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A Global Carbon Market?

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Abstract This paper explores the prospects for a global carbon market as the centrepiece of any serious attempt to reach the ambitious goal for greenhouse gas (GHG) reductions set by climate scientists. My aim is to clarify the extent to which we know what policy might best support global decarbonisation. I begin by discussing what we might mean by a global carbon market and its theoretical properties. I proceed to discuss the EU Emissions Trading System experience and the recent experience with the Australian carbon tax. Next, I assess the evolving carbon market initiatives in the US and in China. In the conclusion, I apply some principles of 'good' energy policy making to the prospects for a successful global carbon market.

Keywords carbon market, carbon tax, EU ETS

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1. Introduction

Dealing with climate change caused by dangerous levels of man-made greenhouse gas (GHG) emissions is seen as one of the most pressing global problems currently faced. Climate scientists tell us that, in order to have a 50 per cent chance of limiting the rise in global temperature to just 2 degrees (relative to 1850-1900) from 1990 levels, there needs to be a global 40-70% per cent cut in carbon dioxide equivalent (CO_2e) emissions[2] levels by 2050 relative to 2010 (see for example Allen et al., 2009 and IPCC, 2014).[3] This has been translated into an approximately 80% target reduction in CO_2e for advanced countries relative to 1990.[4] If CO_2e emissions do not decrease there is a heightened risk of dangerously high global temperatures that will have difficult-to-predict impacts on the stability of the global environment.

On the face of it this looks like a very challenging situation that requires action on a scale that we have not seen so far. That seems increasingly unlikely to happen in the time frame identified. The Kyoto Protocol of 1997 led to initial agreement on action to reduce GHGs at the global level, but was only ratified by 83 countries (out of over 190), and only included quantified emissions limitation or reduction objectives for a much smaller group of industrialized countries (so called Annex 1 countries). Countries that have ratified the Protocol account for approximately 63% of emissions from these advanced economies.[5] But more than a decade since the Kyoto Protocol entered into force, annual GHG emissions have not yet started to decline, and the prospects for a 'Global Deal' (Stern, 2008) on emissions reduction seem remote.

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[2] For simplicity, CO_2e will be used interchangeably with 'carbon' throughout the rest of this paper.

[3] Global GHG emissions in 1990 were 38 Gigatonnes of CO_2e, in 2010 they were 49 Gigatonnes of CO_2e (IPCC, 2014, p. 22). A 70% cut relative to 2010, is a 60% cut relative to 1990.

[4] See for example: https://www.theccc.org.uk/2014/11/25/the-ipcc-report-and-the-uk-2050-target (accessed 24 November 2015).

[5] See: http://unfccc.int/files/kyoto_protocol/status_of_ratification/application/pdf/kp_ratification.pdf (accessed 24 November 2015).

Against that backdrop, this paper explores the prospects for a global carbon market as the centrepiece of any serious attempt to reach the ambitious goal for GHG reductions set by climate scientists. My aim is to clarify the extent to which we know what policy might best support global decarbonisation.

My starting point is that the policy solution to excessive emissions of GHGs is actually well established in theory as well as in very large-scale experiments, specifically the European Union's Emissions Trading System (EU ETS). These give some confidence that carbon emissions reduction policy based around restricting the quantity of emissions permits to the level suggested by climate scientists would be the most sensible approach to delivering the depths of emissions reductions that is required.[6]

Indeed, we should stop giving the impression that we do not know what policy to put in place to deal with global GHG emissions. Climate science may be constantly evolving and contentious, but the economics of emissions control is not. An example of this was the recent suggestion that there needed to be a big increase in global publicly funded renewable energy research and development (RD+D) expenditure, from $6 billion to $15 billion per year for the next 10 years (under the 'Global Apollo Programme').[7] This type of proposal suggests that dealing with decarbonisation is still primarily a research project. This is not the case.

On the contrary: it is already the case that significant sums are being spent on renewable energy RD+D. In 2014 the world spent an estimated $11.7 billion p.a. on renewable energy RD+D. Also, in the power sector, global RES investment is closing in on global fossil investment (UNEP/BNEF, 2015). In 2014 global renewable power investment was around 90% of the fossil fuel power investment level. Within member countries of the Organisation of Economic Co-operation and Development (OECD), the picture is even more striking with perhaps less than 75% of power generation investment being spent on zero carbon technologies over the period 2007-2013 (World Economic Forum and Bain Consulting, 2015). A transition in the research base and in investment is underway at least in electric power – these suggest that the technological barriers to decarbonisation are being overcome.

Instead my contention is that the way forward is that we should (simply!) implement a reasonably comprehensive set of quantity restrictions on CO_2e, building on experience with existing policies such as the EU ETS.

The paper proceeds as follows. First, I discuss what I mean by a global carbon market and its theoretical properties. Next, I discuss the EU ETS experience and the recent experience with the Australian carbon tax. I then go on to assess the evolving carbon market initiatives in the US and in China. In my

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[6] Indeed one could go further and suggest that any other conceivable policy (or set of policies) seems to have no realistic prospect of adding up to a policy strong enough to reach the required cuts in GHG emissions.

[7] King et al. (undated).

conclusions, I apply some principles of 'good' energy policy making to the prospects for a successful global carbon market.

2. What Do We Mean by a Global Carbon Market?

2.1 Why Price Carbon?

At the heart of a carbon market is the idea that putting a single price on CO_2e emissions regardless of their source is a good idea. Carbon pricing through a market has most value in the early stages of decarbonisation. The market can help with identifying the mix of sectors to decarbonise; the mix of existing low carbon technologies per sector; the role of demand side reduction and substitution; and with guiding consumer and climate NGO pressure. A single price of carbon is fundamentally about identification of low cost decarbonisation options within a general equilibrium (i.e. multiple interconnected markets) setting. This sort of idea is in sharp contrast to a technology-based approach, which assumes both the efficacy of the technology and the extent to which it should be implemented. It is because at the whole economy level we are unlikely to know how best to approach decarbonisation that carbon pricing, rather than a technology driven approach, is so valuable. Putting a price on pollution is a policy that has wide support among environmental economists because it directly tackles the environmental externality involved in pollution and because it has a good track record, especially when contrasted with conventional command and control approaches based on the mandating of particular technological solutions.

Carbon markets (cap and trade schemes) and carbon taxes are the two standard ways of putting a price on carbon emissions. The major difference between these two approaches is that carbon markets set the quantity of carbon to be emitted and let the price vary in the market for emissions permits, while carbon taxes fix the price but let the quantity of emissions vary. As such, carbon markets introduce a price risk for those exposed to the spot price of permits, while carbon taxes introduce quantity risks on the climate. As we shall see, carbon markets are the more popular form of carbon pricing globally.

Many societal stakeholders do not like carbon markets precisely because they deal so effectively with the general equilibrium issues and ensure that the overall quantity of permits is fixed no matter what the demand conditions are in permit markets.

Properties of carbon markets that allow them to achieve general equilibrium are their transparency and their ability to highlight the following: differences between included and non-included parties; the incidence of final costs and prices, especially to consumers; the financial flows within and between countries; the cost impact of political interventions; and the lowest cost interventions, which effectively acts to restrain special interests. Thus if governments choose to enact limited carbon trading schemes, it will soon become clear what effect they are having and on whom. It is also clear when the initial quantities of permits available in the market are too few or too many by the evolution of prices. In addition, any announcement on the extension of current trading scheme will have a verdict given on its tightness by the price reaction in the permit market.

Basically, political opposition to the use of carbon markets is based on the fact that they do work in a predictable way.

2.2 What Are the Characteristics of a Global Market?

What would a global carbon market look like? This is an interesting conceptual question. One might imagine that it would involve a single type of emissions permit issued by a global authority and a single global monitoring and enforcement authority. The United Nations Framework Convention on Climate Change (UNFCCC) does issue Certified Emissions Reductions (CERs), which approximately have this property and in some sense already provide a global carbon price at the moment.

However, in general, global markets do not have this type of framework. Global markets are actually made up of voluntarily interconnected markets, which produce and trade broadly similar products with price arbitrage between them. The individual markets within the interconnected system have their own systems of property right definition and enforcement. A good example of this is the global market for oil. While one can clearly speak about the global price of oil and global supply and demand conditions, actually the global market is made up of a number of interconnected markets (such as West Texas Intermediate (WTI) and Brent Crude). These markets give rise to their own prices (WTI is usually cheaper than Brent, due to the quality difference). The situation in global natural gas is even less integrated, with major regional markets (in the US, Europe and the Pacific Basin), but prices do to some extent move together.

For us to talk about a global market, all that needs to be true is that markets are interconnected enough for major price differences between significant regions to be arbitraged. This clearly does happen in oil and is happening to a greater extent in natural gas. A single trading platform or integrated regional platforms (as for oil, or foreign currency) are not required, though clearly end-users can arbitrage between markets for both oil and gas because the underlying commodity can be used in any location. The parallel for a global market in carbon emissions permits is simply that individual markets recognise a permit from another market as being exercisable in their market.

The idea of a global market does not require all sectors of the economy to be exposed to global price fluctuations. Whole sectors can be exempted from such exposure, either by contractual hedging with longer-term private contracts or by government intervention. Thus even in market based energy systems, energy companies can sign long term contracts for the supply of gas or coal which effectively reduces the exposure of their customers to spot market fluctuations in international commodity prices. This happens with carbon when the government buys renewables or nuclear power with multi-year fixed prices above the expected average long-term market price. It also happens when governments fix final (i.e. administered) prices of energy regardless of the fluctuating fossil fuel price, such as in the many oil producing countries who choose to sell oil to their domestic consumers at much less than the world market price equivalent price. By contrast developed countries with very high taxes on oil products, such as gasoline, also reduce the exposure of their domestic customers to global oil price fluctuations. Doing this dulls the exposure of the domestic economy by reducing the demand below what it might otherwise have been.

Once a global market emerges for any commodity we might expect the degree of exposure to prices based on the global market price to increase over time. This occurs because the costs of non-alignment are likely to grow over time, especially for countries with abnormally low prices. These countries are over-consuming the commodity with the loss of export revenue (if they produce it domestically) or an increasing import bill. Thus one might expect that internal prices might converge over time, though this process may be very slow. [8]

This process of convergence might also apply to global carbon pricing, with initially very different approaches to the determination of national carbon prices giving way over time to more market integration and price convergence. This would imply that even if countries started off with initially purely domestically determined carbon pricing (via, say, a carbon tax), there would be pressure to align domestic carbon prices with those emerging from large international carbon markets. Indeed, Stiglitz (2015) has recently made the case for a hybrid approach with some countries opting for cap and trade, and others going for carbon taxes, each as they see fit, as part of a global solution to GHG emissions.

2.3 A Global Carbon Market?

The global oil market provides a good backdrop to thinking about a global carbon market. The basic parameters of a global carbon market are the following.

In 2012 the amount of CO_2e emissions was 48,000m tonnes (WRI, 2015) (of which around $^2/_3$ is CO_2). Assume the long run price of CO_2e needs to be \$100 per tonne CO_2e by 2050 to be consistent with the emissions reduction target needed. This would suggest that the market might be worth \$4800 billion per year. However this would overstate the value of the likely carbon market at any point in time. A plausible long run equilibrium might therefore be 10,000 m

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[8] Indeed the IEA (2015, pp. 96-99) does discuss some evidence that global fossil fuel subsidies are beginning to decline, after adjusting for oil price effects.

tonnes at $80 per tonne.[9] If 10% of the value of this market were traded between regional markets (say US, China, EU etc), this would require global flows of funds equal to $80 billion per annum. How large is this market? For comparison, the global oil market is roughly 85 million barrels per day (BP, 2015). At $100 per barrel (which might be a long run price) this adds up to $3102 billion per year. Meanwhile looking at the potential financial flows between regional carbon markets, $80 billion is less than the current global international aid budget (which is $135 billion per annum).[10]

These numbers suggest that if all GHGs were part of a global carbon market, then this would be a large market but not out of all proportion to the sorts of markets that already exist at the global level.

2.4 Creating the Global Carbon Market – Is it Possible?

There are around 190 states in the world. It would seem that reaching a global agreement on allocating the quantity of GHG emissions to each state would be very difficult, but global emissions are highly skewed as Table 1 shows. The top 10 emitters alone, including the European Union, cover 68% of emissions.

Table 1: Top Ten Emitters of GHGs Globally (incl. Land use change and forestry (LUCF)) 2012

China	22.4%
United States	12.2%
European Union	8.7%
India	6.1%
Russian Federation	4.7%
Indonesia	4.2%
Brazil	3.8%
Japan	2.5%
Canada	1.8%
Mexico	1.6%
Total	**68%**

Source: World Resources Institute CAIT database.

Looking at the G20[11] + Spain (the group of leading countries who regularly meet to discuss international affairs), this covers 85% of world GDP and 75% of world CO_2e (incl. land use change and forestry). If we include the next 10 largest emitting countries, we get to 85% of world CO_2e. A reasonably sized initial large

[9] See IPCC (2014, p. 21), in the years out to 2070-2080.

[10] See http://www.oecd.org/dac/stats/development-aid-stable-in-2014-but-flows-to-poorest-countries-still-falling.htm (accessed 24 November 2015).

[11] The G20 consists of Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States and the European Union. Spain is a permanent invitee.

carbon market, with border tax adjustment (Neuhoff and Ismer, 2007)[12] would be sufficient to incentivize emergence of an increasingly global carbon market drawing in all the largest countries. How difficult would it be to get 31 countries to agree to quantitative emissions reduction targets?

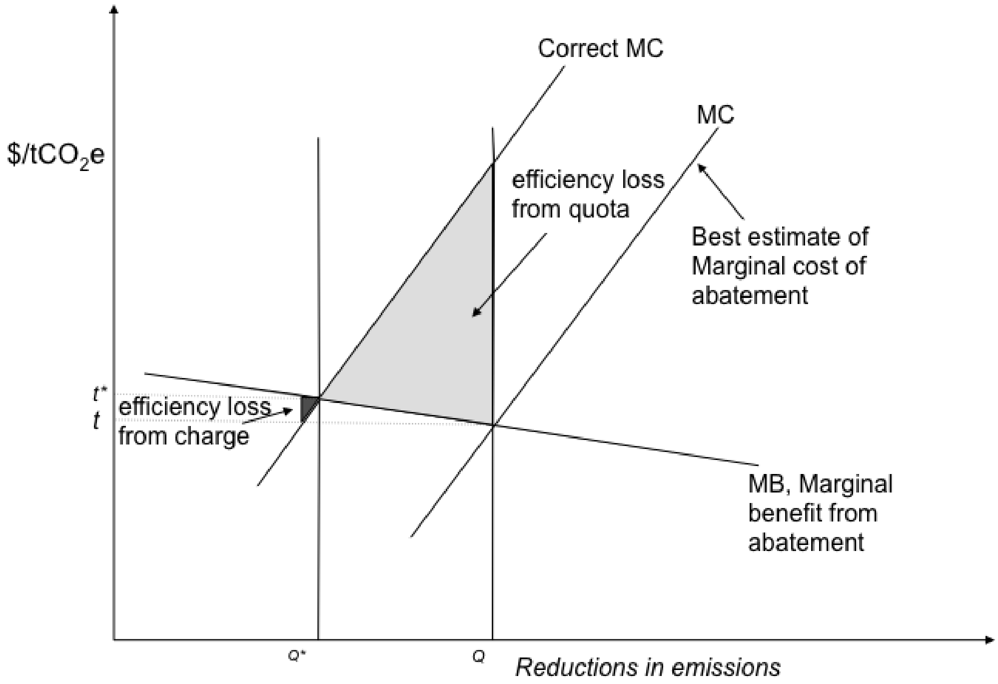
The EU ETS has 31 countries participating at the moment (28 EU member states plus Iceland, Norway and Liechtenstein). Of the G21, 6 (including the EU itself) are in the EU ETS. Of the 34 OECD countries, 21 are in the EU ETS. Of the rest of the world, many are in the spheres of influence of the largest 31 emitting countries. This suggests that agreeing a reasonably comprehensive agreement of quantity controls for GHGs is not primarily a problem of the complexity of the negotiations that might be involved. The EU is clearly not a representative sample of countries in the world, but what it does exhibit very well is the power of shared interest on a number of issues to enforce agreement on a particular issue, where the majority of countries harbors a strong political position.

2.5 Carbon Trading vs. Carbon Taxes?

An important theoretical discussion in environmental economics relates to the relative efficacy of emissions trading vs emissions taxes. Should the world attempt to co-ordinate on quantity targets for GHG emissions or a set of reasonably consistent carbon prices (taxes)? Weitzman (1974) makes a strong case for pollution taxes, which can be illustrated by the diagram in Figure 1. He argues that if the slope of the marginal cost of abatement curve (MC) is steeper than the slope of the marginal benefit of abatement curve (MB), then it is better to set a tax than to set quantity limits if there is uncertainty about the exact position of the MC curve. This is because the cost of mistakes in the estimation of the position of the MC curve (cost of abatement uncertainty) is lower if we get the tax level wrong than if we get the quantity level wrong, something that is illustrated by the size of the deadweight loss from the mistakes in the following diagram:

[12] Border tax adjustments could impose carbon tax adjustments on imports from countries that choose to remain outside the large carbon trading area.

Figure 1: Carbon Taxes or Carbon Markets? Weitzman Argument: Costs of Errors Setting Quantities



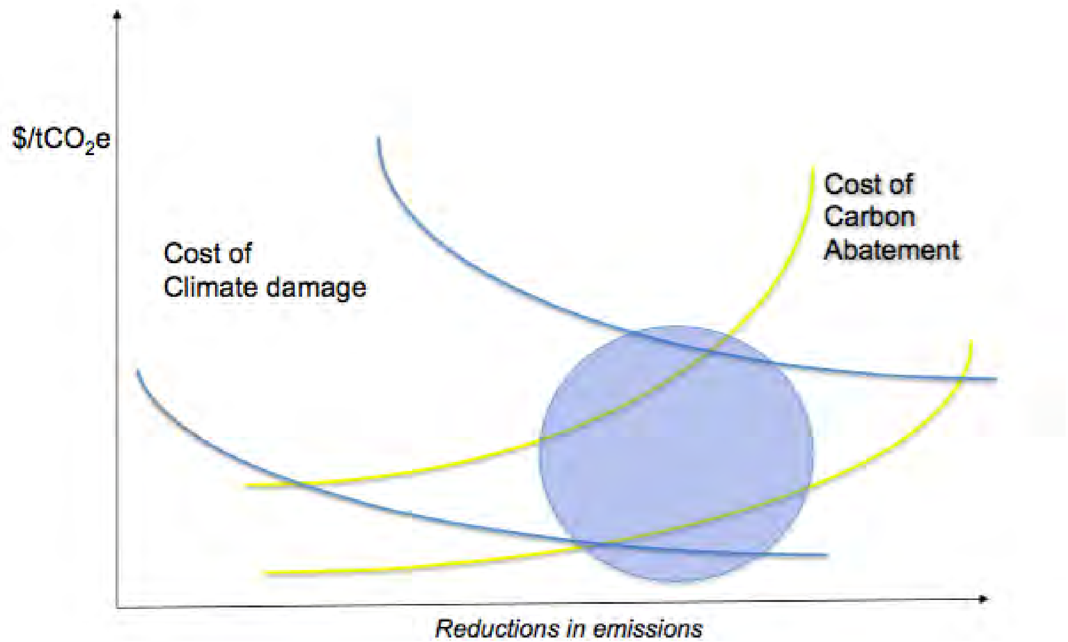
It may be questioned, however, whether this sort of argument applies well to GHGs.

The Weitzman result depends on the relative slopes of two curves, and his analysis suggests that the extreme cases where the relative cost of setting taxes is higher is more 'likely' than the extreme cases where the cost of setting quantities is higher. Since we do not really know where the MB curve is, and since it might involve big discontinuities in environmental damage (and hence be very steep in places), that is an argument in favour of quantity setting. In reality, a lot of uncertainty exists about the marginal benefit curve (i.e. we do not know where the climate damage effects exactly kick in, or how societies will adjust if they do). This is indicated by the wildly differing estimates on the value of the social cost of carbon (Hope and Newbery, 2008).

It is worth pointing out that if there is no uncertainty in the MC curve, but only in the MB curve, then the cost of mistakes is the same under both quantity or price setting. Thus if the marginal cost of abatement is actually relatively well defined or lower than predicted, then it is unlikely that the mistake in quantity is worse than the mistake in price.

In practice there is no suggestion that we would ever seek to impose a single price or quantity limit for all time, as the model is set up to analyse; instead, we would look to tighten the pollution control regime over time. This significantly reduces the cost of mistakes, allowing the incorporation of learning on the position of curves in the light of further information on the position of the MB and, especially, the MC curve. Thus a better representation of the situation is perhaps Figure 2, where identifying the optimal price (in the region of the blue ball) is very different, given the uncertainty in both the MC and MB curves.

Figure 2: A Better Argument?
Prices Harder to Identify than Dangerous Quantity



Source: Grubb and Newbery (2008, p. 282)

Weitzman's arguments are based on the relative deadweight losses arising from price setting vs. quantity setting. Weitzman (2015) has recently made three additional arguments in favour of a global carbon tax over a global quantity cap. These are: that revenues are nationally collected with a tax; that negotiating one price is easier than negotiating *n* quantities; and that governments have an incentive to coordinate upwards on the tax, rather than try and reduce the price under a quantity cap by seeking higher quantities. It is worth addressing each of these in turn. First, revenues from auctioning permits under carbon trading can be (and indeed are in the EU ETS) collected nationally, so this is not in reality a difference. Except that under central allocation of permits, one can (additionally) use the national quantity allocation to transfer wealth to countries bearing heavier costs of adjustment, in a way that might be easier than under the direct transfer of tax receipts. Second, the complexity of negotiation point is an interesting one. This is superficially attractive, but in international tax coordination, one suspects the devil is in the detail of implementation in each country and the fact that the nominal tax rate (in US dollars?) is the same is not really the issue – it could equally well be different without any loss of difficulty of implementation. Finally, on the fact that self-enforcement on a higher tax rate is likely, I am not sure there is any evidence that countries do coordinate upwards in negotiations on taxes. The EU carbon tax experience was that countries could not even agree to introduce the tax, let alone coordinate it upwards.

Cramton et al. (2015) make a further important conceptual point in favour of a uniform global carbon tax. Namely, that it introduces less volatility into the pricing of carbon and hence into the flow of funds that must necessarily flow between nations to achieve ambitious climate goals. Of course, this is an important argument. However it is easy to overstate the extent to which carbon prices within a cap and trade system are volatile, relative to the non-volatility of carbon taxes. Yes, prices in carbon markets are volatile in the same way as other commodities, such as oil and gas. However this is a volatility that can be managed and indeed is managed by long-term contracts, with the exposure to short run carbon prices ultimately being quite limited. Carbon taxes may not exhibit daily or monthly variability, but they can be reduced, increased or even removed by future government action (c.f. the Australian carbon tax discussed below). What is more, carbon taxes can introduce volatility into the outturn quantity of GHGs released, with consequences for climate risk.

There are some other types of arguments that are very important in favour of carbon trading.

First, there is the importance of consistency between the recommendations from climate science and the economic instruments employed to act on that science. Climate science can and does frame the climate problem as being about the absolute quantity of GHGs emitted (e.g. Max = c. 1000 Gigatonnes (Gt) of Carbon = c. 2440 Gt CO_2e) if the rise of significant warming is to be contained (e.g. Allen et al., 2009). Clearly, emissions trading based on quantity limitation coordinates the economic framing and the scientific framing in a way that setting a target price for carbon emissions does not.

Second, there are important legal precedents that an international agreement on emissions reduction must work within. As we have seen with the global oil market, global markets can and do exist based on internationally respected property rights. The idea that commodities and ownership rights can be traded internationally is well established in international law. This can happen while respecting national sovereignty. Thus tradable quantities of emission permits with initial allocations of pollution rights is consistent with the current basis of property rights and trade (as the EU ETS and other international agreements to respect nationally created property rights demonstrate). By contrast, co-ordination of taxes across borders is not something that is consistent with national sovereignty, and there are no examples globally of co-ordination upwards[13] of environmental or any other tax rates.

[13] There are some good examples of global coordination on the reduction or elimination of tax rates (e.g. as part of the General Agreement on Tariffs and Trade (GATT) free trade rounds). However coordinating on tax increases is quite a different story. The closest example is perhaps

Third, there is a rather important point to do with the rebound effects of a carbon tax. It is common to argue that carbon taxes produce a double dividend, in that higher carbon (and indeed any environmental taxation) leads to reduced taxes elsewhere and hence may stimulate the economy by reducing the inefficiencies associated with conventional taxes which are leveled on earned income and are therefore distortionary of work – leisure choices.[14] If environmental tax revenue is then used to target benefits on lower income consumers (as was the intention in Australia) this may also stimulate the economy via the multiplier effect arising from their re-distributional effects. Both of these types of effects mean that environmental taxes may raise demand for goods and services and hence produce some offsetting rise in CO_2e emissions. Thus carbon taxes may not produce as big a reduction in aggregate emissions as expected. This is not a problem with quantity restrictions on carbon emissions, where there is no possibility of a rebound effect being at work in aggregate.

Fourth, a key advantage of carbon trading is that the price of carbon dioxide permits is pro-cyclical. This is a good way of protecting the mechanism at times when the economy is doing poorly. There are good reasons why this makes sense from a social cost benefit analysis point of view, namely that social discount rates rise in times of recession: this is because inequality aversion goes up and hence social discount rates rise. Fixed tax rates become more burdensome and hence difficult to defend in times of recession, and more vulnerable to being reduced in a way that undermines the long-term credibility of the carbon tax mechanism.

Finally, Gollier and Tirole (2015) make an interesting set of arguments in favour of cap and trade based on the relative ease of enforcing a global carbon tax vs global quantity restrictions. Their point is that actually enforcing a global carbon tax would be very difficult to monitor. This is because it would be easy to turn a blind eye to enforcement of payments from particular polluters where this produced a national benefit. In addition, other taxes could easily be adjusted to mitigate the impacts of the carbon tax, in particular other taxes on fuel. This would undermine the overall impact of carbon taxes.

2.6 The Evidence on Carbon Emissions Trading vs. Carbon Taxes

The European Union spent five years in the early 1990s discussing a carbon tax at the EU level.[15] It could not agree on a carbon tax, but it did subsequently agree on introducing an emissions trading system. Other international or multi-jurisdictional systems for carbon pricing have all made use of carbon trading,

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the EU's effort to co-ordinate Value-added Tax (VAT) rates within the EU, but this is not about equalizing the VAT rates, and rather about keeping them within bands.

[14] For a discussion see Smith (1998).

[15] The carbon tax was proposed in 1992 and finally withdrawn in 1997. The proposed level of the tax was initially \$3 per barrel of oil (which is approximately \$7 per tonne CO_2) rising at \$1 per year to \$10 (European Commission, 1992).

notably California and Quebec under the Western Climate Initiative (WCI) and nine states in the U.S. Northeast and Mid-Atlantic under the Regional Greenhouse Gas Initiative (RGGI). Even within countries, carbon taxation has proved very difficult to enact.

This is not only about the sovereignty of governments with respect to taxation, which they expect to be able to adjust annually within the budget. It is also about the fact that tax rates are subject to periodic review, making any initial scheme vulnerable to subsequent political interference. In particular, it may be difficult to raise taxes from their initial levels in order to strengthen the price signal. Differences in the political cycle mean that it would be difficult to coordinate increases to tax rates across countries, at least more difficult than coordinating agreements to tighten the quantities within an emissions cap.[16]

Energy taxation on different fuels shows wide variance within and between countries. This suggests the political difficulty of coordinating on taxes, given very different attitudes to energy taxation in general. This is perhaps because vested interests in many jurisdictions find it easy to keep taxes at a low level or have been able to secure substantial exemptions, due to the lack of transparency around the domestic tax setting process.

Table 2 shows the relative size of the biggest actual and planned carbon trading schemes in 2014. The coverage for all carbon trading schemes is about 9% of global GHGs, which together with carbon taxes, brings about 12% of GHGs under some form of carbon pricing.

Table 2: Emissions Trading Schemes

EU ETS	2084 Mt p.a. (2013)
China pilot schemes	1115 Mt p.a. (2013-14)
Australia (initially a tax)	283 Mt p.a. (2012-13)
California-Quebec	184 Mt p.a. (2013)
RGGI – Eastern United States	165 Mt p.a. (2013)
Kazakhstan	147 Mt p.a. (2013)
New Zealand	31 Mt p.a. (2011)
Switzerland	3 Mt p.a. (2013)
UNFCCC – CDMs	350 Mt p.a. (3013)
Total	**c. 9% of global emissions**

Source: World Bank (2014).

The prices and the coverage of the current schemes remains low (World Bank, 2014, p.52). Prices are often very low and a long way short of the $80 that might be necessary to actually help achieve the emissions reductions required. In the EU ETS, for instance, the price is currently (November 2015) only around $9.50 (8.40 Euros) per tonne of CO_2; in California-Quebec it is $12.90 per tonne of

[16] The EU has recently agreed to tighten its carbon cap out to 2030.

CO_2e; and in RGGI it is $6.02 per tonne of CO_2. The global value of carbon pricing is thus around $50 billion p.a. – a long way short of the $800 billion envisioned above. Some carbon taxes are very high (e.g. the Swedish carbon tax is $130 per tonne of CO_2), but these high prices are rare. Emissions coverage within pricing systems ranges from 20-85% of GHG emissions, and typically amounts to around 40-50% (the EU ETS covers 45% of EU emissions). Normally this will include the power sector and energy intensive industry (such as steel and cement).

By contrast governments are much keener to subsidise renewables (via Feed-in-tariffs and Renewable Certificate Schemes) and fossil fuels by selling them below economic cost. In 2014 renewable subsidies were $135 billion globally, while fossil fuel subsidies were $493 billion (IEA, 2015). At the moment governments are clearly willing to spend large amounts of money subsidising energy production and use, but much less on pollution control.

However the World Bank (2015, p. 11-12) has documented the progress with carbon pricing, and in particular emissions trading. As of 2017, 38 countries (and 23 sub-national territories) will have some form of carbon pricing. This has increased from 2 countries in 1990.

3. Lessons from the EU ETS and the Australian Carbon Tax

3.1 The EU Emissions Trading System

The EU ETS began in January 2005 and has now been extended to 2030. It is still the biggest emissions trading scheme in the world, covering 11,000 individual stationary sources of emissions in the power and industrial sectors, as well as aviation within the EU. The EU ETS has had a chequered history as the evolution of prices within the mechanism shows (see Figure 3). Prices have been as high as 30 Euros per tonne of CO_2, but are now less than 10 Euros. This is partly a result of the way an emissions trading system works to minimise the cost of complying with a given quantity cap within the scheme. Lower than expected prices are a sign of success in achieving a given quantity target.

Figure 3: EU ETS – Price History

Source: European Environment Agency, see http://www.eea.europa.eu/data-and-maps/figures/eua-future-prices-200520132011/eua-future-prices-200520132011-eps-file/image_original (accessed 24 November 2015).

The initial collapse of prices in 2007 was due to over allocation of quantities in the initial trading period (which were not bankable to the second period from January 2008). This primarily happened because national governments were able to set their own quantity targets within the scheme. The second price collapse in 2009 followed the global financial crisis, which particularly effected EU GDP and demand growth.

However the scheme has continued and has now been extended from 2020 to 2030.[17] The scheme has evolved and been strengthened to some extent. There is now an EU wide cap with allocation of auction shares to national governments, preventing the over allocation problem at the national level. Free allocation of permits to existing polluters, which comprised most of the permits in the early trading years, has now been replaced with residual free allocation to trade impacted sectors, with most sectors having to buy permits at auction. This reduces the problem in the power sector of double payment to polluters, who gained free allocation of valuable permits, plus the ability to increase electricity rates based on the rise in the marginal price of power due to the opportunity cost of extra permits at the marginal price setting plant.

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[17] For a discussion of progress with the EU ETS and future directions, see Meadows et al. (2015).

There is a move towards linking the EU ETS with other emissions trading systems, rather than allowing the introduction of large numbers of offset reductions from CER projects; the introduction of large numbers of CERs served to keep the price down in the initial years. However in spite of promising recent developments in the overall design of the scheme, there remains a substantial overhang of permits in the market, perhaps as much as one year's emissions, banked for future use. This serves to keep the price low into the future. The EU has decided to introduce a market stability reserve (MSR) to take some of the permits out of the market and raise the price in the short run (and potentially reduce high prices in the future), but the MSR is small in relation to the size of the overhang of permits.[18]

The most encouraging development spearheaded by the EU Commission (which is responsible for administering the scheme) is that, when setting the new 2030 energy and climate policy targets, carbon emission reduction is now the centre piece of the policy, rather than one of three potentially conflicting policy goals. Thus the 2030 target for decarbonisation is a 40% reduction in GHG emissions (relative to 1990), i.e. a further 25% emissions reduction relative to the 2020 target in 10 years, implying a 43% reduction of ETS covered sectors relative to 2005. This is in addition to an EU-wide renewable energy (RE) target of 27%, which is subject to weaker enforcement than the current 20% target for 2020, and seems capable of being delivered by the necessary national efforts to achieve the decarbonisation target.

Similarly, the energy efficiency target of a 27% reduction in energy use relative to business as usual (up from 20% in 2020) is also not subject to national enforcement and is capable of being delivered by the decarbonisation target.

Ellerman et al. (2010) give an initial and broadly positive assessment of the EU ETS. They note that carbon has been priced, and while initial allocation was controversial, emissions did fall by 2-5% in the early years of the scheme. Moreover, the market for permits is liquid and efficient, and the negative effects on traded sectors has been small. The EU ETS remains an impressive multi-country environmental policy instrument capable of further tightening if other jurisdictions agree to also restrict their emissions, reducing the problem of carbon leakage. Boasson and Wettestad (2012) label it a good example of what they call international institutional entrepreneurship, which clearly established the EU as the leading policy maker with respect to decarbonisation.

3.2 The Australian Carbon Tax

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[18] See http://ec.europa.eu/clima/policies/ets/reform/index_en.htm (accessed 24 November 2015).

If the EU ETS provides a broadly positive experience of the carbon pricing generally and carbon emissions trading in particular, the Australian experience with carbon pricing is rather different.

The Australian Carbon Pricing Mechanism (CPM) was introduced as a carbon tax in July 2012 at AUD 23.00. It rose to AUD 24.15 (c. 16 Euros) per tonne of CO_2e in 2013-14, with a view to transitioning to a cap-and-trade scheme in July 2015. The CPM covered 60% of Australian emissions. On the face of it, this was an impressive achievement, which opened up the possibility of linking Australia with the EU ETS and other cap-and-trade schemes.

The problem was that the scheme was controversial from the outset. Unlike in Europe, where there has been a widespread consensus on the need to do something about the climate problem and cross-party political support for carbon emission reductions,[19] this was not the case in Australia. The Clean Energy Act 2011 passed narrowly in the legislature.[20] The then opposition Liberal party campaigned on a promise to abolish the CPM as one of their flagship policies. They won the election in 2013, and the tax was abolished in July 2014.

Robson (2014) offers an interesting analysis of the failure of the Australian carbon tax, suggesting that other measures (such as subsidies to renewables) might have been more effective. In particular, his analysis shows that although the government did attempt to mitigate the impact of the tax on voters by substantially recycling the revenue, this was poorly targeted and most taxpayers were worse off as a result of the combination of higher energy prices and lower non-energy tax rates. Robson highlights calculations which show the effective marginal tax rate going down for 0.56 million lower income tax payers, but going up for 2.21 million middle income tax payers. Overall, the fiscal impact was large, with AUD 27.7 billion (c. $20 billion USD) of taxes being raised over four years, of which only AUD 15.3 billion was returned to households, with the government fiscal position actually worsening after taking into account the free allocation of permits and other measures undertaken.

The failure of the Australian carbon tax highlights once again that taxes are clearly not superior to cap-and-trade as a way of reducing price volatility, given that the key to policy certainty is the political sustainability of any pricing scheme and the basic economics were not affected by the lack of daily volatility in carbon prices. As Robson points out, the initial price of carbon was actually quite high, especially relative to the wholesale price of electricity. Introducing the carbon tax produced a sharp spike in wholesale electricity prices (of around 20%, at a time when prices were rising), which could have been avoided if the tax had been introduced at a lower level initially.

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[19] In the UK the Climate Change Act 2008 passed its final vote in the House of Commons 463-3.

[20] 36-32 in the Senate, see http://www.rsc.org/chemistryworld/News/2011/November/14111101.asp (accessed 24 November 2015).

4. Signs of Progress in the United States and China

4.1 Progress Under the Clean Air Act in the United States

The US already has a number of regional carbon trading schemes. Indeed, as of late 2015, no less than 10 US states are already participating in regional carbon trading. All of these schemes cover the power sector and have been the result of state-level initiatives.

The US Congress failed to ratify the Kyoto Protocol of 1997 and hence has not signed up to emissions reductions targets as part of the UNFCCC process so far. The EU, by contrast, did ratify the Kyoto Protocol, and the EU ETS is a major part of its policy response. National carbon trading proposals have been presented in Congress, but so far have not progressed. These include, for instance, the Lieberman-McCain Bill in the Senate in 2003, and the Waxman-Markey Bill in the House of Representatives in 2009.[21] Both of these bills proposed a reasonably comprehensive carbon market, covering 85% of CO_2e emissions, including the power sector, industry and transportation.

However, another potential route to a federal carbon market is being pursued, with the support of President Obama, under existing legislation around the Clean Air Act, which is administered by the Environmental Protection Agency (EPA) (see Palmer, 2014).

In 2007, the EPA established its authority to regulate GHGs under the Clean Air Act, when the Supreme Court ruled in its favour in a case between it and the US State of Massachusetts. In 2009, the EPA established that GHGs were an 'Endangerment' to public health and that GHGs did 'Cause or Contribute' to negative environmental impacts. These rulings established that the EPA was free to regulate GHGs at the national level. In 2010, the EPA reached a settlement between various state and environmental petitioners who were demanding that the EPA take action on GHGs from power plants.[22]

The EPA has now established a three-part plan for reducing GHG emissions. This consists of improvements to mobile source standards, construction permitting and stationary sources. The mobile source standards (5% per year to 2025), involve moving the vehicle fleet average fuel efficiency to 35.5 miles per gallon (mpg) in 2016 to 54.5 mpg in 2025. The construction permitting sees improvements to the energy efficiency of new buildings, to be implemented by the states. And finally, the introduction of performance standards for new and existing electricity generators. This covers around 32% of

[21] The Waxman-Markey Bill (the proposed US Clean Energy and Security Act 2009) actually passed 219-212 in the House of Representatives, but failed to progress in the Senate.

[22] The Settlement is available at:
http://www.eenews.net/assets/2010/12/23/document_gw_02.pdf
(accessed 03 December 2015).

current emissions. The first two approaches were set out in 2011, and the third, known as the EPA Clean Power Plan, was set out in 2014.

The EPA's approach involves setting out conditions where a carbon market might emerge as the cheapest way to meet the emission standards it has set (Environmental Protection Agency, 2014 and 2015). To that end, the EPA has proceeded as follows: it has taken a number of technology building blocks to arrive at a Best System of Emission Reduction (BSER) standard for each state out to 2030. These technology building blocks suggest actions that each US state could take with respect to its existing fossil fuel plant fleet. The final BSER standards are arrived at by combining: an improvement in the heat rate of coal fired power plants; an increase in the utilisation of national gas power plants; and increased use of zero carbon renewables. The Final Rule published in October 2015 shows projected power plant emissions reductions of 32% by 2030, relative to 2005 (Environmental Protection Agency, 2015, p. 64924).

At the state level, the BSER translates into proposed state level goals for adjusted MWh-weighted-average pounds of CO_2 per Net MWh covering all Affected Fossil Fuel-Fired units. Because the existing mix of fossil fuel power plants is different the state level goals vary by state (see some examples in Table 3).

Table 3: Final State Goals
(lbs CO_2 per MWh - rate-based standard)

State	Interim Goal (2022-29)	Final Goal 2030
Montana	1534	1305
Kentucky	1509	1286
Illinois	1456	1245
Ohio	1383	1190
Pennsylvania	1258	1095
Texas	1188	1042
New York	1025	918
California	907	828
Idaho	832	771

Source: Environmental Protection Agency (2015, p. 64824).

Under the policy each state is to submit a plan for compliance. State level plans must be presented to the EPA by 2016 (with the possibility of a two-year extension) with the compliance period due to begin in 2022. The states are free to pursue multiple pathways to compliance using a CO_2 per unit of MWh (rate-based) or a total emissions (mass-based) standard. They could comply, for instance, through emissions trading with other states. Thus states could participate in multi-state plan in order to achieve their emissions reduction goals.

A key feature of the EPA's impact assessment of their clean power plan is that there is substantial net present value in the social cost benefit assessment of their plan. Most interestingly half (or more) of the benefits arise from associated reductions in other types of pollutants (produced with the CO_2) that directly impact on local and regional health within the United States. Total compliance costs are estimated to $5-9 billion p.a. Table 4 shows the detail for rate-based scheme. Mass-based schemes are estimated to have lower compliance costs ($3 billion p.a. less in 2030) and lower air pollution health co-benefits, but similar net benefits. This is partly because mass-based schemes can benefit from (cheaper) demand reduction measures. Existing state carbon trading regimes are consistent with a mass-based approach.

Table 4: Summary of Estimated Monetized Benefits, Compliance Costs and Net Benefits for the Proposed Guidelines in 2030 (billions of 2011$)

	Rate-Based Plan 3% discount rate
Climate Benefits	20
Air pollution health co-benefits	14-34
Total compliance costs	8.4
Net Benefits (with climate benefits at 3% discount rate)	**26-45**

Source: Environmental Protection Agency (2015, p. 64680).

The EPA's plan is still subject to potential legal challenge, modification and delay (Carson and Kreilis, 2015), but it looks increasingly likely that it will give a significant boost to the prospects for a national carbon market to emerge in the US by 2022.

4.2 Chinese Progress With Carbon Trading

China is now the world's biggest emitter of GHGs (22.4% in 2012) and has been making significant progress with its carbon policy.[23]

[23] Indeed the US and China have made a joint Presidential announcement about their carbon trading plans. See https://www.whitehouse.gov/the-press-office/2015/09/25/us-china-joint-presidential-statement-climate-change
(accessed 03 December 2015).

The National Development and Reform Commission (NDRC)[24] has stated that China's climate change-related goals for 2020 include the following: reducing CO_2 per unit of GDP_by 40-45% relative to 2005, and increasing the ratio of non-fossil energy to the consumption of primary energy to 15%. Its current Five Year Plan (12th FYP 2011-2015) goals, to be completed at the end of 2015, are: to reduce CO_2 per unit of GDP by 17% relative to the end of the end of FYP 11, and to reduce national energy consumption per unit of GDP by 16% relative to the end of FYP 11. During the current 12th FYP, seven local pilot carbon trading schemes have been established, following approval from the NDRC in October 2011, and the intention is to move to a national carbon market by 2017.

The characteristics of the 7 pilot schemes are indicated in Table 5. They all cover the electric power sector and other heavy industry. The pilot period is currently 2013-2015, with emissions capped at the same annual level for Shenzen, Shanghai, Beijing and Tianjin, and capped at levels requiring a decrease of 4.13% p.a. for Chongquing, and allowing moderate increases in Guangdong and Hubei (Xiong et al., 2015). The coverage of sectors varies from 4 sectors in Guangdong to 26 sectors in Shanghai (though all cover electric power) (ZhongXiang, 2015).

Table 5: Key characteristics of the Chinese Emissions Trading Pilots

	Shenzhen	Shanghai	Beijing	Hubei	Guangdong	Tianjin	Chongqing
Start of operation	2013	2013	2013	2014	2013	2013	2014
Carbon intensity target 2011-2015	-21%	-21%	-18%	-17%	-19.5%	-19%	-17%
Threshold	>20000 t CO_2	>20000 t CO_2	>20000 t CO_2	>60000 t CO_2	>20000 t CO_2	>20000 t CO_2	>20000 t CO_2
Initial Year Allowances	33 Mt	160 Mt	50 Mt	324 Mt	388 Mt	160 Mt	125 Mt
Entities covered	635	191	490	138	242	114	184
Emissions covered	38%	50%	50%	35%	42%	60%	35-40%
Offsets	10%	5%	5%	10%	10%	10%	8%
Free initial allocation	c.95%	100%	c.95%	c.90%	c.97%	100%	100%
Penalties	3X market price	10-100k CNY	3-5X market price	3X market price	3X market price	NA	2X market price

Source: World Bank (2014, p. 122); Xiong et al. (2015, p. 2511, 2513); ZhongXiang (2015).

[24] The NDRC is a cabinet level department responsible for state economic development planning and for guiding the restructuring of the Chinese economy.

Table 5 indicates that these are large pilots, though the number of covered entities is small. ZhongXiang (2015) reports that there has been a high level of compliance with the scheme in the first year and that there have been some emissions reductions, though the pattern of trading in the markets indicates that covered entities are waiting to the end of the compliance window to buy permits rather than trying to minimise the cost throughout the trading period. However, the experience to date shows that the idea of carbon pricing can work in China.

The NDRC is currently preparing for a national carbon market (ZhongXiang, 2015) to include electric power, metallurgy, non-ferrous metals, building materials, chemicals and aviation. The threshold for inclusion will be 26000 tonnes of CO_2 per year. To prepare for this, all entities emitting 13000 tonnes of CO_2 or consuming more than 5000 tonnes of coal in 2010 have been required to submit their carbon emissions since 2014. The Chinese carbon market might therefore consist of 10000 covered entities, emitting between 3-4000 m tonnes of CO_2, making it the largest in the world.

5. Conclusions

The idea of using the market to deliver carbon reductions is a potent one relative to the alternatives (notably regulatory controls through technology and performance standards, or incentives for low carbon technologies through subsidies and price supports). Carbon emissions permit trading is a globally popular form of carbon pricing. A global carbon market is highly desirable as a low cost way of delivering emissions reduction: indeed a reasonably comprehensive carbon market should be the economic centre-piece of any quantity based target for global GHG emissions, especially in the early stages towards deep cuts in global emissions.

We are still a long way from trading carbon in significant volumes across borders, but once again, there are encouraging signs that this is happening. The EU ETS has achieved transboundary trading of carbon in a wide geographic area. This scheme is capable of being linked globally and has helped create a significant market for CDM CERs from developing countries. Carbon does thus have an opportunity cost in many countries as a result of the EU ETS.

Australia provides a cautionary tale on the steady progress of carbon pricing mechanisms. Clearly, distributional issues need to be addressed within countries, as do the substantial leakage issues associated with the potential impact on traded sectors. However, there are encouraging signs in both the US and China on the potential future direction of carbon markets within those countries. In the US case (but also in China), the association of carbon abatement with local and regional clean air impacts is a powerful and potentially potent way of widening the political support and resolve for domestic action on GHGs by making the national cost benefit case for action.

Is it possible that the creation of a global market can be consistent with the principles of a 'good' energy policy (see Pollitt, 2015)? A 'good' energy policy should address the multidisciplinary issues around: the perception of the policy; the appropriate use of quantification in its justification; its impact on human well-being; its ability to garner public trust; the appropriate roles for state and non-state actors; whether it is capable of being delivered competently; and whether it exhibits consistency with other policy areas such as healthcare. I would argue that a market for carbon arising from quantitative national GHG quantity reduction allocations actually is capable of being a 'good' policy when looked at in the light of these issues.

Perception issues can be addressed and *quantitative justification* can be convincing as the progress with introducing national and regional carbon markets demonstrates. The recent association, by the EPA in the US, of GHG reductions with 'clean' air is a good example of an attempt to address negative perception issues around 'climate change' and 'global environmental problems', while being specific and salient in the area of the link to *human well-being* and making a direct link with *healthcare*. Experiments demonstrate that *public trust* in the operation of carbon markets can be fostered, and that carbon markets do much to set an appropriate *role for the state* in setting a framework within which both the private sector and other non-state actors can make meaningful and verifiable contributions to cutting emissions. Markets for carbon can be *delivered competently* in many jurisdictions, especially where there a possibility exists for small jurisdictions to join a larger regional trading area.

There is still a long way to go before we see emergence of anything like a comprehensive system for pricing of carbon externalities. There is still considerable doubt as to whether the piecemeal actions of individual governments with respect to emissions will ever add up to the necessary amount of emissions reductions that climate science claims to be necessary.[25] While establishing the amount of emissions required and dividing it up acceptably between countries requires an enormous scientific and international negotiations effort, the economic instruments to deliver the agreed targets are readily at hand.

[25] The current public commitments (as of October 2015) of governments to reduce GHGs by 2030 fall well short of what the IPCC (2014) are calling for, see Boyd et al. (2015).

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