BRIEFING

European Parliament

Carbon emissions pricing

Some points of reference

SUMMARY

The need to do more to mitigate climate change resulting from emissions of greenhouse gases (GHGs), in particular in terms of pricing, is widely accepted.

Several countries around the globe are either planning to implement or have introduced carbon-emission pricing measures (i.e. taxing or internalising negative externalities), with varying scope (upstream, downstream), coverage (sector exclusions) and boundaries (subnational or national areas). The objective is to reduce emissions in line with medium-term climate change mitigation pathways.

There are broadly two approaches: the emissions trading system (cap and trade) and carbon taxing. The existing measures are assessed regularly so as to be made more effective as regards emission reductions. The number of jurisdictions having adopted or intending to adopt carbon pricing has increased but still remains limited, in particular as regards the level of emissions covered.

One concern is to address 'carbon leakage', a term that describes shifts in economic activities and/or changes in investment configurations, directly or indirectly causing GHG emissions to be moved away from a jurisdiction with GHG constraints to another jurisdiction with fewer or no GHG constraints. Measures addressing carbon leakage have complementary objectives and outcomes that need to be addressed in their design. They address competitiveness and trade concerns, while their central *raison d'être* is climate change mitigation. They are now at the top of the EU agenda.

In this Briefing

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Context: greenhouse gases and climate change

Climate change has been an emergency of international concern for three decades, but it can no longer be ignored; the issue is more pressing now than ever. Scientific data and findings on climate change provide an assessment of its causes, as well as insights into where action is needed to succeed in limiting the increase in temperature.[1] Climate change is having a global impact on the economy, trade, health and biodiversity; the danger of not doing enough to address it is now widely acknowledged.

Greenhouse gases (GHG) radiating from the earth trap and absorb heat in the atmosphere. This causes global warming, resulting in climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).[2] CO_2 is the predominant GHG produced from burning fossil fuels, manufacturing cement, and forest degradation. CO_2 has a long atmospheric lifetime. Experts broadly agree that it is necessary to stabilise GHG concentrations in the atmosphere in order to avoid dangerous GHG-induced climate change. They also agree that this will require concerted efforts on the part of all major GHG emitting nations.

Measures to mitigate climate change have been discussed and established in a number of countries and sub-national entities. Yet, climate change mitigation has by nature a global dimension that confers a particular role upon international bodies, in particular the United Nations (UN) bodies. A coordinating structure has been developed in the form of the UN Framework Convention on Climate Change (UNFCCC), which was signed in 1992 and entered into force in 1994.[3] Its aim is to stabilise atmospheric GHG concentrations at a level that can prevent 'dangerous interference with the climate system'.

The Intergovernmental Panel on Climate Change (IPCC) is the UN body responsible for assessing the science related to climate change. It was set up by the UN Environment Programme (UN Environment) and the World Meteorological Organization (WMO) in 1988.[4] The IPCC prepares comprehensive assessment reports about the state of scientific, technical and socio-economic knowledge regarding climate change, impacts and future risks, and options for reducing the rate at which climate change is taking place. Overall, studies to date show that there is growing recognition that climate impacts are hitting harder and sooner than assessments indicated even a decade ago. Recent special reports have addressed Global Warming of 1.5 °C, (October 2018), Climate Change and Land (August 2019) and Ocean and Cryosphere in a Changing Climate (September 2019).

Climate change and air pollution

Climate change and air pollution are both environmental challenges for human populations, economies, and ecosystems. However their causes do not match fully, and factors that are particularly dramatic for one may not be so important for the other. This is true of CO_2 which is not an air pollutant as such, although it is one of the most important GHGs. Some substances, on the contrary, are relevant in both processes. Air pollutants also have mixed effects on the climate. Some contribute to global warming, while others have a cooling effect. In turn, climate change impacts on air pollution.

Finally, there are synergies and trade-offs between climate and air policies.

Source: Air quality: Pollution sources and impacts, EU legislation and international agreements, EPRS.

Climate change mitigation and carbon price signals

A number of studies and policies are aimed at designing effective instruments to mitigate the consequences of the ongoing climate change caused by GHG emissions.

Reducing carbon emissions globally

The UNFCCC itself sets no mandatory emissions limits for individual countries and contains no enforcement mechanisms but rather provides for updates or 'protocols'.[5] The central objective of

the December 2015 Paris Agreement (which entered into force on November 4, 2016) was to contain global average temperature increases to 1.5 to 2 °C above pre-industrial levels.

Parties to the agreement committed[6] collectively to limit the temperature increase to well below 2 °C above pre-industrial levels and to pursue efforts to limit it to 1.5 °C. Achieving this objective would require global greenhouse gas emissions to peak by 2020, fall by 45 % below 2010 levels by 2030 and be reduced to net zero by around 2070.[7]

Under the Paris Agreement, each country must draft and submit two documents: a nationally determined contribution (NDC) and a long-term low GHG development strategy. NDCs are to be updated every five years, meaning that the first updates are being submitted now.[8] The NDC must show how the country, as party to the Paris Agreement, intends to reduce its GHG emissions. Each country decides its NDC and emissions targets (pledges) voluntarily.[9]

Carbon emission pricing is one of a number of GHG emission reduction instruments (and one that also acts as an incentive). There is a growing consensus that it is an effective mitigation instrument that countries can use to achieve GHG emission reductions, in line with their commitments.[10] As of 2019, 96 of the 185 parties that submitted NDCs – representing 55 % of global GHG emissions – had stated that they were planning or considering the use of carbon pricing.[11]

Putting a price on carbon emissions to spur emissions reduction

Carbon pricing concepts

Carbon pricing puts an explicit price on GHG emissions expressed as a monetary unit per tonne of carbon dioxide equivalent (CO_2e). The **effective carbon rate** is the sum of market-based instruments (specific energy taxes, carbon taxes and carbon emission permit prices) applied to carbon emissions. **Explicit carbon pricing** meanwhile puts a price directly on greenhouse gas (GHG) emissions. Two instruments that fall into this category are the carbon tax, which is a price-based instrument and the emissions trading system, which is a quantity-based instrument. **Implicit carbon pricing** is used in a variety of ways and refers to policies that impose compliance costs (i.e. an implicit price) on activities that emit GHGs. **Internal carbon pricing** is when organisations assign a monetary value to GHG emissions in their policy analysis and decision making.

Source: State and Trends of Carbon Pricing 2019, World Bank Group 2019.

The idea behind putting a price on carbon emissions is to trigger a behavioural change that should result in reduced emissions (moving towards a net zero situation) in line with the climate change mitigation pathway, curbing the accumulation of GHGs emitted into the atmosphere.

The price signal adds to the cost of activities that generate pollution or harm the environment by adding ('internalising') the relevant social costs, known as 'negative externalities', in accordance with the 'polluter pays' principle. Negative externalities are the costs to society caused by GHG emissions that are not borne by either the producer or the consumer, and not accounted for in their choices. Internalising externalities involves putting a price on the use of the environment, placing a charge on the harmful effects of production and consumption by raising prices to levels that cover their costs to society (the price signal). In other words, charges are levied on activities that result in the release of GHGs in the atmosphere. Such charges[12] can either be internalised in the form of a licence (Coase theorem) or they can consist of levies known as 'Pigouvian taxes', named after the British economist Arthur Pigou.

The objective of Pigouvian taxes is not to raise revenue[13] but to serve as a behavioural or transformational incentive, because economic operators, faced with a tax that internalises the cost of environmental damage, have a choice of either paying it or avoiding it by reducing the harmful environmental impact of their activities. This is achievable in cases where the operators have an alternative. In essence, carbon pricing aims to make the cost of not reducing GHG emissions higher than the cost of making changes geared towards reduced or zero emission production and activities (including transport, heating and land use). For this reason, the price is not fixed around the globe

or over time. The various carbon pricing methods can be referred to as Pigouvian market-based instruments for GHG emission reduction.[14]

Charges of this kind can be passed on from producers to consumers. In short, the price signal increases the price of more carbon-intensive energy sources and activities relative to those that are not as carbon-intensive.

Comprehensive carbon pricing can provide: (i) across-the-board incentives for energy conservation and a shift to cleaner energy sources; (ii) substantial government revenue; and (iii) substantial domestic environmental gains (e.g. fewer deaths from local air pollution).[15] The political difficulty with carbon pricing relates to its direct impact on certain sectors (e.g. energy prices), underscoring the need for accompanying measures to address the trade-offs with other instruments. Ideally, carbon pricing should be comprehensive, well designed (with prices rising predictably over time and effectively targeted for mitigation), with the revenues used wisely.

Pricing carbon emissions

Carbon pricing is an economic signal designed to drive behavioural change. Markets that put a price on carbon encourage emission reductions and discourage high-carbon options.

How to design the price signal

Designing a price-signal measure involves determining what to price (price/tax base) and where to apply the price signal.

Upstream, midstream or downstream tax

The carbon tax can be applied at various points in the supply chain to a range of different actors, from importers and producers (upstream) to distributors or electricity generators (midstream) and consumers (downstream). When the tax is applied to fuels, it is common to place the obligation upstream or midstream, since this is the approach followed under existing excise duty rules. For taxes applied to direct emissions, there are several possibilities.

Source: Carbon Tax Guide – A Handbook for Policy Makers, World Bank Group, March 2017.

The first question concerns **emission coverage**: whether the pricing relates to CO_2 only or to all GHGs. Both options exist. However, the measures required may differ, as all GHGs contribute to global warming and climate change, but not in the same manner and not on the same time scale.[16]

The second question relates to whether the measure applies directly to the **GHG emissions**, or to the **materials** that ultimately generate the emissions – based on their carbon-equivalent contents – i.e. 'emissions inputs'.

Price signal design depends on sector or product scope. As explained in the World Bank Group Carbon Tax Guide, in most cases tax on fossil fuels (product scope) follows the existing rules applicable for the payment of excise duties while for taxes levied on direct emissions, such as emissions from electricity generation (sector scope), industrial processes or waste disposal obligations are generally levied on the legal entity producing the emissions (hence as direct taxes). This raises the issue of exemptions, which can be granted for reasons including competitiveness, fairness and costs. A number of exclusions (in the form of exemptions and rebates) render the price signal far from uniform, potentially altering its perception and efficiency.

When it comes to **tax rates**, different approaches exist, ranging from a method that matches the carbon tax rate to the social cost of carbon (which can vary depending on whether it is calculated locally or globally), the abatement target approach (ensuring a specific mitigation target), the revenue target approach (not primarily a price signal as such), and the benchmarking approach (comparison with other jurisdictions). It is possible to adjust the rate over a number of years, this can involve a static carbon tax rate, a gradually increasing carbon tax rate, a rate that matches the social cost of carbon, an adjustment formula, or a periodical review.[17]

Inventories and footprints

National inventories assess the quantities of greenhouse gases emitted physically within a country's borders and removed by sinks. In this system, GHG emissions from purchases not produced within the country appear in the inventories of the countries of origin. For fossil fuels it is the contrary: they are accounted for in the country where they are consumed. The **consumption footprint** (rooted in the language of ecological footprinting) measures the GHG emissions resulting from the end use of goods and services. The purpose is to calculate the quantities of greenhouse gases generated by the final demand of the country, in other words the consumption. This calculation therefore incorporates the emissions associated with the manufacture of imported products produced in another country (and should exclude local emissions associated with exported products).

Sources: Greenhouse gas emission statistics – carbon footprints; Fiscalité carbone aux frontières : ses impacts redistributifs sur le revenu des ménages, ADEME, OFCE, Beyond Ratings, January 2020.

Another element to consider is the place where the emission reduction is assessed. This relates to the fact that in a global environment not all products and services are used in the place where they are produced – on the contrary, global value chains show the importance of trade. This is reflected in the difference between emissions from the production of goods and services on the territory (inventory) and emissions from the consumption of goods and services (footprint). In developed countries,[18] production-related carbon emission levels have fallen whereas consumption-based carbon emissions have increased. Meanwhile, emissions resulting from the extraction of fossil fuels and the production of basic materials (such as cement, steel and aluminium) can arise in places other than where they are consumed. Recent research distinguishes between direct emissions, indirect emissions and grey emissions, and outlines ways to account for those so as to calculate carbon footprint, possibly with a view to building policy measures, such as the carbon border taxation currently under discussion.

Challenges associated with carbon price signals

Carbon pricing is one of a number of instruments available to spur emission reductions. However, in many countries it is still only in its infancy and is generally not applied at a sufficient level to facilitate a real shift towards a low-carbon society.[19] Furthermore, various policies can be seen as imposing an implicit price on carbon (in particular carbon prices set by fuel taxes and fossil fuel subsidies).

The **carbon pricing gap** measures the difference between a benchmark value compatible with reduction pathways and the actual effective carbon rate (ECR). It describes how current measures are falling short because of a slow narrowing of the gap. In addition, there are substantial variations across sectors; this means that in deepening and broadening the introduction of carbon pricing, countries need to act both on the aggregate carbon pricing gap and the carbon pricing gap across sectors.

Another important factor is the **responsiveness of emissions to pricing**, which varies by sector and source of emissions. In this context, a recent IMF study addresses the 'Potential contribution of emissions sources to mitigation and the practicality of exploiting them with fiscal instruments'. Furthermore, whereas the impact of a particular carbon price level might be easily sufficient to enable some countries to meet their Paris mitigation pledges, others need much higher prices.

Pricing carbon emissions upstream (at production level) raises concerns with regard not only to **competitiveness** and **trade**, but also to its effectiveness in reducing emissions globally. When measures are applied at production level, there is a risk that competitors that are not priced for the emissions they produce will enjoy a competitive advantage. The consequence might be a shift in production (or part of it) to countries that do not price carbon emissions. This phenomenon is known as **carbon leakage**.

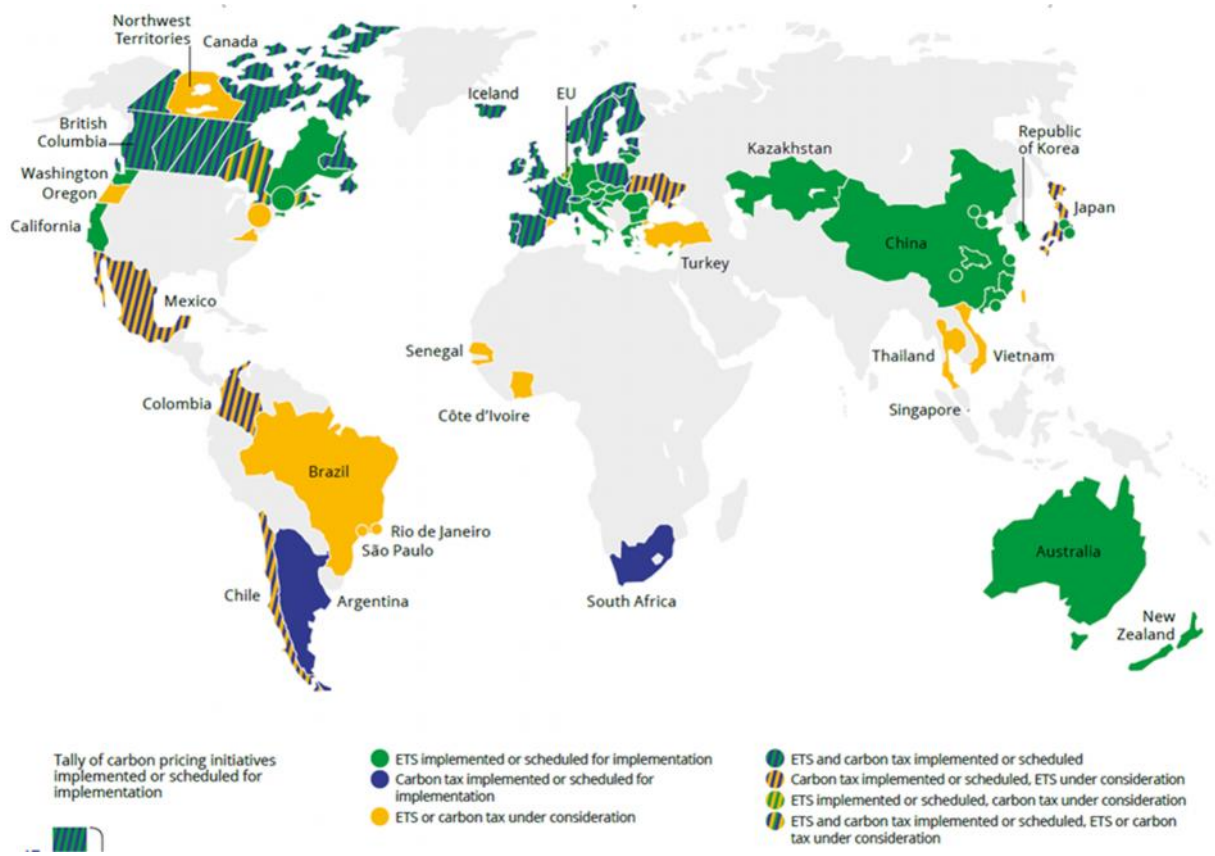
Carbon pricing needs to be seen in conjunction with the tax system of a country in order to be compatible not only with competitiveness but also acceptable in terms of equity and accompanying measures. Finally it is clear that there is no 'one-size-fits-all' approach when it comes to securing and maintaining public acceptability of carbon prices.

Differentiated carbon pricing measures

Measures around the world (in place or planned)

The number of national, sub-national and regional jurisdictions where carbon pricing measures are in place or are planned is increasing in number. Where measures are in place, they are also being broadened and deepened, with regional measures being complemented by state backstop systems – state intervention in cases where the sub-national level has not acted (for instance in Canada). There are now 57 carbon pricing initiatives, including the EU ETS (which covers all Member States plus Iceland, Liechtenstein, Norway and – until the end of the transition period, following its withdrawal from the EU, currently 31 December 2020 – the UK).

Figure 1 – Map of countries or sub-regional entities having adopted or implemented carbon pricing as of early 2019



Source: World Bank Group, State and Trends of Carbon Pricing 2019.

Several emissions trading systems (ETSs) are now in place, most notably the EU ETS, which involves 31 countries. China is planning to introduce a national-level ETS in 2020.

In the US there are regional schemes. The Regional Greenhouse Gas Initiative (RGGI) includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont and took effect in 2009. The California cap-and-trade programme meanwhile came into effect in 2013. The RGGO is estimated to cover a non-negligible portion of US gross domestic product and CO_2 emissions.

Beyond the jurisdictions shown on the map, these efforts have generally been found to be insufficient, as less than 5 % of the global emissions covered by carbon pricing initiatives are priced at a level consistent with achieving the goals of the Paris Agreement. Although the use of carbon pricing is gaining ground, its coverage as regards emissions reduction remains limited. As a result, many jurisdictions are broadening and deepening their carbon pricing instruments so as to align them more closely with their climate goals and contribute more effectively to delivering on the objectives of the Paris Agreement, either by increasing prices, removing exemptions or increasing stringency.

Cap and trade and carbon tax

Carbon pricing can be achieved by means of an emission trading system or a carbon tax. Both involve building the cost of emitting carbon into the price of production, by means either of a tax or by requiring the acquisition and remittance of allowances, internalising negative externalities. Both methods share a behavioural fiscal feature, irrespective of the detail and use of the revenue yielded by the measures.

A **cap-and-trade system** (or emissions trading system or scheme – ETS) is a market-based instrument that places a limit on GHG emissions and divides them up into emission allowances (or permits). One allowance consists of the right to emit one metric tonne CO_2-equivalent.[20] The emission sources covered by the scheme can comply with the emission cap by either reducing their emissions or trading in emissions (or a mix of both). The total quantity of allowances is fixed in relation to the maximum emissions agreed. The jurisdiction controls the total supply of allowances, and the emission price is set through the auctioning and trading of allowances between firms. Emission allowances can be sold (through periodic auctions) or distributed to sources covered at no cost to sectors at risk of carbon leakage (based on, for example, the previous year's emissions), with the possibility to combine both. At the end of the compliance period, sources covered must submit emission allowances to cover the number of tonnes emitted during the period. Auctioning and market trading of allowances establishes a market price for emissions in an indirect way through the surrendering of allowances commensurate with the CO_2-equivalent emission. Trading systems have so far been mostly limited to power generators and heavy industry.

A **carbon tax** is a tax that places an explicit price on greenhouse gas (GHG) emissions or that uses a metric directly based on GHG emissions. The grounds for establishing a carbon tax to contribute to carbon emission reduction lie in the fact that carbon emissions constitute a negative externality. One key difference between cap-and-trade systems and carbon tax programmes is that while the former provide emissions certainty, the latter offer price certainty.

A problem without frontiers and answers within borders

Climate change is a global issue that calls for global answers. The Paris Agreement enshrines a cooperative global commitment to raise the level of ambition to match the climate challenge, while also promoting sustainable development and environmental protection.

Global commitment and national response

Carbon emission reduction and the climate change mitigation objective are the *raison d'être* of carbon pricing, and part of the cooperative commitment. In other words, action taken as a result of pledges and NDCs is supposed to contribute to the collective reduction of the emissions causing climate change. If pricing carbon emissions in one area to mitigate climate change does not translate into a reduction in global emissions it goes against the global cooperative commitment objective.

When it comes to climate change mitigation and carbon emission reduction, what is key is the collective impact of countries' climate pledges. This corresponds to the net result of the collective commitment enshrined in the Paris Agreement. As a result if countries' commitments and

achievements are absorbed by leakage or are simply not matched by other countries, the collective result is reduced accordingly.

Bridging global and national levels: cooperation and addressing leakage

At global level, there has been increased interest in international cooperation. International cooperation through carbon pricing can play an important role in reducing the cost of implementing mitigation actions and increasing resources. Article 6 of the Paris Agreement provides for voluntary cooperation among parties to implement their NDCs, raise ambition, and promote long-term sustainable development and environmental integrity. Article 6 can also provide a basis for establishing new linkages between different jurisdictions to reduce the current fragmentation of carbon markets.[21]

One reaction when carbon pricing is limited to certain regions of production can be the relocation of business activity, shifting the source of emissions in a process known as carbon leakage. This raises a competiveness issue for producers who are obliged to pay a price for their emissions. With carbon leakage, the risk is that climate change mitigation policies can actually lead to increased GHG emissions in other economic sectors or countries.

Carbon leakage

In a nutshell, carbon leakage is caused by asymmetrical carbon policies, whereby in one jurisdiction GHG emissions are priced comparatively highly, while in another there is less-stringent GHG emission pricing or none at all.

Carbon leakage can be defined as a shift of economic activities and/or changes in investment configurations that, directly or indirectly, cause GHG emissions to be moved from a jurisdiction with GHG constraints to another jurisdiction with no or fewer GHG constraints. There are several channels for carbon leakage. Production leakage within the same sector increases short-term competitiveness. Investment leakage comes later and is a longer-term effect, as the loss of competitiveness drives the shift of investment to jurisdictions with fewer or no GHG-constraints.

Source: Carbon leakage an overview, CEPS Special Report No. 79, December 2013, Commission.

There are several ways to address leakage and distributional risks. These fall into the following categories: reduced carbon tax payments (by means of exemptions, reduced tax rates, rebates on carbon tax payments or offsets); support measures (involving output-based rebates, support programmes such as subsidies, non-carbon tax reduction or flat payments);[22] and measures addressing leakage that pertain to border adjustment and consumption-based taxation and tax coordination measures.[23]

Carbon leakage needs to be addressed, first and foremost for environmental reasons, so as to ensure that contributions to the global emission reduction commitment are not diluted as a result of leakage and to preserve the contribution to climate change mitigation resulting from existing carbon pricing measures.

Efficiency and the level playing field: the need for equalisation and carbon adjustment measures

When it comes to the competitiveness issues raised by carbon leakage, an adjustment mechanism is needed to re-establish a level playing. The emergence of carbon pricing has naturally fuelled interest in finding methods to stop carbon leakage. The aim is to prevent businesses resident outside economies where carbon pricing applies from gaining a competitive advantage by not paying carbon prices on their production. In the absence of an adjustment mechanism there are cost differentials for companies operating within and outside the borders of jurisdictions that price GHG emissions. The issue exists because carbon pricing measures apply to activities within a jurisdiction (starting with production). The production-based approach (recorded in national inventories) does not offer adequate tools to reflect overall emissions or to ensure that the carbon pricing delivers a contribution to the global commitment to reduce GHG emissions. By contrast, a

consumption-based carbon price is seen by some as a possible tool to address carbon leakage in terms of both competitiveness and the environment.

In principle border adjustment is simple. Taxes (in a broad sense) equivalent to the burden borne by producers subject to carbon pricing are placed on production originating from non-carbon pricing jurisdictions at the border, adjusting the carbon pricing on companies established in the jurisdiction and outside of its borders. The border adjustment is designed to equalise the tax burden borne, irrespective of the jurisdiction of production. It resolves the competitiveness issue while safeguarding the environment output (contrary for instance to exemptions, which address the competitiveness issue only). On this premise, there has been extensive research into carbon adjustment measures, in particular with regard to their compatibility with WTO rules. However, as the question of the compatibility of such mechanisms has not actually arisen, studies are currently looking into similar situations and how they were addressed in the litigation bodies. These cases provide indications at best as to the possible interpretation of provisions in the case of a carbon border adjustment measure, depending on its design.[24]

Border adjustment design can be more complex, with regard in particular to how the GHG emissions from products are determined (and the benchmark used). Scholars have also developed alternatives to the carbon border tax (considered too complex and too technically risky), in order to reconcile trade and climate. One idea is to set up a group of like-minded countries with a view to applying a low-level uniform tax to combat the outsourcing of polluting activities. This would involve adopting ambitious and binding policies to fight climate change, to be applied to all imports from countries outside the club. The tax would therefore act as an incentive to join the club. It is worth noting that the border adjustment mechanism issue is common to all jurisdictions that have adopted pricing measures towards the rest of the world, primarily for competitiveness reasons.

While the objective of border adjustment mechanisms is not generally questioned, whether the tools contemplated are able to deliver an effective and real contribution is a moot point. For some, a European carbon border tax would be much pain, little gain, when weighing up the advantages and disadvantages of its various potential elements. Other potential alternatives (for instance a consumption-based carbon tax) might be better able to deliver a carbon mitigation output.

Outlook

The new European Commission's European Green Deal, presented in December 2019, aims to step up progress on decarbonisation by speeding up the reduction of emissions in the EU. The measures that will be taken to achieve this goal are currently at the design stage. This is the case for the proposal for a border adjustment mechanism, due to be launched in 2021 'for selected sectors, to reduce the risk of carbon leakage' if differences persist in levels of climate ambition worldwide. This is also the case for the intended extension of the EU ETS to other sectors.

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ENDNOTES

1 See report from the Science Advisory Group of the UN Climate Action Summit, whose 2019 report United in Science provides authoritative information and key messages on climate change. The emission gap is the difference between emission levels under full implementation of possible GHG emission reductions and levels consistent with least-cost pathways to the maximum temperature increase target. For figures relating to the emission gap depending on assumptions (unconditional or conditional commitments (NDCs) under the Paris Agreement) and the target of 1.5 °C and 2°C pathways) please refer to the tables and summary on p.15 of the United in Science report.

2 Less prevalent – but very powerful – greenhouse gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) (UNFCCC Factsheet 2009). They are accounted for in terms of CO2 equivalent (CO2e), which describes the warming potential of a GHG over a long time period, expressed in terms of the amount of CO2 that would yield the same amount of warming.

3 In 1992, the Earth Summit resulted in the UNFCCC (along with its sister Convention on Biological Diversity and the Convention to Combat Desertification) as a first step in addressing the climate change problem. Today, it has near-universal membership. The ultimate aim of the Convention is to prevent 'dangerous' human interference with the climate system. This is not the only international agreement to deal with climate change. See for instance the 2019 working paper by the Stockholm Environment Institute 'Connections between the Paris Agreement and the 2030 Agenda'.

4 The IPCC has 195 member countries.

5 The 1997 Kyoto Protocol includes mandatory emission limits, and provisions relating to carbon trading.

6 The Paris Agreement contains some provisions that are legally binding (such as preparation and implementation of NDCs, as well as reporting), and others that are voluntary, for a summary see G. Erbach, The Paris Agreement: A new framework for global climate action, EPRS, 2016.

7 Negative emissions technologies (NETs) such as Bioenergy with Carbon Capture and Storage (BECCS); terrestrial Enhanced Rock Weathering (ERW); and Direct Air Capture with Storage (DACS) are designed to mitigate the consequences of CO_2 emissions in the atmosphere and also reduce emissions; the most important are trees and wetlands. See for instance E. Cox and N.E. Edwards, 'Beyond carbon pricing: policy levers for negative emissions technologies', *Journal of Climate Policy*, Vol. 19, 2019; or Sinking to zero: the role of carbon capture and negative emissions in EU climate policy, CEPS, January 2019.

8 Those commitments are analysed by the Climate Action Tracker (CAT), which covers more than 30 countries (including the EU and some of its Member States). The list of the NDCs is available in Annex III of State and Trends of Carbon Pricing 2019, which specifies if they include a mention of carbon pricing. The first NDCs to be updated are being adopted as from 2020. Progress is monitored by organisations such as the World Resources Institute (WRI) and the Climate Action Tracker (CAT).

9 Following the distinction that existed under the Kyoto Protocol between 'Annex I countries' having made a special commitment and the other (developing) countries.

10 See also OECD, Effective Carbon Rates 2018.

11 See Part 3 'International carbon pricing initiatives' of the World Bank Group, State and Trends of Carbon Pricing 2019, p.53.

12 The word 'charge' describes the addition of a cost (irrelevant of its legal nature whether it is a tax or a fee). Some experts use the word 'penalty'.

13 If the tax is successful in reducing the adverse environmental impact, the fiscal revenue it generates (its yield) will diminish, indicating that economic actors have chosen to modify their behaviour.

14 They are complementary to non-market-based instruments such as performance and technology standards, as well as prohibition of certain products and practices.

15 In general terms because of the synergies and trade-offs between climate and air policies. For example biomass can be considered low-carbon but can contribute to air pollution. Also, effective filters on fossil power plants can do more to reduce air pollution than reduction of CO_2 emissions.

[16] For instance methane has a shorter atmosphere-life (12 years) (see Why carbon pricing matters – implementation guide, April 2018, World Business Council for Sustainable Development – WBCSD).

[17] An example is provided by the mechanism used in Switzerland, see description provided in A Proposal for the Climate: Taxing Carbon not People (CAE march 2019) 'To make credible the environmental commitment of its tax and its only objective to provide incentive, Switzerland uses a mechanism whereby scheduled increases are automatically applied if emission targets are not met. On the other hand, increases are postponed if they are exceeded. In this way, the incentive nature of the tax is claimed and credibility is lent to it since the State will not have any additional revenue when its objectives are achieved. Beyond that, each citizen understands that, if everyone's efforts are strengthened to achieve the desired objective, taxes will be reduced.'

[18] See for instance Fiscalité carbone aux frontières : ses impacts redistributifs sur le revenu des ménages, ADEME, OFCE, Beyond Ratings, January 2020, in particular Annex III on carbon accountancy ('Comptabilité carbone, un état des lieux').

[19] Continuation of the quote 'Even when considering energy-specific taxes together with explicit carbon pricing policies, half of the emissions from fossil fuels are not priced at all, and only 10 % of global emissions from fossil fuels are estimated to be priced at a level consistent with limiting to 2 °C. p.16, United in Science.

[20] This accounts for differing GHG global warming potentials.

[21] But the discussions failed to yield an agreement on the rulebook for implementing Article 6 at COP24 and COP25.

[22] See, for instance, free allocations in the EU-ETS for energy intensive industries (industries with high carbon intensity and high trade intensity) together with national, European and international measures excluding certain sectors and activities.

[23] See in Carbon Tax Guide – A handbook for policy makers, World Bank Group, March 2017, Part 7, 'Avoiding unwanted effects of carbon tax'.

[24] See namely S. Garufi, Border Tax Adjustments and Environmental Protection: The Role of Taxes and the GATT Limits, Bocconi Legal Studies Research Paper No. 2360226, 2013; A. Pirlot, *Environmental Border Tax Adjustments and International Trade Law – Fostering Environmental Protection*, New Horizons in Environmental and Energy Law series, Edward Elgar Publishing, 2017. Chapter one provides background on the 'History and theoretical foundations of traditional BTAs'; Demystifying carbon border adjustment for Europe's green deal, Bruegel, October 2019; Border Carbon Tariffs: Giving Up on Trade to Save the Climate?, Bruegel, August 2019; A. Dias, S. Seeuws and A. Nosowicz, 'EU Border Carbon Tax Adjustment and the WTO: Hand in Hand Towards Tackling Climate Change', *Global Trade and Customs Journal*, Volume 15(1), 2020.

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