Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

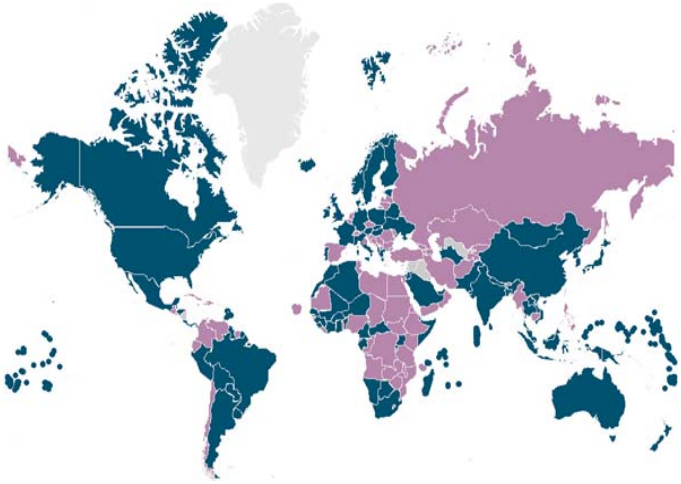
No. 187
December 2016

TRÉSOR-ECONOMICS

Economic analysis of the Paris Agreement

- While traditional economic approaches in international climate agreements differ in some respects, they are all based on three main principles:
  - Universality: Because the causes and consequences of climate change are global, all countries must participate in efforts to reduce greenhouse gas emissions, with no free riders.
  - Efficiency: To achieve the greenhouse gas (GHG) reduction objective at least cost, the economic instruments used must be consistent with a uniform global carbon price.
  - Equity: In global negotiations for a mechanism culminating in a global carbon price, efforts must be shared among countries in accordance with an equity principle that all parties accept.
- Yet the failure of the Copenhagen climate talks showed that in a world of sovereign States, each holding a de facto veto, international discussions on the sharing of a global carbon budget or a global carbon price are unlikely to succeed. Climate talks are subject to real-world constraints, and an international negotiation is not conducive to determining which fairness principle should be adopted.
- A polycentric approach, based on immediate actions to reduce GHG emissions at multiple levels – global, national and subnational – may be justified by economic analysis, even if the analysis is not based on the conventional approach. The polycentric approach allows for implementation of different types of policies, so that the resolution of the problem no longer depends on a single solution whose failure would be catastrophic. Lastly, the risk of free-riding is limited by the local co-benefits arising from the reduction in GHG emissions, such as lower air pollution and a reduced energy bill.
- The Paris Agreement, which entered into force on 4 November 2016, embodies this kind of polycentric approach. It allows for universal participation, overcoming the obstacle of "fair effort sharing" by enabling each State to determine what it considers to be its fair contribution. It recognizes the impossibility of setting up an international enforcement system with sanctions and therefore turns to incentives supported by peer pressure and civil society. The "global stocktake" every five years provides an opportunity to review the national contributions and to encourage higher ambition in order to achieve the Agreement's long-term objective: global picking of emissions in the near future, and then achieving zero or negative net emissions in the second half of the century.
- The success of the Paris Agreement in achieving its long-term objective, however, will depend primarily on building greater trust and confidence across countries, and therefore on the transparency of the actions conducted. It will also depend on seeking greater efficiency by mobilising appropriate economic instruments effectively.

Map of countries that have signed and ratified the Paris Agreement as of 23 November 2016



Source: CAIT.
Blue: Ratified or otherwise joined the Paris Agreement
Pink: Signed the Paris Agreement but have not yet ratified
Grey: Have not signed the Paris Agreement

MINISTÈRE DE L'ÉCONOMIE
ET DES FINANCES

1. Conventional economic analysis of international climate agreements focuses on three main principles justifying a top-down approach in international climate negotiations

1.1 Under the principle of universality, because the causes and the effects of climate change are global, the agreement can achieve its goal only if all countries participate in efforts to reduce GHG emissions

The conventional economic approach to climate negotiations focuses, first, on the stability of the negotiated climate agreement. Invoking game theory, this approach insists on the need to limit the possibility for "free riders" to benefit from other countries' mitigation efforts (i.e., efforts to reduce GHG emissions) without taking appropriate action on their own. Free-riding would defeat any agreement, or indeed any attempt to combat climate change. This risk can be subdivided into two interrelated elements:

- The risk of the agreement collapsing: in the absence of penalties for free-riding, ambitious countries could discontinue mitigation efforts, leading to a domino effect that could cause the agreement to collapse. In game theory, this situation would be characterized as a sub-optimal Nash equilibrium[1].
- The risk of carbon leakage: if not all countries participate in a similar manner in efforts to reduce emissions, the countries with the strongest emission constraints could see their firms decide either to offshore production or to invest in countries with laxer controls, merely shifting the emissions from one territory to another.

The conventional economic approach holds that the only efficient solution to the problem of free riders is to implement a system with sanctions for non-participants and compensations for participants. W. Nordhaus (2015)[2] proposes the creation of Climate Clubs. Countries in the club commit to achieving ambitious emission-reduction objectives, leading to relatively high carbon prices. To prevent carbon leakage and encourage a maximum number of countries to join the club, Nordhaus recommends establishing a uniform percentage tariff at club members' borders, which would affect all imports from non-participating countries. According to the results of his C-DICE model, the tariff must increase with the target carbon price in order to maintain a constant Climate Club participation rate.

For target carbon prices of $12.50 to $25 per tonne of CO2, complete and efficient participation by all countries in the club could be achieved with a tariff rate of 2%. As the target carbon price increases, the tariff rate must also increase in order to preserve the equilibrium of the agreement: for a target carbon price of $50 per tonne of CO2, the tariff must be at least 5%.

1.2 Under the efficiency principle, the only way to achieve the stated objective at least cost requires implementation of a single global carbon price

Economic theory considers climate change to be an externality[3] that greenhouse gas emitters must be forced to internalise. The internalisation of emission costs (cost per tCO_2eq[4]) is done through a carbon price, whether through taxes or a market mechanism.

Conventional economic models of climate change show that the lack of coordination of mitigation actions increases their overall cost. The additional cost is explained not only by the fact that the emission-reduction actions are not located where they would be least expensive, but also by carbon leakage and impacts on trade. Studies have accordingly shown that the smaller the portion of global emissions covered by a climate agreement, the higher the cost and the greater the difficulty of achieving the emission reduction objective (IPCC, 2014).

In line with this, Gollier and Tirole (2015)[5] argue for establishing a global carbon price – through either a universal carbon tax or preferably a universal carbon market – in order to reveal a single global carbon price:

- In the ideal case of an international emissions market in which emission permits are allocated across all countries, the total volume of emissions is capped to ensure that the desired emission reduction objective is achieved. A broad range of keys for allocating permits across countries can be envisaged (see §1.3 below). On the basis of the allocation, countries would have to prove compliance in each period (for example, every five years) by returning as many permits as were issued in their territory during the period, with each country able to buy or sell allowances to other countries.
- In the case of a universal carbon tax, all countries would agree on a carbon tax trajectory binding on all, which would limit the temperature rise to well below 2°C[6], as provided in the Paris Agreement. Ignoring the political and institutional constraints on implementation (see below), a single uniform tax across the planet would fail to take account of the diversity of national conditions, as the allocation of allowances would. It would be possible, however, to imagine a financial compensation system that would address equity issues by transferring tax receipts from North to South, as proposed by economists including Gollier and Tirole.

(1) In game theory, a Nash equilibrium is a situation in which no player can find a better strategy, given the strategies chosen by the other players. In the absence of a higher authority capable of enforcing compliance with a potential agreement among players, cooperation is fragile and can lead to a non-optimal equilibrium.

(2) Nordhaus, W. (2015), "Climate Clubs: Overcoming Free-Riding in International Climate Policy", *American Economic Review*, April.

(3) In economic theory, externalities represent the impacts of action by an economic agent that were not included in its optimization program, despite their impact on the welfare of other agents. For climate, greenhouse gas emissions are considered a negative externality caused by economic activities such as transport or fossil-fuel fired electric power generation. Once released into the atmosphere, greenhouse gases lead to overall climate warming, which in turn causes a multitude of economic agents to bear financial losses and the costs of adapting to global warming. The regulator's role is therefore to introduce the externality into the optimisation programs of economic agents whose activities cause greenhouse gas emissions.

(4) tCO2eq: tonne of CO2 equivalent.

(5) Gollier, C. and Tirole, J. (2015), "Negotiating effective institutions against climate change", Opinions and Debates, Special issue. October. http://www.louisbachelier.org/wp-content/uploads/2015/11/BD-OD-CLIMAT-Gollier-Tirole1.pdf

(6) The Paris Agreement aims to limit the temperature rise to well below 2°C above the preindustrial level, and to pursue efforts to limit the temperature increase to 1.5°C.

A choice between taxation and market pricing depends primarily on the comparison between the costs arising from climate warming on the one hand, and those arising from mitigation on the other. From a theoretical standpoint, if the abatement costs[7] and the benefits of pollution reduction were both known, the two approaches would be equivalent. In practice, however, public authorities do not have precise knowledge of these variables, and the choice between taxation and market pricing accordingly depends on a comparison of the probable paths of abatement costs, on the one hand, and the benefits of pollution reduction, on the other (Weitzmann, 1974[8]). In the case of GHG emissions, there are two risks. The first is failure to sufficiently reduce GHG emissions relative to the costs arising from the impacts of climate change. The second would be to reduce GHG emissions at too high a cost relative to the benefits in terms of reduced impacts of climate change. Following Weitzmann, if the damage arising from climate change increases rapidly with the level of GHG emissions, then the greater risk would be the former, and it would be preferable to achieve a given level of emissions with certainty using market pricing. On the other hand, if the damage arising from climate change does not vary much with the level of pollution, the greater risk would be that of reducing emissions at too high a cost. It would thus be preferable to use taxation in order to avoid paying too high a price for a limited reduction in damage. In the case of climate change, the damage is linked to the concentration of GHG in the atmosphere (i.e., the stock of GHG), whereas abatement costs concern reductions in emissions (i.e., flows). Because of the high stock of carbon in the atmosphere (3040 $GtCO_2eq$, of which 2160 $GtCO_2eq$ was released before the industrial era and 880 $GtCO_2eq$ during the period 1750-2011[9]), the concentration changes fairly slowly, irrespective of the level of emissions, as average annual net flows of CO_2 came to 14.7 $GtCO_2$ in 2000-2009[10]. As a result, Newell and Pizer (2000)[11] concluded that it is highly likely that abatement costs rise faster than reductions in damage caused by climate change. The authors argued that taxes are preferable to market-based systems for cases where abatement in the short term is below 40%. That conclusion, however, should be revised in 2016 in light of progress in climate science; the temperature has reportedly already risen by 1°C[12] above the 1850-1900 average, and as warming increases, the risk of a runaway increase in climate disorders also rises[13].

Setting the global carbon tax at the appropriate level is a complex challenge. Under conventional economic theory, the pollution reduction objective should be set such that the costs of reduction equal its benefits. But because of imperfect information, governments generally do not know the actual costs or the benefits[14]. They therefore set reduction objectives–for example, limiting emissions so as to hold the temperature rise to 2°C–that translate into a global carbon budget, and seek to achieve those objectives in the most efficient manner. In this situation, determining the appropriate level of the carbon tax is a complex task, for it depends on many factors that impact emission reduction and change over time. They include pre-tax energy prices, tax or regulatory policies that influence the cost of reducing GHG emissions, technological progress, and changes in behaviour.

In a global carbon market, each country could be allocated a carbon budget, and the sum of those budgets would be consistent with the 2°C objective. Actual country allocations would be based on criteria that remain to be determined, and would address the issues of equity across countries (see §1.3 below). Because the units would be tradable between countries, several options for national governments could be considered:

- Compliance with the number of units allocated for the period, by national actions only (such as standards, taxes and national trading markets) without trading with other countries
- Emitting more GHG than the number of units received in the allocation, and buying units from other countries; or emitting fewer GHG than the number of units received, and selling units to other countries
- Starting from the country's carbon budget, establishing a national carbon market where the permits traded between companies are equivalent to the carbon units allocated to the country, and then linking the national carbon market, in full or in part, with other carbon markets (as in the link between the Quebec and California markets): in this case, countries allow companies that are subject to their respective domestic markets the right to buy or sell allowances or units from the other linked countries.

These options depend on abatement costs in each country and national preferences (as well as the initial effort-sharing allocation between countries) and, through trading, should lead to the emergence of a global carbon price that minimises the total global cost of the climate change effort.

(7) Abatement costs are costs borne by an economic agent to reduce the pollution resulting from its own activity.

(8) Weitzmann, M.L. (1974), "Prices vs. Quantities", *Review of Economic Studies*, vol. 41.

(9) French Ministry for Ecology, Sustainable Development and Energy, I4CE, *Key figures on climate, France and worldwide*, 2016 edition, based on IPCC, Working Group I, 2013.
http://www.statistiques.developpement-durable.gouv.fr/fileadmin/documents/Produits_editoriaux/Publications/Reperes/2015/highlights-key-figures-climate-2016-edition.pdf

(10) Ibid.

(11) Newell, R.G. and Pizer, W.A. (2000), *Regulating Stock Externalities Under Uncertainty*, Resources for the Future, Discussion Paper 99-10, Washington, D.C., February.

(12) According to the World Meteorological Organisation: see *WMO Statement on the Status of the Global Climate in 2015*, http://library.wmo.int/pmb_ged/wmo_1167_en.pdf

(13) IPCC, *Climate Change 2014, Impacts, Adaptation, and Vulnerability*, Summary for Policymakers: "With increasing warming, some physical systems or ecosystems may be at risk of abrupt and irreversible changes. Risks associated with such tipping points become moderate between 0-1°C additional warming, due to early warning signs that both warm-water coral reef and Arctic ecosystems are already experiencing irreversible regime shifts (*medium confidence*). Risks increase disproportionately as temperature increases between 1-2°C additional warming and become high above 3°C, due to the potential for a large and irreversible sea level rise from ice sheet loss." (p. 12)

(14) In 2007, the IPCC noted the broad variety of estimates for the social costs of carbon (SCC): "IPCC (2007b) highlights available estimates of SCC that run from -3 to 95 US$ /tCO2 from one survey, but also note that another survey includes a few estimates as high as 400 US$/tCO2 (*IPCC, 2007b; Chapter 20, ES and Section 20.6.1*)."

Conventional economic analysis recommends the emergence of a single global carbon price[15], but the main obstacle to global convergence is political (see below).

1.3 Under the equity principle, the efforts required of different countries should be differentiated and/or should involve compensatory financial transfers

For a given level of economic efficiency, the redistributive consequences can vary substantially depending on the criteria employed to allocate the total global allowances among countries (emissions per capita, historic emissions, or GDP per capita) or to set the level of a global carbon tax. The specification of the actual equity principle used is therefore fundamental.

Economists have proposed widely differing forms of effort-sharing, based on different forms of equity principles. De Perthuis and Jouvet (2015)[16] proposed implementing a "bonus-malus" international tax system to fund financial transfers from high emitters to low emitters. The proposal is based on per capita GHG emissions. Every country with GHG emissions per capita above the global average would pay a tax of $7.50/tCO2 for all emissions above the global average; conversely, all countries with below-average GHG emissions per capita would receive $7.50/tCO2 for emissions between the global average and the average for that country. The tax amount was calculated so as to fund annual transfers of $100 billion to countries with low per-capita emissions, in keeping with the commitment made by the developed countries in Copenhagen[17]. On the basis of 2011 emissions, the main contributors in the scheme would be the United States ($35 billion), China ($16 billion), Russia ($11 billion) and the European Union ($10 billion), while the main beneficiaries would be India ($39 billion), Bangladesh ($6 billion), Pakistan ($6 billion), Nigeria ($5 billion) and Indonesia ($5 billion).

Piketty and Chancel (2015)[18] consider an allocation key for contributing to a global climate adaptation[19] fund using an equity principle applying to individuals rather than countries. In addition, their paper proposes to calculate the CO2 emissions with a consumption-based method instead of the usual production-based method. This provides in the end a very different world map of climate responsibilities. The study proposes two solutions for financing a global climate adaptation fund: a global progressive carbon tax on an individual basis, or higher taxes on air tickets. The authors themselves recognize that in practice, it would be impossible to introduce a progressive carbon tax, whereas their proposed alternative of taxing air tickets captures only very roughly the inequality of carbon emissions. Additional work would be required to define the public policies better capable of addressing the individual inequalities in GHG emissions identified in the study.

2. Climate negotiations are subject to real-world constraints far removed from an idealised theoretical framework

While traditional economic theory holds that a global carbon price would be the most efficient solution, issues of national sovereignty, notably in the area of taxes, make a global price solution unlikely in the short and medium term. Yet the dangers arising from global warming are such that mitigation actions must not be delayed.

2.1 The Kyoto Protocol and the failure of Copenhagen illustrate the practical difficulties of implementing a top-down climate agreement

The 1997 Kyoto Protocol was the first agreement seeking to implement the 1992 United Nations Framework Convention on Climate Change (UNFCCC). This was a cap-and-trade agreement binding on the developed countries that established emission budgets for each country, i.e., a volume of allowances for the period 2008-2013 based on the reduction objective for the period, and emissions in the reference year. The Kyoto Protocol is therefore relatively close to the cap-and-trade mechanism recommended in the previous section, but with the key shortcoming of not being universal. Under the Protocol, developing countries made no commitment to reduce their emissions and could therefore increase them without constraint.

When the Protocol was adopted in 1997, 38 developed countries (representing 39% of global GHG emissions in 2010) committed to cut their emissions in 2008-2012 by 5% from a reference year (1990 in most cases).

After the failure of the United States to ratify the Protocol and Canada's withdrawal[20], the commitment of the remaining 36 developed countries (now representing only 24% of global GHG emissions in 2010) was to reduce their emissions by 4%. These 36 countries collectively reduced their emissions by more than the objective, mainly owing to the overallocation of allowances to the transition countries of Central and Eastern Europe; this was due, in turn, to the sharp post-transition

(15) Other approaches, which are also based on a single uniform carbon price, propose alternatives to a global carbon tax or global carbon market. David Bradford, for instance, in *Improving on Kyoto: Greenhouse Gas Control as the Purchase of a Global Public Good* (2004), outlined an alternative to the Kyoto Protocol based on emission allowances linked to fossil fuel imports that would then be purchased and retired by an international bank, whereas C. de Perthuis (2010) proposed that carbon pricing be based on a cap on extraction rights for fossil energy producers.

(16) De Perthuis, C. and Jouvet, P.A. (2015), "Routes to an ambitious climate agreement in 2015", *Opinions and Debates*, Special issue, February.

(17) In the model proposed by Perthuis and Jouvet, only $60-80 billion would come from the developed countries, with the amount depending on the reference year.

(18) Chancel, L. and Piketty, T. (2015), *Carbon and inequality: from Kyoto to Paris. Trends in the global inequality of carbon emissions (1998-2013) and prospects for an equitable adaptation fund*, Paris School of Economics.

(19) In the climate negotiations, the term "adaptation" relates to actions aiming to anticipate the consequences of climate warming, such as rising ocean levels, increased frequency of extreme climate events, and desertification.

(20) Neither country achieved the targets assigned during the Protocol negotiations: U.S. emissions rose by 10%, when they were supposed to decline by 7%; Canada registered a 19% increase, instead of the 6% reduction target.

decline in emissions[21]. Countries that failed to achieve their assigned reduction objectives (Japan, Liechtenstein, Norway and Switzerland) bought allowances or carbon credits to comply with their Kyoto commitments.

Table 1: Emission reduction objectives associated with the first period of the Kyoto Protocol (CP1, 2008-2012)

Countr	Kyoto objective 2008-2012 (%)[a]	Actual change (%)a	Distance from Kyoto objective (points)
EU 15	−8	−12	4
Bulgaria	−8	−53	45
Croatia	−5	−11	6
Estonia	−8	−54	46
Hungary	−6	−44	38
Latvia	−8	−61	53
Lithuania	−8	−58	50
Poland	−6	−30	24
Czech Republic	−8	−31	23
Romania	−8	−57	49
Slovakia	−8	−37	29
Slovenia	−8	−10	2
Australia	8	4	4
Iceland	10	−6	16
Japan	−6	−3	−3
Liechtenstein	−8	4	−12
Monaco	−8	−12	4
Norway	1	5	−4
New Zealand	0	−2	2
Russia	0	−36	36
Switzerland	−8	−4	−4
Ukraine	0	−57	57
TOTAL	−4	−24	20
United States[b]	−7	10	−17
Canada[c]	−6	19	−25
Belarus[d]	−8	−36	28
Kazakhstan	0	−25	25

a. Relative to reference year, generally 1990.
b. Did not ratify Protocol.
c. Withdrew from Protocol in 2011.
d. The amendments adding Belarus and Kazakhstan to Annex B were not ratified, and therefore were not applied.

Source: I4CE, based on UNFCCC, 2015.

Blue: EU countries; black: non-EU countries with obligations under the Protocol; red: countries to which the Kyoto Protocol does not apply in the first period.
Interpretation: The EU-15 objective was to reduce emissions by 8% from 1990, for the 2008-2012 period. During the period, in 2012, the EU-15 achieved a 12% reduction in emissions relative to 1990, and therefore exceeded its objective by 4 points.

The United Nations Climate Change Conference (COP[22]) in Copenhagen in December 2009 failed to adopt a universal agreement to follow up from the Kyoto Protocol, highlighting the extreme difficulty of multilateral negotiations to establish emission reduction targets for 196 countries. The principle of a second commitment period of the Kyoto Protocol was agreed upon in Durban in 2011, pending the adoption by 2015 of a universal agreement that would enter into force in 2020. However, several countries that participated in the first commitment period announced that they would not participate in the second period (Russia, Japan and New Zealand), leaving the European countries virtually alone in committing at the 2012 Doha COP to reductions in the second period of the Kyoto Protocol[23]. The Doha amendment, which set out the new commitments by the developed countries and amended several articles of the Kyoto Protocol, has still not come into force; as of 23 November 2016, it had been ratified by only 73 out of the 144 countries required for its entry into force.

(21) While allowances can be transferred between periods, the surplus allowances allocated to these countries in the first period are called "hot air" because they allow greater GHG emissions in the following period. A June 16 paper in *Climate Policy*, "Compliance of the Parties to the Kyoto Protocol in the first commitment period", reports: "Overall, the countries party to the Protocol surpassed their aggregate commitment by an average 2.4 $GtCO_2e$ yr. Of the possible explanations for this overachievement, 'hot-air' was estimated at 2.2 $GtCO_2e$ yr […]".

(22) Conference of the Parties to the United Nations Framework Convention on Climate Change.

(23) 37 countries, representing approximately 15% of emissions, have a commitment in the second period: Australia, Belarus, Croatia, EU-27, Iceland, Kazakhstan, Liechtenstein, Monaco, Norway, Switzerland, and Ukraine.

Table 2: Targets of countries with commitment for the second commitment period (CP2) of the Kyoto Protocol (2013-2020)

	CP2 commitment relative to reference year[a] after Doha amendment[b]	CP2 commitment relative to 2008-2012 emissions after Doha amendment and transfer of surplus[c]
Australia	−1%	+2.3%
Belarus	−36%	0.4%
Croatia	−20%	−13.5%
Iceland	−20%	−13.4%
Kazakhstan	−27%	−2.6%
Liechtenstein	−16%	−18%
Monaco	−22%	−7.7%
Norway	−16%	−21.9%
Switzerland	−15.8%	−15.1%
EU-27	−20%	−1.5%
Ukraine	−57%	+81.1%
TOTAL	**−23.50%**	**+3.4%**

a. Generally1990.
b. Part of the amendments adopted at Doha sought to limit the impact of "hot air" in the second period.
c. The surplus is calculated relative to 2008-2012 emissions and does not include allowance trading and carbon credits.

Source: I4CE based on UNFCCC, 2015.

The fifteen years between the Kyoto Protocol in 1997 and the Doha amendment in 2012 saw growing rejection of Kyoto's cap-and-trade approach. The percentage of global emissions generated by countries willing to accept the protocol's international framework fell in the period from just over 40% to 15%. Apart from the EU, all the leading emitters (including China, the U.S., India and Indonesia) did not want to commit to a new agreement of this type. Canada, whose emissions exceeded its objective in the first period, simply withdrew from the Protocol. The fifteen years were marked by acceleration in global emissions, which increased faster in 2000-2010 (by 2.2% per year) than in the previous decade (0.6% per year). During this first period of international climate governance, China–which had no emission reduction target–more than doubled its GHG emissions (from 4.4 $GtCO_2eq$ in 1997 to 11 $GtCO_2eq$ in 2012)[24]. More generally, developing countries that had no reduction target in the period increased emissions substantially (from 14.4 $GtCO_2eq$ in 1997 to 26.5 $GtCO_2eq$ in 2012)[25]. Evidence from the period suggests that the governance system put in place at EU level[26] is not readily transposable to the entire planet[27].

Instead of negotiating effort-sharing through emission reduction targets, Weitzmann (2015)[28] and other economists have argued that it would be easier and more efficient to agree on a global carbon tax. Still, there is no evidence that all the world's countries would agree on a uniform carbon price; disparities across nations are very high, with annual per capita emissions ranging from under one tonne to several tens of tonnes.

Even if all countries were to agree on a global carbon price, no existing international institution currently has the legitimacy to impose such a tax on national governments or to oversee its proper implementation in all countries. Such control would be relatively complicated, for it would require verifying that the tax is properly applied and not offset by other tax adjustments on energy products. It would seem unrealistic to expect all countries to accept this transfer of tax sovereignty, and not even in the EU has it been possible to introduce this type of tax.

A further issue is that addressing climate change would mean that the amount of the tax could not be set once and for all, but would require defining a path for the tax, and then adjusting the path in order to achieve emission neutrality in the second half of the twenty-first century. A prerequisite at global level would be for an international institution to impose and revise the path taking account of the many factors that can impact emission reduction costs, such as fossil fuel prices and technological progress.

2.2 Climate negotiations take place in a legally binding framework that is quite different from the theoretical framework

International climate negotiations are governed by the 1992 UN Framework Convention on Climate Change (UNFCCC), which sets out the major principles, including the "common but differentiated responsibility" of countries, entailing an obligation for the developed countries to make greater efforts. In the climate talks, developing countries often point to the historic responsibility of the developed countries for climate change. The principle is embodied in the UN Framework Convention on Climate Change that posits the "common but differentiated responsibility" of the countries that are parties to the Convention. The Convention divided the world into two categories: Annex I countries (the OECD in 1990 and former USSR countries) and non-Annex I countries (the rest of the world). This was the

(24) WRI, CAIT Climate Data Explorer.
(25) WRI, CAIT Climate Data Explorer.
(26) A European target broken down between a functioning EU-ETS (Emissions Trading System) market and effort sharing among Member States for non-ETS emissions.
(27) Unlike the international system, the EU is a space of shared sovereignty, with primacy of EU law over national law, qualified majority voting, and co-decision with the European Parliament.
(28) Weitzmann, M.L. (2015), "Internalizing the Climate Externality: Can a Uniform Price Commitment Help?".

basis on which the Kyoto Protocol set binding targets only for the Annex I countries. Climate negotiations have always been conducted "under the Convention" and its related legal instruments, so protocols and agreements under the UNFCCC must reflect the differentiation between the categories. The resolve of a majority of developing countries to preserve the binary division at Copenhagen in 2009 was instrumental in preventing agreement on a successor to the Kyoto Protocol.

Climate negotiations must deal with the absence of any international enforcement system with sanctions comparable to those at national level. Most international legal experts agree that the Kyoto Protocol was one of the most binding of international environmental law agreements, with a quasi-judicial Compliance Committee. This may help to explain why some countries did not participate in the Protocol. The decisions of the Compliance Committee, however, do not involve fines or other penalties, but aim towards "the restoration of compliance to ensure environmental integrity, and [for the provision of] an incentive to comply". As noted by the IDDRI (2014), "[…] despite being very sophisticated, the system is not fool-proof. Notably, Canada's withdrawal from the Kyoto Protocol has recently shown how the Committee is powerless to cope with non-compliance. This highlights the inherent weakness of international environmental law to provide for the enforcement of state obligations against their will.[29]" Because global governance is based on equal and sovereign States, such a sanction process has little chance of succeeding; thus, rather than buying allowances from other States, Canada simply withdrew from the Protocol.

The climate clubs described by Nordhaus would face a challenge to their conformity with international trade law, because increases in customs duties are controlled by WTO agreements. To overcome this difficulty, Nordhaus proposes a set of amendments to international trade law, but the problems in concluding the Doha Round make such amendments unlikely in the medium term. Another proposal–carbon inclusion mechanisms–is potentially more compatible with WTO law, subject to certain conditions[30], but Nordhaus himself acknowledges that they are "complicated to design, have limited coverage, and do little to induce participation [in the Agreement]". Unlike customs tariffs, carbon adjustment mechanisms at borders would impose duties on imports based on their carbon content. However, detailed data on the carbon content of imports is available only for very simple products, such as cement. Further, such mechanisms affect only traded goods and have no impact on domestic policies.

2.3 The variety of possible equity criteria adds to the complexity of any top-down approach to climate negotiations

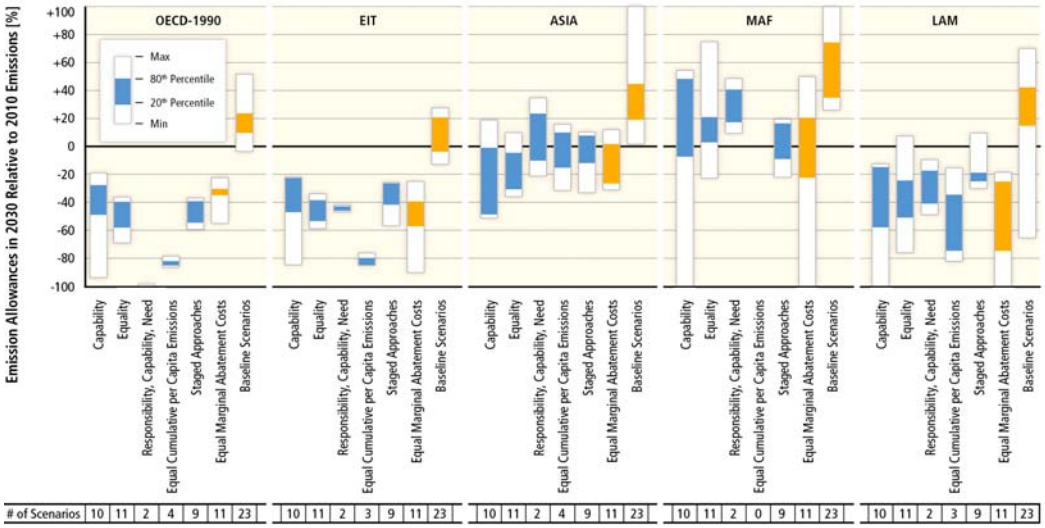
As noted in §1.3, the choice of the equity principle is crucial for determining what is fair in "fair effort sharing" among countries. The more countries in the Agreement, the larger the number of equity principles advocated; which effort-sharing proposals a country defends will depend on cultural values and the country's economic interests.

The latest IPCC report sets out various categories of effort-sharing models, based on:

- "Capability": frequently deduced from GDP or human development index (HDI). The studies concerned also include approaches focused exclusively on basic needs.
- "Equality": allocations based on immediate or converging per capita emissions.
- "Responsibility, Capability, Need": a country's historical responsibility based on past emissions, capabilities and needs.
- "Equal cumulative per capita emissions": several studies allocate equal cumulative per capita emission rights based on a global carbon budget, but the studies diverge on how they assign the resulting budget for a country to individual years.
- "Staged approaches": multiple criteria, where countries take differentiated commitments in various stages.
- "Equal marginal abatement costs": implementation of a single global carbon price.

(29) IDDRI (2014), *A comprehensive assessment of options for the legal form of the Paris Climate Agreement*, Working Paper, November.
(30) Provided that it satisfies the fundamental GATT principle of non-discrimination, i.e., that taxes on imports must be equivalent to taxes on similar national goods. For example, the tax on imports must be equivalent to the obligation on EU enterprises to buy GHG emission allowances.

Chart 1: 2030 emission objectives relative to 2010, by country category, for pathways holding temperature rise to 2°C, with different effort-sharing methods[31]



Source : IPCC, 2014.

Interpretation: Each bar corresponds to a set of scenarios estimating the level of effort for a country category (e.g., OECD-1990) in accordance with a given principle (e.g., "capability"). The blue portion represents the concentration of outcomes for 60% of the corresponding scenarios, the white portion of the bar above the blue portion represents the outcomes of the 20% of scenarios resulting in lower levels of effort, and the white portion of the bar below the blue portion represents the outcomes of the 20% of scenarios resulting in more ambitious levels of effort. The same reasoning applies to the orange bars, which represent the distribution of scenarios corresponding to the implementation of a single uniform carbon price and the baseline scenarios. Accordingly, 60% of the scenarios that tested effort-sharing based on the "capability" principle found that the OECD-1990 countries should reduce their emissions by 30-50% in 2030, relative to 2010.

Chart 1 illustrates the difficulty of agreeing on which equity principle should be used for global effort-sharing when the allocation models yield considerable differences in reduction targets. For the OECD-1990 countries, the targets would range from approximately –30% to –128%.

2.4 Economic analysis can justify a polycentric approach to climate action

In a 2009 paper, E. Ostrom[32] challenged the conventional economic approach to international agreements on climate change, relying on several arguments:

- **The absence of an international agreement on a system that satisfies the criteria of universality, efficiency and equity should not delay mitigation action.** Ostrom writes that massive disagreements regarding objectives (what level of emission reduction?), instruments (cap-and-trade or taxes?), and effort-sharing make it unlikely that a perfect agreement–from the standpoint of conventional economic theory–could be reached in the near term. However, given the severity of the danger from climate change, action cannot wait until such an agreement is reached.
- **Local co-benefits linked to reductions in GHG emissions should allay concerns over automatic free riding as an impediment to climate action.** Ostrom notes that in fighting climate change, "multiple benefits are created by diverse actions at multiple scales". She points to the examples of better health achieved by biking to work rather than driving, and lower energy bills for households and private firms from improved insulation of buildings. There is also a link between a reduction in GHG emissions and a reduction in local pollutants (particles, SOX and NOX), as the instruments deployed to reduce the latter also contribute to reducing GHG emissions.
- **The dangers of climate change make it risky to base all action on a single global policy, which could fail.** Ostrom reports that "extensive research on

(31)CInterpretation: Emission reductions in 2030 relative to 2010 emissions by effort-sharing category, reaching 430-480 ppm CO_2eq in 2100.

- EIT: Economies in transition (ex-USSR countries).
- MAF: Middle East and Africa.
- LAM: Latin America.

Greenhouse gas reductions (all gases and sectors), in $GtCO_2$eq, in 1990 and 2010 respectively, came to 13.4 and 14.2 for OECD-1990, 8.4 and 5.6 for EIT, 10.7 and 19.9 for ASIA, 3.0 and 6.2 for MAF, 3.3 and 3.8 for LAM. Emission reductions are shown compared with 2010 levels, but this does not imply a preference for a specific base-year. For the OECD-1990 countries in the "responsibility, capability, need" category, the emission reductions in 2030 are –106% to –128% (20th to 80th percentile) below the 2010 level (therefore not shown here). The studies with the "Equal cumulative per capita emissions" approaches do not include the MAF countries. For comparison, in orange: "Equal marginal abatement cost" (allocation based on the imposition of a global carbon price) and baseline scenarios. Source: Adapted from Höhne et al. (2014). Studies were placed in this CO2eq concentration range based on the level that the studies themselves indicate.

(32) Ostrom E. (2009), *A Polycentric Approach for Coping with Climate Change*, Background paper to the 2010 World Development Report.

institutions related to environmental policies has repeatedly shown that creative, effective, and efficient policies, as well as disasters, have been implemented at all scales. […] Reliance on a single 'solution' may be more of a problem than a solution." It would thus be rational to promote deployment of multiple policies against greenhouse gases at all levels in order to limit the negative impact of the failure of any one of them.

Ostrom ultimately argues that the most rational approach involves multi-policy, multi-scale action.

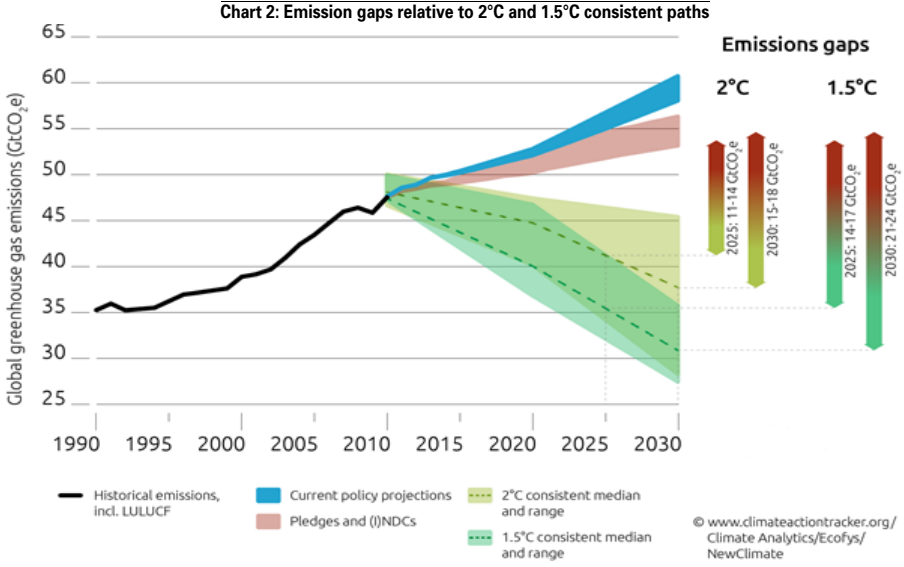
3. While the Paris Agreement embodies a universal approach with polycentric actions that should progressively lead to an increase in ambition, its success will depend on strengthening trust between countries and achieving greater efficiency

3.1 By providing for national contributions, the Paris Agreement overcomes the obstacle of "fair effort-sharing" and allows universal participation

The strong increase in emissions in 2000-2010 showed that universal (or near-universal) participation is a prerequisite for an efficient climate agreement. The commitment to universality is at the heart of the Paris Agreement. That the Agreement was adopted in Paris by the 197 Parties to the UNFCCC (including the EU) and that it was signed by 192 of them provides initial evidence of its universality. The most crucial criterion, however, will be ratification. By 23 November 2016, it had been ratified or otherwise accepted by 113 Parties. Further evidence comes from the massive participation in the national contributions (INDCs[33]), as 190 Parties (including the EU) have submitted their contribution.

This universal participation is explained by the new approach in the Paris Agreement, based on national contributions in which each country sets its own objective. While nearly all countries have submitted their contribution, the sum of those contributions nevertheless leads to emissions higher than least-cost paths consistent with holding global warming to under 2°C[34]. This is consistent with the notion of subscription equilibrium in economic theory[35], which holds that when a public good (here, the climate objective) is funded by voluntary subscriptions, the resulting equilibrium is sub-optimal.

Chart 2: Emission gaps relative to 2°C and 1.5°C consistent paths



LULUCF: Land-Use and Land-Use Change and Forestry.

Source: http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html

Even if the immediate ambition is inadequate, the Paris Agreement provides a process for enhancing mitigation ambition through a revision every five years. In addition, the Agreement requires the Parties to submit ever more ambitious contributions, under the principle of no "backsliding"[36]. This acts as a ratchet effect that should enable a progressive convergence towards the objective set out in the Agreement. **In other words, the Paris Agreement is built to last, without requiring renegotiation as was the case at the end of the Kyoto Protocol.**

The universality of the Paris Agreement is also embodied in the Decision accompanying it. In several places, the Decision mentions non-State actors–"non-

(33) INDC: Intended nationally determined contribution.

(34) The UNFCCC Secretariat's synthesis report on the aggregate effect of the INDCs estimates that emissions achieved by implementation of the INDCs would exceed by 10 to 21 GtCO2 in 2030 the emission levels of the least-cost scenarios consistent with holding the temperature rise to 2°C in 2100 with a 66% likelihood. According to Climate Action Tracker, the emission trajectories resulting from the INDCs in 2030 would hold temperature rise to 3°C with a 66% likelihood, or to 2.7°C with a 50% likelihood. The UNEP Gap Report considers that implementation of conditional INDCs would hold the temperature rise to 3-3.5°C with a 66% likelihood.

(35) Malinvaud, E. (1972), *Lectures on Microeconomic Theory.*

(36) Article 4.3 of the Paris Agreement provides that: "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution […]."

Party stakeholders" such as businesses, communities and NGOs–in line with the Lima-Paris Action Agenda. COP20 and COP21 provided the opportunity to promote and structure the actions of coalitions of partners in many areas to counter global warming[37]. The Decision also inaugurates the role of climate action "champions" for the period through 2020. The two champions, appointed by the President of the year's COP and the President of the following year's COP, must seek to facilitate and coordinate participants' actions and promote the sharing of best practices. These actions are entirely consistent with the polycentric approach advocated by Ostrom.

3.2 Recognizing that it would be impossible to put in place an international sanctions mechanism, the Paris Agreement relies on incentives through peer pressure and civil society. This system can only function if there is a high degree of trust, a stronger system of transparency and compliance with commitments

While the level of ambition of each country's contributions is determined domestically, the Paris Agreement nonetheless sets out obligations for all countries. This marks a significant change from the Kyoto Protocol. Every five years, countries must submit a new contribution showing progress in emission reduction compared to the previous contribution. Every two years, all countries must report on their greenhouse gas emissions and progress made towards achieving the objective of their contribution (except the least developed countries and small island developing States, which may submit their information at greater intervals). The developed countries must also report biennially on the funds provided for climate action. This information will be subject to an independent review by UNFCCC experts. All countries will then undergo a multilateral assessment to determine the achievement of their objective.

To promote compliance with these obligations, the Paris Agreement is relying on transparency and political pressure rather than sanctions. The Paris Agreement currently in the process of ratification has the status of a treaty in international law, binding on the States that ratified it. However, there is no penalty mechanism for States that fail to abide by the Agreement's provisions or their objectives. The binding force of the Agreement, therefore, is more political than legal. States that fail to fulfil their commitments will be subject to pressure from their peers under the multilateral assessment, and from civil society that will have access to information verified by independent experts attesting to the actual results achieved by all countries. This enhanced transparency represents very significant progress over the current situation, particularly for emerging and developing countries that account for most emissions and are not today subject to this level of transparency.

Work on the specific modalities for implementing the transparency framework must move forward swiftly and present a high level of environmental ambition: this is one of the keys to building the necessary trust among countries. It is encouraging to see this work get off to a good start at COP22 in Marrakech: a technical work programme to operationalise the Paris Agreement was defined, and rules for implementation should be adopted no later than the COP24 in 2018. Ostrom has stressed the importance of trust for effective climate action and for overcoming fears that other countries may be free-riding. The joint China-U.S. presidential statement in September 2015[38] that set out the levels of the two countries' INDCs before COP21, together with their simultaneous acceptance of the Paris Agreement in September 2016 at the G20 summit[39], underscore the need for each country to be assured that its partner is acting in a similar way.

Compliance by the developed countries with their financial obligations under the UNFCCC and the Paris Agreement will also be crucial for strengthening the trust of developing countries. At Copenhagen in 2009, the developed countries committed to a goal of mobilizing jointly $100 billion per year by 2020 from public, private, bilateral and multilateral sources, including alternative sources, in order to fund adaptation and mitigation actions in developing countries. The decision adopted at the time of the Agreement urged the developed countries to increase their efforts to achieve this goal by defining a concrete roadmap, which was published by the developed countries on 17 October 2016[40]. The Paris Agreement extends to 2025 the developed countries' objective of mobilizing $100 billion per year in funding for climate action in favour of the developing countries. A further collective quantitative objective, of no less than $100 billion per year, should be set before 2025.

If trust and confidence among the parties, and if peer pressure and pressure by civil society are strong enough, a virtuous circle of rising ambitions over time can develop. The Agreement will oblige all countries to raise their ambitions every five years starting in 2025. A "global stocktake" will be undertaken in 2023 and every five years thereafter to assess the collective progress achieved and inform the parties as they update and enhance their objectives. This five-year ambition mechanism, with its two steps– global stocktake and revision of contributions–is intended to collectively strengthen the ambition of all countries. This approach is however open to the criticism that parties could play a waiting game[41] : to justify claims of raised ambition, there may be an incentive for States to begin by proposing only easily achievable targets. Further, were any Party to renege on its pledges, for example owing to a change in government, the effect could imperil– at least temporarily– the mutual trust needed among parties to secure global ambition.

(37) The NAZCA website has captured the voluntary commitments of 2,364 cities, 167 regions, 2,090 companies, 448 investors and 236 civil society organisations: http://climateaction.unfccc.int/

(38) https://www.whitehouse.gov/the-press-office/2015/09/25/us-china-joint-presidential-statement-climate-change

(39) https://www.whitehouse.gov/blog/2016/09/03/president-obama-united-states-formally-enters-paris-agreement

(40) http://www4.unfccc.int/Submissions/Lists/OSPSubmissionUpload/261_295_131233554162587561-Roadmap%20to%20the%20US$100bn%20(UNFCCC).pdf

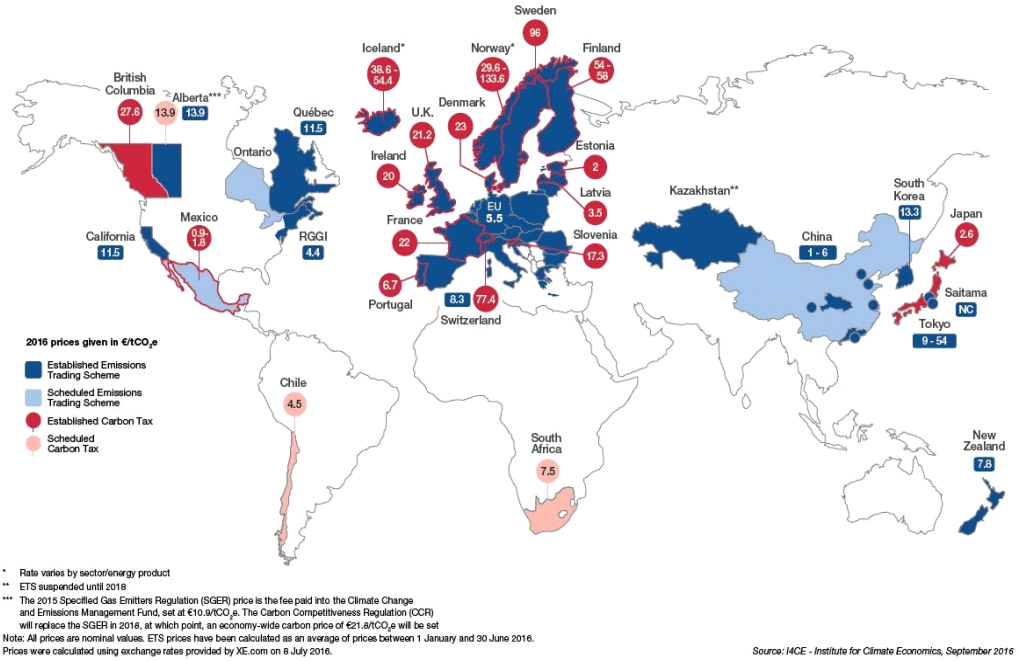
(41) Beccherle, J. and Tirole, J. (2011), "Regional Initiatives and the Cost of Delaying Binding Climate Change Agreements", *Journal of Public Economics*, vol. 95, December.

3.3 To achieve the long-term objective of the Agreement at least cost, efforts must be made to progressively increase the efficiency of mitigation policies

The Paris Agreement introduces a mechanism for "internationally transferred mitigation outcomes" (Article 6) which may lead to higher ambition. These transfers will enable countries with comparable levels of ambition to transfer emission reduction units. They will allow for a gradual increase in the efficiency of the Agreement and, by reducing mitigation costs[42], may encourage States to raise their ambition[43]. However, because the Paris Agreement is based on individual contributions of countries with highly heterogeneous ambitions, countries with the highest ambition will have to protect themselves against potential "hot air" in the form of emission reduction units from less ambitious countries, which would easily exceed their objective.

Lastly, support for national carbon pricing as the most efficient way of implementing a country's INDCs should be encouraged. Even if such advocacy fails in the near term to lead to a single carbon price, as recommended by conventional economic analysis, it contributes to reducing resistance to the use of price mechanisms to fight global warming. This is the message of the heads of State and government, city and provincial leaders on the Carbon Pricing Panel of the Carbon Pricing Leadership Coalition (CPLC), who call for "enhancing international cooperation, by facilitating and promoting the alignment or possible convergence of domestic carbon pricing programs"[44]. The CPLC is a good example of coalitions of stakeholders who have come together for climate action to further the goals of the Paris Agreement. Its members include national governments, subnational and local governments, businesses and NGOs that promote carbon pricing. By developing arguments for decision-makers, and showing that developed and developing countries, businesses from every sector, NGOs and communities speak with a single voice in promoting carbon pricing, the CPLC contributes to improving efficiency in achieving climate objectives.

Chart 3: Carbon prices across the globe



Source: I4CE, Institute for Climate Economics, September 2016.

In 2016, roughly 40 countries and over 20 towns, regions, states or provinces set carbon prices. These entities account for nearly one-fourth of global GHG emissions. On average, these entities' carbon-pricing initiatives cover approximately half of their emissions. This means that roughly 13% of global GHG emissions are covered by carbon pricing, or three times more than in 2006.

Jean GIRAUD, Nicolas LANCESSEUR, Thomas ROULLEAU

(42) According to the October 2016 World Bank report, *States and Trends of Carbon Pricing*, an international carbon market could reduce the cost of the emission reductions identified in existing INDCs by one-third between now and 2030, and by half before mid-century.

(43) Article 6.1 of the Paris Agreement specifies that countries that choose to cooperate voluntarily in the implementation of their INDCs do so in order to "allow for higher ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity".

(44) http://www.carbonpricingleadership.org/posts-op-eds/2016/10/18/carbon-pricing-panel-setting-a-transformational-vision-for-2020-and-beyond

A counterpoint by...

Dominique Bureau

The adoption and speedy ratification of a universal climate agreement are a magnificent success for COP21. Discounting doubts of climate-change sceptics, the agreement found a workaround to deal with the strict distinction between the respective efforts of Annex I and emerging economies, whose emissions are rising fastest. China recognized the concept of an emissions peak. On the "glass half-empty" side, the commitments fail to achieve the "well below 2°C" global objective.

The consensus on these points does not carry over into other aspects of the Agreement. Critics argue that it contains few tangible new developments and stress the continuing ambiguity of "raising ambition" so long as countries can benefit from understating their mitigation capabilities, while others focus on the momentum produced and the mobilisation of cities and other new participants.

As the negotiations are multi-faceted, their ultimate outcome will be hard to judge, even with hindsight. How to differentiate between developments arising from the multilateral process and those produced by bilateral China-U.S. talks? How to account for the unprecedented recognition of the role of the carbon price signal, when the topic is virtually absent from the Agreement itself? How to explain that despite the marginalisation of the Kyoto Protocol since COP17 in Durban, emissions trading markets have nevertheless developed, as seen in the California-Quebec market and in China?

These developments are sometimes claimed as evidence that the instruments recommended by economic analysis are not appropriate at the global level. An alternative interpretation points to our inability, so far, to implement effective policies. From this viewpoint, the inadequacy of efforts to date is fully consistent with what the economic theory of public goods has to say about subscription mechanisms-that free-riding cannot be ignored.

The economic analysis developed most notably by Weitzman, Tirole or Nordhaus seeks a remedy in the recognition that international development negotiations are dominated by Realpolitik. Whatever the differences in their approaches, their analysis stems from a shared diagnosis of the nature of the problem, namely, that climate risk is a "global commons" issue. In other words, if emissions are excessive, it is because, in the absence of a carbon price, agents incur no liability for the damage caused by their behaviour; and minimizing the impact of mitigation efforts on growth demands a uniform, global carbon price-which in turn requires credible compensations for the countries of the South. Irrespective of the instrument chosen for climate action, this issue must be resolved if we are to raise climate-change ambition.

Dominique Bureau
General Delegate of the Economic Council for Sustainable Development,
Chairman of the Green Economy Committee
The views expressed above are the author's own

Publisher:
Ministère de l'Économie
et des Finances

Direction Générale du Trésor
139, rue de Bercy
75575 Paris CEDEX 12

Publication manager:
Michel Houdebine

Editor in chief:
Étienne Chantrel
+33 (0)1 44 87 18 51
tresor-eco@dgtresor.gouv.fr

English translation:
Centre de traduction des
ministères économique
et financier

Layout:
Maryse Dos Santos

ISSN 1962-400X
eISSN 2417-9698

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