Meeting CO2 Targets with Carbon Pricing through Taxation and Trading

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Abstract: - We review various alternative sustainability strategies for combating climate change as goal posts for meeting CO2 reduction targets towards zero net economy periodically have to be replaced. Research on policy success in reducing CO2 emissions through taxation and emission pricing/trading in various countries is analyzed to provide insight for policy makers. Economies with large energy sectors may consider appropriately designed cap and trade system that will achieve emission intensity reduction. In addition, carbon tax will incentives energy efficient economic and consumer behavior. Any combination of strategies for mitigating climate change should be adjusted to specific aspects of local social, economic and environmental factor and should be periodically attuned to their changes.

Key-words: Environment, Carbon Prices, Sustainability, Climate Change, Energy Sources

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1 Introduction

Since the United Nations adoption of the Kyoto Protocol in 2005 (COP 11, 2005), putting a price on carbon emissions has emerged as one of the most promising component of any combination of strategies for mitigating climate change. Its rationale is straightforward; if there is a reasonable cost attached to carbon pollution, then there is an incentive to avoid emitting more than is necessary and for that matter ensuring low-carbon sustainability.

We define the emissions challenge as equivalent to the anthropogenic climate change creating events of extreme weather patterns with consequential destructions leading to human suffering. It is noteworthy that these events are spread across continents, i.e. globally regardless of the location of the emitters. This feature underscores the need for a global response with shared responsibilities.

The foregoing also underlines the general need for a change in how we live, in order to preserve the earth. Practices in manufacturing, agriculture, resource exploration and exploitation, and transportation especially need to be relooked at with the aim of reducing their current negative environmental externalities. The burning of fossil fuels for energy has been identified as the heaviest culprit in greenhouse gas (GHG) emissions.

Energy has been the key sector for global GHG mitigation, accounting for about 60% of global carbon dioxide emissions and also accounting for about 30% of almost all industrial and other wealth creation activities (IPCC, 2007). As at 2016, Energy production of all types accounted for 72% of all emissions. Globally, the primary sources of GHG emissions have been electricity and heat (31%), (World Resources Institute, 2017).

Fossil-fuel-fired electricity-generating plants and oil-prospecting and processing units are particularly notorious and together, accounted for about 26% of global GHG emissions between 1990-2000, increasing to over 30% between 2000-2010 (IPCC AR5, 2014).

Thus, the growth in GHG emissions has continued since the released of the IPCC Fourth Assessment Report (AR4) in spite of more efficient vehicles (road, rail, water craft, and aircraft) and policies being adopted. Consequentially, the transport sector which produced 7.0 GtCO2eq of direct GHG emissions (including non-CO2 gases) in 2010 and hence was responsible for approximately 23% of total energy-related CO2 emissions (6.7 GtCO2),

an increase from about 13% in 2004 (IPCC AR5, 2014, Chapter 8).
Share of GHG emissions from industry also increased from 19% in 1990-2000 to between 24-31% in 2000-2010, depending upon the accounting structure of the industrial sector (IPCC, 2007; 2014; Statistica, 2022).
Agriculture and Forestry together usually called AFOLU[1] sector share of GHG emissions however has dropped from 31% in 1990-2000 to just under 25% in 2000-2010, total emissions was about 10–12 GtCO2eq/yr) (IPCC AR5, 2014, Chapter 11).
The majority of the world's heavy emitters are linked with the global energy sector. Consequently, in developed countries such as Canada and the United States, the major villains are almost always electricity-generating companies, and oil and gas companies. Since all economic sectors run on energy, substituting other methods of energy generation should lead us to a cleaner and healthier world. However, this has proven an inadequate strategy due to limits to the speed of development of technologies that efficiently harness alternative sources.

2 Alternative Sustainability Ways for Combating Climate Change

Energy-source substitution on a global scale cannot be an instantaneous occurrence, therefore some proven options are concurrently being pursued by relevant stakeholders.
The major option that is being given the most attention currently is mitigation; which is described by Fawzi et al. (2020), as entailing the reduction of emissions by the establishment of projects that reduce anthropogenic emissions of greenhouse gases into the atmosphere.
These projects include those that enhance and reward the efficient industrial use of fossil fuels, renewable energy projects, and carbon-sink forestry projects (Stern Review, 2007). The main focus of mitigation is on carbon emissions which account for about 76% of GHG emissions Methane, primarily from agriculture, contributes 16% of GHG emissions and nitrous oxide, mostly from industry and agriculture, contributes 6% to global emissions (Centre for Climate & Energy Solutions, 2022)
The emission-reducing projects are expected to be paid for ultimately by emitters, who shall be required to buy up chunks of the carbon called emissions allowances in order to continue producing after exceeding their allotted emissions limit. The added cost of production from purchase of emissions allowances may itself discourage excessive emissions and encourage firms to develop better emissions-efficient processes and technology- thereby speeding up the process of achieving more sustainable habits in pursuit of an inhabitable future.
Other mitigation options being proposed are carbon-dioxide removal (CDR) such as carbon sinks, biomass for carbon sequestration, direct engineered capture of CO_2 from the atmosphere, and ocean fertilization as well as some methods of solar radiation management (SRM) such as earth-surface albedo enhancement, marine-cloud reflectivity enhancement, sulphate-aerosol injections, and space-deflectors. The major difference between CDR and SRM approaches is that CDR approaches attempt to tackle the problem at its root by removing the excess carbon-dioxide, while SRM methods focus on correcting radiation imbalance by shading or shielding the earth (see Lenton and Vaughan (2009)
Another option other than mitigation is Adaptation which is defined as "to prepare for and adjust to both the current effects of climate change and the predicted impacts in the future" (EU, 2021). This option is a crisis control strategy which cannot be entirely separated from the mitigation, but distinct to the extent that it aims at boosting resilience to extreme weather conditions such as floods and cyclones, and enhancing efficiency in the management of scarce natural resources including forestry, water bodies.. Its theme is that climate change might not be entirely preventable and humanity must be prepared when some extremely damaging changes start to appear. Given the scale of climate change and the fact that it will affect many areas of life, adaptation also needs to take place on a greater scale. Thus, our economies and societies need to become more resilient to climate impacts.

3 Some Major Sustainability Debates and Issues

3.1 Emissions Reduction Versus Emissions Intensity Reduction

Cap and Trade systems function by imposing a limit (cap) on the quantity of allowable carbon emissions in a system, which causes a scarcity of

[1] Agriculture, Forestry, Land Use under IPCC nomenclature

emission-allowances and thus creates a market phenomenon. That limit could either be an absolute one, or an Intensity limit. An absolute limit specifies an amount of GHG emissions that must not be exceeded within a period of time while an intensity-limit specifies the amount per unit of production. Obviously, the Intensity limits emphasize efficiency while the Absolute limits emphasize specific targeted quantities. Invariably, both limits aim at achieving behavioral changes with respect to emissions; the major difference being in the level of certainty about the magnitude of emissions-reduction that would result, and their implications for economic growth. Absolute limits have been used before in curbing emissions of Sulphur-dioxide and Nitrous-oxides in some developed markets like the United States. The Kyoto Protocol also specified limits in an absolute sense. However, according to Ellerman and Wing (2003), they are much less commonly used than the Intensity limits which for instance has been used for the US's State Implementation Plans, the EU's Large Combustion Plant Directives, Canada's Carbon Policy and carbon mitigation plans of many developing countries such as Argentina and India to mention a few.

Zeng et al. (2016) compare the economic and political benefits of the EU and Chinese Emission Trading Systems.

The main debate currently resides on the efficacy of either limit in reducing carbon emissions. The chief arguments in favor of an absolute cap are that it assures certainty in quantity of emissions to be reduced (thus it is useful for precluding emission growth), and is simple to communicate to stakeholders. Its disadvantages are mainly that it could lead to escalating costs, and consequently, stifle economic growth pending the development and accessibility of new carbon-free technology in the not-so-near future (Nordhaus, 1994). Absolute caps are also criticised for causing and/or perpetuating economic disparities particularly to the disadvantage of less-developed countries, for which economic growth is more tightly coupled with emissions growth and which are unequipped with resources including technology, with which to meet most reasonable absolute targets (Pizer, 2002; Mideksa, 2019). Intensity limits on the other hand, have the distinct advantage that they accommodate economic growth and instead focus on performance as a function of efficiency. The key obvious disadvantage of intensity limits is that given accelerating economic growth, emissions may burgeon faster than ever even in the face of decreasing emissions intensity; this will happen insofar as the economy grows faster than emissions.

From the brief expose above, it is rather obvious that the debate is charged, not by intrinsic qualities of either approach, but by how climate change is conceived by different parties. At an extreme, an intensity approach is naturally acceptable to those who believe that the amount of "global-cooling" we can achieve in the short-run through mitigation is not worth the possible sacrifice in economic growth, while, at another, an absolute cap is likely to be more acceptable to those like Hansen et al (2006), who believe that it is necessary to aggressively tackle global warming before it reaches thresholds that force an irreversible climate change that may potentially result in several degrees of disasters including the melting of permafrost, the extreme consequence of which is the extinction of species including the human race.

While the motivating scenario of the latter viewpoint is indeed possible, it is shrouded in uncertainty. Given this uncertainty, the majority of policy makers the world over seem to have chosen (possibly under the influence of the press) to pursue economic growth on the chance that climate change will not be too harsh. The evidence for this decision seems to be strongly reflected in the prevalence of intensity limits relative to absolute ones. Thus, although absolute caps may be the more effective method (at least from an emission-reduction perspective), as Quirion (2005) opines, intensity limits are more politically acceptable and more likely to thrive subsequently in future emission policies. Reviewing the literature, Doda (2016) finds that «no single mechanism emerges as a dominant option for capturing the welfare gains associated with responsive carbon pricing instruments».

That said, according to the World Resources Institute (Herzog et al, 2006), how effective either policy-option is in reducing emissions depends more on how stringent its application is, how widely defined its scope is, and how legally binding its compliance is. Even an intensity limit could be made very stringent, defined to capture most significant sources and be made mandatory by law enough to yield substantial mitigation dividends, whereas an absolute cap may be made so high, encompass few significant sources, and left open to volition such that it hardly has any impact. Such a high absolute cap is however likely to be more easily perceived as weak than an equally ineffective intensity target which often deceptively appears high and ambitious. Kolstad (2005) has provided an elaborate discussion on this topic. Wang et al. 2021 derive the welfare comparison between tradable performance standards and a price-based alternative.

3.2 Emissions Taxes Versus Emissions Trading

Emissions trading and emissions taxing are two alternative market-based approaches to attributing the cost of pollution to emitters[2]. As with most other economic debates, it is unlikely that there is a strictly superior policy option between emissions taxes and emissions trading. In a world of absolute certainty, both options should yield equivalent results (Green, 2008). However, we live in a world fraught with uncertainty and either option is only more likely to be effective in certain circumstances, while being less effective in others. Dissou and Karnizova (2016) find the cap has lower volatility but higher welfare costs for shocks to energy sectors. In order to appreciate this point, we briefly explain the theoretical mechanisms of both market-based instruments, and conclude with comments on instances where each could be an effective policy option.

The theoretical underpinning of emissions taxes, as observed by Ekins and Barker (2002), is generally agreed on by economists; if the production of a commodity causes negative externalities not reflected in the price of that commodity, social welfare can be improved by imposing a tax. Emissions taxes are designed to tackle the emissions problem by fixing a price per unit of emission, and allowing those on whom the burden is imposed to determine how much to emit. However, an emissions tax has to reflect the social cost of the taxed good to a reasonable degree in order to increase the price of emission-intensive production, thereby making emission-intensive products less competitive relative to low-emission substitutes. Karmaker et al. (2021) identified that environmental taxes stimulate technological innovation in high and middle-income nations which should lead to cost savings. Thus, it aims at achieving behavioral change using a direct price-fixing mechanism that reflects the popular “polluter pays” principle. Each participant in the system it covers is levied an amount of tax per unit of emission released in the course of its production or consumption process. In theory, emission-taxes equalise marginal abatement costs across all emitters and can achieve emission reduction at the least cost to society. By and large emission-taxes are simple and easy to communicate to stakeholders. While electorates and industry are usually tax-averse, a carefully designed emission-tax, revenues from which might be used to grant the low-income class some meaningful rebates from other historically unpopular taxes or fund some welfare program, is likely to meet with acceptance. One primary problem that faces the international adoption of the carbon tax strategy is the fact that it is virtually unrealistic for countries that hitherto protected, supported, and even subsidized their energy sector and other heavy emitters, to suddenly erase those policies and start to penalize these same industries upon which their growth has been predicated.

Shmelev and Speck (2018) employed an econometric approach to analyse the effectiveness of energy and carbon taxes in Sweden, leading in CO_2 tax as well as an extensive environmental tax reform. The results showed that taken in isolation a CO_2 tax was not sufficient to result in a significant change in CO_2 emissions, except for petrol. Niu et al. (2018) found that environmental tax shocks could drive the reduction of carbon emissions in China. Li and Yu (2020) propose a collaborative coordination scheme to improve energy sharing, which reduces cost and carbon emissions. They assert that implementing carbon tax would lead to a decrease in energy exchange. Dissanayake et al. (2020) evaluated a carbon tax, a fuel tax and an ETS for Indonesia and asserted that carbon tax is simpler and more swiftly implementable than the ETS. He at al. (2021), examined the relationship between environmental tax, economic growth, energy consumption, and carbon dioxide emissions in China, Finland and Malaysia from 1985 to 2014 and confirmed that the double-dividend effect of environmental tax exists in all three countries in the long run.

On the other hand, emissions trading is designed to fix the quantity of emissions allowed within an economic system at the level of a predetermined target, and by the scarcity that ensues, create a market within which price is formed. Players within the trading system are then left to determine the least costly way to meet the effective limit by buying or selling emission permits (Sijm, 2005). The expectation is similar to that of a tax; polluting firms get punished by incurring the added cost of buying emission-permits, and attempt to explore low-carbon technologies and processes in order to

[2] A third approach – regulation – is generally unpopular among policy-makers due to its inherently high cost, potential damage to industry and economic growth, and poor efficiency relative to market mechanisms (taxes and trading schemes).

avoid that cost. Those who switch successfully and are able to reduce their emissions below a given benchmark – for example 21% below 1990 emission benchmark levels in the EU ETS Phase III plan (UK Department of Climate Change, 2008)– generate permits that they can resell to those who still require them for compliance purposes. Herein lies the main appeal of emissions trading systems; under them, emitters have an incentive, not only to reduce their pollution in order to avoid compliance costs but, to reduce emissions beyond the statutory requirement through innovation, and thereby generate permits which they can sell. This spells competitive advantage for such proactive participants, and a least-cost reduction in emissions to society, by creating a compliance system in which those emitters who find it most economical to reduce their emissions do, while others without that comparative advantage can simply purchase from them.

Emissions' trading however is not without some serious demerits, some of which are high price-volatility and high susceptibility to corruption. Nordhaus (2005) reviews several emissions markets within which volatility is rife, while data from the European energy exchange (2015, 2016,) indicate that EU allowance prices fluctuated by more than 15% monthly on average between May 2015 and April 2016, and experienced an 80% crash and equivalent recovery in the subsequent 3 months. Similarly, the US Environmental Protection Agency (2012) reports annual average fluctuations in Sulphur-dioxide permit prices of over 40 percent between 1997 and 2012, with price increasing from $106 in 1997 to $860 in 2006 and $2 in 2011. Such volatility if experienced on a global scale portends huge costs and shall negatively impact both the business and consumption of carbon-intensive economies, potentially crippling them. Taxes on the other hand are by design not sensitive to the changes in weather or economic growth that drive volatility.

Trading also leaves more room for cheating than taxes would for the mere fact that among other reasons, governments are naturally more incentivised to perform their monitoring and enforcement roles under tax regimes where they collect revenue, than in a trade scenario (Nordhaus, 2005). Moreover, taxes could be easily administered through pre-existing tax collection mechanisms while emissions trading would require the design from scratch of new mechanisms.

Weitzman (1974), and subsequently Hepburn (2006), attributed the objective determining factor in choosing between both options to the region of uncertainties. Weitzman showed in his much-acclaimed paper "Prices vs. Quantities" that where there is uncertainty about the cost functions or a possibility that costs are very sensitive to above-optimal emissions reduction, a tax is preferable; whereas where the uncertainty lies in the damage function (that is how grave the impact of that externality is) or where the damage function may be very sensitive to above-optimal level of emission, a trading system is preferable. Cost function uncertainties are already being resolved, and are likely to be mostly resolved in the near future, however damage function uncertainties are unlikely to vanish even in the long run. Therefore, given this criterion, our current climate predicament seems to support some combination of both instruments in the short run (after which cost functions will likely become more certain), while trading will be preferred as a longer term instrument.

In essence, the more appropriate question for debate may not be "Which is better?", but "How much of each to use and when?" This raises further hard questions of how such policy-instruments could best be combined to avoid conflicts such as distortion of substitution objectives (Sorrell and Sijm, 2003), instrument-redundancy and other practical problems that breed inequity. In any case whatever instrument choice is made, adequate commitment must be made to its enforcement, stringency and coverage in order to reap any significant benefits.

In administering carbon taxes in the short-run, it is also practically useful to remember Baumol and Oates' (1971) work on environmental externalities, which cautions that in the absence of comprehensive information about cost functions, taxes on goods with associated negative external effects, should be applied iteratively in order to meet up with emission-reduction goals, since there is no hard and fast way to know a priori what level of taxes would result in the desired changes. Taxes and trading schemes would both require keen monitoring and continuous adjustments in order to achieve meaningful goals. Moreover, Fu 2017 proposes a framework of combinatorial mitigation actions which is characterized as collaborative iterative dynamics with multiple players in the EU electricity sector. Cooperative behavior in a complex system requires trust and transparent information for sustainable outcome.

Carbon pricing, which is a means of providing economic incentives for reducing carbon emissions is found to be another cost-efficient way in mitigating climate change. According to the World

Bank (2020) there are 61 carbon pricing initiatives in place or scheduled for implementation, covering around 22% of global GHG emissions. The adoption and implementation of an efficient carbon pricing system is however a complex process. There are technical, institutional, economic, and political factors that restrict the opportunities for implementing a uniform and comprehensive system. Carbon pricing should therefore be seen as part of a policy package and not a silver bullet. The design of the systems thus should be adapted to meet different socio-economic interests and consequently compromises in design are often necessary. For instance, subsidies and tax exemptions are common. Khan and Johansson (2022) provided an overview of factors identified as influential in terms of the adoption, implementation and design of carbon pricing policy instruments, analysing policy instruments that were implemented between 2000 and 2015.

4 Conclusions

We have been witnessing political will and economic efforts to reduce CO2 emissions in order to avoid climate catastrophe. Political decisions informed by scientific evidence should allow us to avoid disastrous consequences. In economic terms, if there is a reasonable cost attached to polluting, then there is an incentive to avoid emitting more than is necessary and sustainable. However, what price to put on carbon emissions (in essence, what this 'reasonable cost' should be) and how to arrive at this price such that it is effective enough to align production and consumption patterns with environmental goals remain much debated issues. While some policy-makers and researchers favor a carbon tax mostly for its simplicity and direct effect on price; others support mitigation through a cap-and-trade framework due to its advantages with respect to the certainty it affords in meeting emissions-reduction targets, its efficiency in cost allocation and tolerability in a tax-averse world. There is definitely an argument for a combination of these two tools in addition to other mitigation and adaptation efforts to alleviate the impact of climate change on livelihood, health and prosperity.

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