to not encourage population growth, by effectively reducing funding per capita if populations are not stabilized and continue to grow. All the total need factors across all nations will be summed by (8) and used for normalization in (9). Equation (10) asserts that all climate aid funding to nations should add up to the total global climate aid.

$$U = \sum_{n=1}^{N} \frac{A_n + S_n + M_n + L_n}{A_{\max} + S_{\max} + M_{\max} + L_{\max}} \frac{P_n^{2010}}{(W_n + 1)} \quad (8)$$

$$F_n^{ca} = \frac{F_g^{ca}}{U} \frac{A_n + S_n + M_n + L_n}{A_{\max} + S_{\max} + M_{\max} + L_{\max}} \frac{P_n^{2010}}{(W_n + 1)} \quad (9)$$

$$F_g^{ca} = \sum_{n=1}^{N} F_n^{ca} \quad (10)$$

These equations are used with published data to give an example of how the funding can work. The climate funding graphs in figure 3 use financing equations (1,2,3,8,9 & 10) and available historical data as an example for collecting revenue for the global climate fund and dispersing funding aid. Historical responsibility R_n was based on fossil fuel emissions between 1950-2007 (Boden 2009), with some modifications. Emissions were combined retroactively in some countries such as east/west Germany. Emissions were split retroactively between other countries, such as the former Soviet Union, by using post breakup ratios. Prior to 1950, the data are incomplete, but 1950 onwards provides a good estimate for historical responsibility, considering the world did not acknowledge the climate problem until the United Nations conference in Rio de Janeiro in 1992. Between 1900-1950, emissions rose 16 ppm. Using a CO_2 atmospheric half-life of 31 years, the current contribution of those years is approximately 4 ppm, less than 2 years at current emissions levels. Emissions data due to deforestation and land use changes are incomplete, so they were excluded. For global climate fund contribution calculations, deforestation is less important, because much of the deforestation occurred in countries of low wealth, and so they would not be contributing to the global climate fund anyway. To calculate national wealth W_n in (2), GDP per capita data for 2007 was used (UNdata 2009) and the offset Z was set to zero. With historical responsibility R_n and (5), contribution percentages C_n for each nation were calculated as shown in Figure 3A. To calculate the total contributions F^{in} into the global climate fund, (3) was used. In (3), national emissions E_n used 2007 data for greenhouse gas emissions without land use, land use change and forestry of the 40 UNFCCC Annex I countries (UNdata 2009). The global contribution rate G_r was set to 0.46 to achieve a total of $11 billion in funding for 2011 and increasing to $110 billion annually in 2020. This assumes 10% of revenues will fund global R&D, climate monitoring and compliance, leaving $10 billion for global climate aid in 2011 and $100 billion in 2010. Funding contributions only came from the 40 Annex 1 countries with a positive W_n, or the 23 Annex II countries plus the Czech Republic, Estonia and Slovenia. 58 countries actually had a positive W_n, but those excluded were mostly small (except Greenland, Israel, Kuwait, Oman, Republic of Korea, Saudi Arabia, United Arab Emirates) and equivalent greenhouse gas emission data was not available. As an example of how this would work, the United States (US) would contribute 51.8% of the global climate fund, based on historical fossil fuel emissions and national wealth. If the carbon tax is $9 per MtCO2e for 2011, the US would contribute 16% of that or $1.44 per MtCO2e towards the global climate fund. If the carbon tax increases $9 each year, it will be $90 per tCO2 in 2020, and the US would still contribute 16% or $14.4 per MtCO2e towards the global climate fund. The remainder would be used internally in the US for addressing climate change, including mitigation and adaptation.

To show an example of how disbursement of climate aid can work, it is assumed all nations with a wealth factor W_n of less than zero (2) have equal need factors, except for China and India, which have been set to zero, since both countries declared they would not need climate aid during the Copenhagen climate summit. The need factors for the nations of Europe are intentionally not reduced to show distribution effects. In reality, all need factors would vary across countries. For example, the Small Island States would likely have high need factors for adaptation.

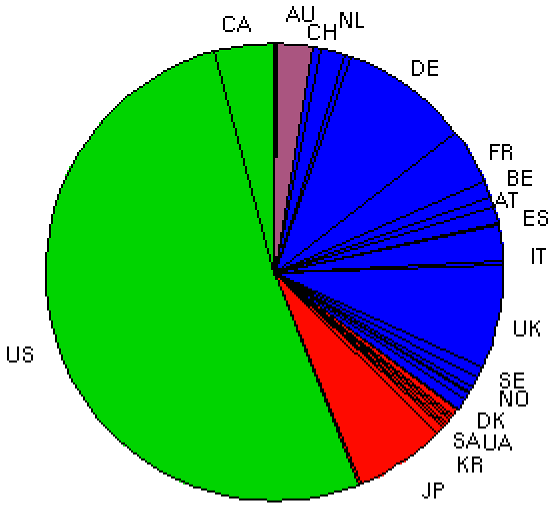

Figure 3A. National contributions into the global climate fund based on historical responsibility and national wealth.

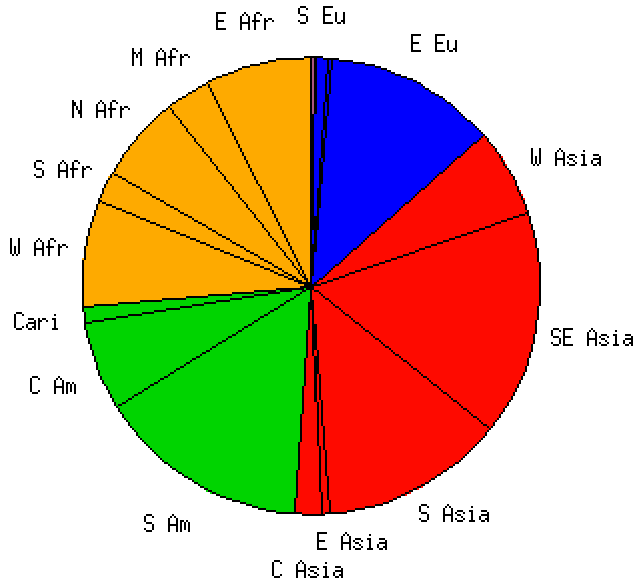

Figure 3B. Distribution of aid from the global climate fund into regions based on national need factors.

On the funding side in figure 3A, the United States (US in green) comes out as the largest contributor at 51.8%. Europe (in blue) is the second largest contributor at 32.4% and Japan (JP in red) follows at 6.4%. The reason for this is that US has a per capita GDP of $45k, the 2nd highest emissions per capita and the highest historical responsibility for CO_2 emissions. Figure 3B shows climate aid distribution. With the set need factors, Asia (in red) would receive most of the funding, followed by Africa (in orange), Americas (in green) and Eastern & Southern Europe (in blue). Several countries in Eastern Europe and a couple of them in the EU (such as Romania, Hungary, Poland) have a negative W_n.

5. Discussion

This global climate fund collection and distribution strategy can be adjusted with a few parameters, which include the harmonized carbon tax rate, global contribution factor, a wealth factor cutoff adjustment and need factors for all countries who receive climate aid. This strategy can be applied at the global or regional level, such as within the EU or across the states of the US. For example, Poland is less wealthy than many nations in the EU and relies heavily on coal. By applying these formulas at the EU level, aid from more wealthy nations can help Poland either move away from coal or deploy carbon sequestration technologies. In the US, states such as Wyoming, Montana, Pennsylvania, Ohio and West Virginia are heavily dependent on coal. As such, they often seek to block national climate legislation that disadvantages them. However, with the right approach, states which are dependent on coal can be aided by other states less dependent to reduce emissions and thus make legislation more likely. While a carbon tax of $90 MtCO2e by 2020 is higher than many suggest, most of the revenue would be reinvested in climate mitigation and adaptation at the national level, such as building more efficient transportation systems, power plants or energy grids. These necessary improvements will require additional public funds, which are typically not accounted for in other approaches. Sovereign debt levels are already very high in most developed countries, so issuing more bonds may prove difficult. Carbon taxes are likely to reduce energy demand, resulting in a drop in energy prices. This means that actual energy costs including a carbon tax will be lower than untaxed energy costs plus a carbon tax. Carbon taxes can be regressive by taking a larger percentage of income from lower income households (Ackerman 2008). Some proposed legislation in the US has included a cap and dividend approach, where some carbon revenue is returned on a household or per-capita basis, effectively providing a carbon allowance. This can be done with harmonized carbon taxes as well, as long as the harmonized carbon tax rate is sustained. For example, a fuel tax could contain a carbon tax above the harmonized tax rate and return the difference to households to remove regressive properties. In this case, the harmonized tax rate within a country could be a mean carbon tax rate. In the least developed countries where poverty is high and carbon emissions are low, a national carbon allowance could be allowed, free of carbon taxes. However, this national allowance should perhaps be based on land mass rather than population size and emissions per capita since using population size here would also encourage population growth. Consider that climate change is a planet-centric ecological and environmental problem caused by humans, not a human-centric one.

While emissions caps set useful goals for reductions, carbon taxes and regulations are a better approach to stay below those caps. With a harmonized carbon tax, behavioral changes are encouraged from the bottom up, while not relying on setting national or per capita emissions targets. Some have argued that a small carbon tax does not alter behavior. However, fixed small tax is substantially different than a tax which starts small but steadily increases over time, evoking continued consumer attention to act on consumption. Completely relying on national targets is very risky, because they are very hard to adapt with changing environmental conditions that are truly global in nature. Harmonized carbon tax rate increments can be accelerated if global emissions targets are not being met. The fact is, new revenue is needed to address climate change, so it is not enough to replace some existing taxes with carbon taxes. It would also be best in the long run if carbon tax revenue is focused exclusively on climate change rather than mixing it with other revenues. Carbon tax revenue can be reinvested in climate change needs in the near to mid term, but eventually used to finance removal of newly emitted carbon from the atmosphere for achieving a carbon equilibrium. This is the fastest way to transition to low-carbon economies and this will create economic growth.

A global climate fund requires global institutions with collection, administration and disbursement processes to function. While collection and administration will not be further addressed here, the disbursement process should likely be decided by all parties and not by the concentrated political power of a few countries. Otherwise developing countries will distrust the whole process. One way to avoid this is to employ distributive justice and let all parties determine the need factors of all other parties, as discussed earlier. Finding completely unrelated revenue such as financial transaction taxes to pay for climate change will lead to unwanted or unforeseen dependencies which would make revenues unstable, be uncoupled from environmental changes and will increase risk. It is better to use financial taxes to regulate financial markets and use carbon taxes to manage the environment, in particular because these challenges are global in nature and very complex.

Funds are needed to help developing countries with adaptation and mitigation as well as to develop and deploy new low-carbon technologies worldwide. While a carbon market driven by CDM utilizes some private capital for offset projects in developing nations, it is a risky approach with a high potential for fraud. It also disproportionally favors emerging countries, leaving little for the least developed countries. Instead of CDM, a much better approach is to provide top-down mitigation funding from the global climate fund, based on need factor M_n , which could be known as an M-fund. These funds can be combined with carbon taxes collected locally in developing nations, so that local governments and communities will have a vested interest and "skin in the game", helping to assure mitigation project quality. Governments can manage mitigation projects with bids and audits, just as transportation and highway systems are now. Mitigation projects can be peer reviewed, helping to identify best practices by governments. This would develop efficient mitigation projects instead of what investors may pass off as an offset project and sell to financial firms for pooling and securitization. Private money can still be involved in creating mitigation projects, but under the administration of a local authority, who can choose mitigation projects strategically for optimal effectiveness. In this case, the money to generate mitigation projects still comes from the emitters through a carbon tax, and the pool of capital would probably be higher than with a cap-and-trade system such as ETS with CDM, because less is lost to carbon trading and fraud. Mitigation project quality would likely be higher than offset projects as well. Private industry still can play a large role in addressing climate change. While a harmonized carbon tax can eliminate the need for carbon markets, a huge potential exits for creating low-emissions products and services as wells as building and maintaining low-carbon infrastructure. Carbon tax revenue and mitigation funding may also leverage private capital by helping to cover higher near-term cost differences in building low-carbon infrastructure and energy-production. Public and private loans can provide additional capital with stability, payable with incrementally increasing carbon tax revenues.

6. The current political climate

Copenhagen appears to have failed to produce a comprehensive treaty because of the sheer complexity of trying to get 192 nations to agree on what action to take on climate change. While input from all nations is important, a better structure is needed. It is not enough to limit discussions to major polluters such as the G20, because those affected the most, such as the Alliance of Small Island States (AOSIS) and African nations, would not be represented. A better solution would be to have a hierarchy for discussion, analysis and decision making. Each nation could be directly represented at the bottom of the hierarchy. The next level could be represented by groups of nations with common qualities. Nations are free to move between groups if another one is more representative. A further level might contain groups of groups. At the top level, treaty negotiations would occur. Large nations such as the US, China, India or the EU may have direct representation at the top level. Ideas and concerns could be introduced by any nation for discussion within a group. If one third of the nations in a group agree on ideas and suggestions, they can propagate up the hierarchy. At the top level, a policy proposal is created with these suggestions in mind. This proposal is propagated down the hierarchy for feedback. Updating and feedback iterations can continue until at least 2/3rds of the nations in each top group agree. If deadlock exists at the top level, a majority of the top-level groups or large nations may choose to break off from the others and form a separate agreement. For example, China, the US or OPEC nations should not be able to block an agreement if others have achieved a consensus.

While the Copenhagen climate summit did not generate a comprehensive political agreement to address climate change, it did help identify the positions of many nations. China and India do not want emissions caps, or even a defined peak year for emissions in the foreseeable future. China even blocked the EU from imposing on itself an emissions limit of 50% or 80% of 1990 levels by 2050. Presumably, this is to avoid pressure for imposing its own actions for significant emissions reductions. In the final hours, the US together with the BASIC coalition nations Brazil, South Africa, India and China, took working texts for an agreement and removed all references to emissions limits and any timelines for negotiating a new climate treaty. Limited progress was made on verifying nationally reported emissions. The group retained the Copenhagen green climate fund, but did not indicate any funding mechanisms. While this was called the Copenhagen Accord, the EU was not invited to participate in during the accord negotiations. The reason appears to be that the parties were not ready to make significant commitments and wanted to effectively stall, but still create the appearance of not obstructing progress. The Copenhagen accord did establish a list for voluntary pledges of national emissions reductions and a goal of $30 billion in fast start funding for 2010-2012. While this is a start, current emissions reduction pledges will not achieve the necessary reductions and will likely lead to increases in total global emissions 10-20% by 2020 (Rogelj et al. 2010). The accord is not enforceable and ultimately lets major emitters off the hook. While Fast Start funding is approaching commitments of $30 billion, some commitments are existing funding reclassified as Fast Start climate financing. It also is highly fragmented with a growing plethora of funds, which ultimately will lead to fragmented capital investments, inefficiency and redundancy. A much more coherent strategy is needed.

At Copenhagen, there was discussion about fairly sharing atmospheric space, or the right to emit carbon. Least developed countries including Africa fear of being locked out of access to atmospheric space, locking them into perpetual poverty. If the world has an emissions cap to stay below 2° C, and developed nations reduce emissions to 50% of 1990 levels by 2050, then there is little room left for poorer nations to emit for economic development. However, there is another way to look at this. Consider that there is no longer any free atmospheric space left, because atmospheric CO_2 levels are already too high. All carbon emissions have an environmental cost across the globe. Part of the revenues from carbon taxes in nations with historical responsibility can be used to cover the additional expense in underdeveloped countries of low-carbon development over utilizing fossil fuels. Those additional expenses may be higher initially, but will drop as deployment increases. Thus, development is not constrained, but shifted towards sustainability. Initially developing with fossil fuels and shifting later to low-carbon infrastructure is not only environmentally unsustainable, but more expensive in the long run. The most threatened by climate change are the small island nations, represented in Copenhagen as the 43 members of the Alliance Of Small Island States (AOSIS). Nations such as a Maldives are only a few meters above sea level, and could disappear with rising sea levels. They have contributed little if anything towards global carbon emissions, yet are at the most risk. For them, the desire for environmentally unsustainable economic development or protecting jobs in the coal industry seem trivial. If they lose their countries, where will they relocate to and who will compensate them?

China's economic growth is aided by cheap labor, relatively weak regulations as compared to developed nations, cheap energy from coal and an undervalued currency. While economic growth is essential to reduce China's poverty, this growth appears to be valued above all, despite the fact that climate change will actually increase poverty. Resistance to revaluing its currency may indicate a similar resistance to reduce emissions, already the highest in the world. China is actively pursing development of clean and renewable energy and invested $34.6 billion during 2009 (Pew 2010). However, this isn't enough. China produces and burns more coal than any other country, obtaining 71% of its energy from this. Further, Chinese coal consumption is expected to increase about 150% by 2035 (EIA 2010). Even if China meets its stated goal of reducing carbon intensity by 40-45% of 2005 levels by 2020, its emissions will continue to grow. Assuming a carbon intensity reduction of 45% and an average GDP growth rate of 8% between 2005 and 2020, emissions growth would be 74% above 2005 levels in 2020. This largely wipes out reductions by other parties. Although China correctly asserts that developed nations have historical responsibility for carbon emissions, China itself has substantial historical responsibility as well. From 1950-2007 it contributed 11.2% of the global carbon emissions from fossil fuels and was burning coal as far back as the Han Dynasty, about 206 BC – 220 AD. China is already experiencing serious air pollution from burning coal and the effects of climate change. This includes the rapid disappearance of grasslands on the Tibetan plateau along with desertification and water scarcity. China has an ambition of becoming a dominant superpower and is in a competitive struggle with the US. Despite claims of an open market, it is reluctant to buy foreign goods and instead wants indigenous companies to dominate in most industries, including green technology. With its massive foreign currency reserves, it could be purchasing all available technologies to more quickly build a lower carbon infrastructure or purchase fuels with lower CO_2 emissions. The US has lost industry to China and won't be willing to reduce emissions substantially unless China does as well because otherwise China would have even more of a competitive advantage. Unfortunately, this competitive struggle has the potential to derail or sufficiently delay any effective climate response for preventing catastrophe. In fact, it has already contributed significantly to climate change, because it was the main reason the US stayed out of the Kyoto protocol. This conflict is becoming another Mutually Assured Destruction on an environmental level, but unlike a nuclear standoff where there is some probability of disaster with a triggering action, this one is likely to occur with inaction.

Historically, the US is the largest contributor of carbon emissions into the atmosphere, yet at the national level, it is doing the least among industrialized countries to limit or reduce those emissions. Politically, the US Republican party does not appear willing to address climate change. According to a recent survey, none of the 37 Republican candidates for the US Senate in November 2010 support climate action (Johnson 2010). Some of these candidates deny climate change exists while others assert pricing carbon would hurt the economy. However, in recent history, US economic growth has been largely due to the development of new technologies. Without a price on carbon, the US has a weak internal market for new greener technologies and will likely miss opportunities to develop them, negatively affecting both US competitiveness and the US economy. True economic growth needs drivers. Ultimately, the failure to act exposes the US to willful negligence and damages resulting from global warming, potentially causing major international conflicts which would be more damaging politically and environmentally and even more expensive over the long term. California is already feeling the effects of climate change, with less snow melt and more serious forest fires. If droughts become common in the southwest and spread east to the farm belt, it will be too late to avoid serious consequences of climate change. While several bills have been proposed in Congress, all of them are based on cap-and-trade and none of them set sufficient emissions reductions targets, provide enough funding to make significant infrastructural changes or provide any direct funding for a global climate fund. With strong Republican opposition to addressing climate change, legislation is not likely to pass before 2012. The US Environmental

Protection Agency is planning to start regulation of CO_2 emissions in early 2011, but this too may end up in limbo if successfully blocked by Republicans, who are actively seeking to do so. Because the US generates considerably more carbon emissions per-capita than almost all developed countries, it is likely more sensitive to carbon pricing, and larger business and lifestyle changes will be necessary than in Europe, for example. It may require considerable external pressure on the US to achieve the political acceptance necessary to seriously address climate change.

India is aligned with China's position within the BASIC coalition, perhaps to prevent limiting economic growth. However, India has a high risk of impacts from climate change. By the 2030s, temperatures are projected to rise about 1.7 – 2.0° C and temperature extremes will have considerably higher variance than they have today (INCCA 2010). Some southern, coastal and central areas of the country are expected to receive less rainfall and have higher evapotranspiration rates, increasing the likelihood of water scarcity and reduced crop yields. Northern areas near the Himalayas are expected to experience increased precipitation, and risks of major flooding will increase as well, not only in India but also neighboring Bangladesh and Pakistan. Flooding in the Ganges river delta could be devastating. In addition, population growth will contribute to continued poverty and is also not environmentally sustainable. India has a goal of reducing carbon intensity 24% by 2020 from 2005 levels, but this too means substantially increased emissions. Already, India is the 3rd largest emitter at 5% of global emissions after China at 23% and the US at 22%. However, India is actively engaged in transparently measuring and reporting emissions. Additionally, in July 2010, India introduced a carbon tax on coal to fund clean energy research projects and is pursuing nuclear energy, including research on Thorium reactors.

The EU appears to be motivated to significantly reduce emissions and to help establish a new global climate treaty. Unfortunately, because it was first to establish a carbon-based cap-and-trade system with ETS, it now has a vested interest in such a system. As such, it is less likely to look objectively at the failings of ETS and may try to perpetually fix it rather than to consider dropping it in favor of a harmonized carbon tax. Although ETS and carbon taxes can coexist, this is overly complicated on a larger scale, creating market uncertainties and high regulatory overhead. It also could create gaping loopholes for avoiding carbon costs and would not integrate well with the rest of the world. Perhaps different sectors could utilize only carbon taxes or carbon markets, but this would have to be consistent globally. The EU is considering carbon tariffs on nations without a cap-and-trade system. But depending on how they are implemented, carbon tariffs imposed at trade borders have the potential of starting a trade war. They may also be challenged in the World Trade Organization (WTO) (Hufbauer and Kim, 2009).

If import tariffs are imposed to protect industries under a carbon tax or cap-and-trade system and revenue is transferred into national government coffers, this could be considered protectionist. However, if tariffs are only assessed on differences between carbon prices between the importing and exporting countries and the all proceeds are transferred to the global climate fund, there is no national protectionism. This would likely be compatible with WTO General Agreement on Tariffs and Trade (GATT) article III. Neither China nor India wish to receive aid from a global climate fund, presumably to avoid emissions limits. However, without their participation in a climate treaty, preventing catastrophic climate change will be very difficult, if not impossible. But because they will not impose emissions limits, they cannot participate in a global cap-and-trade system, except through CDM. And any local CDM projects, even when legitimate, will at best only slow down emissions growth. Should China or India create a cap-and-trade system having a rising cap and exchange carbon credits with the EU ETS having a falling cap, carbon credit fraud could reach a whole new level. Globally, coal is a huge contributor to CO_2 emissions and should be addressed directly. Climate simulations show soot in snow and ice accounted for 25% of global warming (Hansen 2004). A global moratorium in developed countries may be a good idea for all new coal fired power plants, unless a dirty one is replaced. However, as a concession to the coal industry, carbon taxes on coal emissions could be explicitly used to accelerate R&D and implementation of carbon capture and sequestration technologies, if they prove to be viable.

7. Possibilities for a new climate treaty

So what is a possible approach for a new treaty to reduce global carbon emissions? Keep some existing principals in the Kyoto protocol such as the common but differentiated responsibilities of nations, but change the implementation of burden sharing rules and the mechanisms. Phase out all existing cap-and-trade systems and carbon credits within Kyoto by 2012. A fast failure is better rather than one with a likely outcome of insufficient emissions reductions. Ignore the extensive lobbying of the financial industry, which is motivated by self interest and not the global interest. Establish a new treaty, where all participating nations agree to a harmonized carbon tax and common environmental regulations. Have nations with historical responsibility contribute a percentage of internally collected carbon tax revenues to the global climate fund, as described earlier. In return, limit climate change liabilities from historical emissions. Have a global climate committee meet quarterly to adjust the global levers, which are the harmonized carbon tax rate, the global contribution rate, global climate fund priorities and need factor adjustments for each nation. Annually, let treaty nations decide the need factors of their peers. Base climate related project funding on national need factors to fairly distribute funding across all countries. To receive financing from the global climate fund, a nation should be part of the treaty. Finance the existing Adaptation Fund directly from the global climate fund instead of a 2% levy on the carbon market. Treaty nations with climate-related projects should contribute part of the financing with locally collected carbon taxes to give them a sense of ownership. Technology developed with R&D funding from the global climate fund should be shared with all treaty participants. The harmonized carbon tax should be assessed on emissions from international shipping and transport between treaty participants and non-participants, with the entire proceeds going into the global climate fund. Nations which do not wish to participate in the treaty should be assessed a tariff on carbon emissions from goods and services imported into participating nations, equal to the harmonized carbon tax rate. All tariff proceeds from the harmonized carbon tax should also go into the global climate fund. If a nation decides to assess their own import tariffs in retaliation, this would still be a superior outcome than avoiding a tariff and perpetuating climate change. In this case, re-localization of manufacturing to treaty nations with higher energy efficiency and less need for global shipping also has the benefit of reducing global carbon emissions.

The longer action is delayed, the harder a solution will become, both environmentally and economically. Accelerating climate change will later require steeper emissions cuts, even as adaptation costs rise. The fastest and ultimately cheapest way to respond to climate change is to briskly drop cap-and-trade, establish a globally harmonized carbon tax and use all proceeds to directly address the problem. The challenge comes down to this: Has human civilization advanced enough to look beyond national, corporate and individual self interests to not irreparably destroy the global environment that sustains it? Thus far, this has not been demonstrated, but with time running short, the defining answer is not far away.

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