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Routes to an Ambitious Climate Agreement in 2015

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THE HARVARD PROJECT ON CLIMATE AGREEMENTS

The goal of the Harvard Project on Climate Agreements is to help identify and advance scientifically sound, economically rational, and politically pragmatic public policy options for addressing global climate change. Drawing upon leading thinkers in Argentina, Australia, China, Europe, India, Japan, and the United States, the Project conducts research on policy architecture, key design elements, and institutional dimensions of domestic climate policy and a post-2015 international climate policy regime. The Project is directed by Robert N. Stavins, Albert Pratt Professor of Business and Government, Harvard Kennedy School. For more information, see the Project's website: http://belfercenter.ksg.harvard.edu/climate.

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Routes to an ambitious climate agreement in 2015

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The multinational framework has already shown itself capable of dealing with global environmental threats. The Montreal Protocol, signed in 1987, led the international community to virtually stop emitting CFC gases[1], the build-up of which in the atmosphere was causing the destruction of the ozone layer. The success of this agreement with universal reach was based on three pillars: strong political commitment by the governments concerned, a rigorous and independent monitoring system, and appropriate economic instruments. More than twenty years of climate negotiations have so far failed to yield comparable results. Is what was possible for ozone in the troposphere unattainable for greenhouse gases?

The implementation of an international climate agreement comes up against the classic problem of "the free rider" (Olson (1965)). For each actor in isolation, there is no direct correlation between the level of effort he agrees to make to reduce emissions and the benefit he will derive in the form of reduced damage. Climate disruption is related to the overall stock of greenhouse gases and this is only weakly correlated with each country's annual emission flows. In addition, the most severe impacts are distant in time, prompting each actor to pass on the full costs of climate change to future generations. In such a situation, each player's interest to wait until his neighbours initiate action, the ideal position being that of the free rider, who makes no effort at all, while all other actors undertake to protect the common good. Conversely, no player has an incentive to commit himself unilaterally until he is convinced that others will follow as part of a broader coalition (Nordhaus (2013)). Faced with this free-rider problem, Europe and the United States have so far responded in opposite ways. High-minded Europe has always considered that the unilateral commitment by high-income rich countries is likely to induce other countries to spontaneously join a broad international coalition. In contrast, in 1997 the US Senate adopted, by an overwhelming majority, a resolution opposing the ratification of any climate treaty that would bind the United States unless countries such as China and India committed themselves to equivalent efforts (105th Congress, 1997).[2] This resolution made it impossible for the US to ratify the Kyoto Protocol and contributed to the stalling climate negotiations. Yet the lack of effective coordination led

to alarming results: during the 2000s, global greenhouse gas emissions accelerated and are further increasing our collective exposure to climate risk (IPCC WGIII AR5, (2014), Boden and Andres (2014)).[3] The central issue in international negotiations is to go beyond the vision of "substitutable strategies" deployed by the actors in the face of climate risk and to implement "complementary strategies" (Sandler, T. (2004)).[4]

The foundations of the negotiations

The climate issue was introduced into international life in 1992 with the signing of the United Nations Framework Convention on Climate Change (UNFCCC). Two years previously, the Intergovernmental Group of Experts on Climate Change (IPCC) released its First Assessment report to provide negotiators with reliable information on the state of scientific knowledge with regard to climate change.[5] This linkage between the IPCC and UNFCCC is an important component of climate negotiations. Faced with local pollution, exposed populations mobilize themselves spontaneously and exert pressure on local government to reduce the damage they suffer. In the case of climate change (like the destruction of the ozone layer), policy makers were not alerted by the public or environmental activists but by scientists, who drew attention to the complex causal chains between the atmospheric build-up of greenhouse gases and climate disruption.

Coming into force in 1994, the UNFCCC was ratified by the great majority of countries, including the United States. It lays down three basic principles and a mode of governance as the framework for international climate negotiations.

a/ The first UNFCCC principle concerns recognition: in ratifying the treaty, each party recognizes the existence of on-going climate change and human activities. Legally, climate scepticism is prohibited for heads of state who have ratified the Convention! But for this principle to change decision-making and help form coalitions, it is still necessary to ensure their adherence. This is the main function assigned to the IPCC, whose five Assessment Reports, published between 1990 and 2014, provide high quality information for decision-makers. In the United States, successive editions of the National Climate Assessment play a complementary role to the IPCC for domestic aspects. In the United States, successive editions of the National Climate Assessment play a complementary role to the IPCC for the national components.[6]

These advances in knowledge provided by the scientific community have not eradicated climate change scepticism. Science cannot convince militant climate sceptics, who

deny the very existence of climate change. We are here in the realm of irrationalism and mystification, in a somewhat comparable way to the members of the Flat Earth Society,[7] who pursue the debate as to whether the planet is spherical or flat several centuries after the death of Galileo. A more insidious form of climate change scepticism involves downplaying the risks of climate change, because of its uncertainty, so to postpone any action until a later date. Uncertainty, however, is precisely central to scientific debate. Uncertainties should therefore not be denied, but incorporated into the decision-making process while carefully weighing up the various components of climate risk.

b/ Secondly, the UNFCCC sets an ultimate goal, namely "to stabilize concentrations of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The 1992 text is careful not to specify what this level should be.

The objective of limiting average warming to 2°C compared to the preindustrial era was adopted in December 2009 at the Copenhagen summit and formally integrated into international climate agreements the following year at the Cancun conference. This objective in terms of temperature remains relatively unconstraining, since it is not associated with a specific greenhouse gas emission and concentration trajectory. The work of the IPCC allows such trajectories to be traced, although based on a considerable number of assumptions and uncertainties. One simple idea to bear in mind is that unless emission trajectories alter, the planet will experience average warming of around 3 to 5°C by the end of the century and such warming will continue during following century. If we are to take a less perilous route, it will be necessary to reduce global greenhouse gas emissions by 40% to 70% between 2010 and 2050. Getting agreement by the major emitters on such trajectories is the central challenge of climate negotiations.

c/ Lastly, the UNFCCC asserts the principle of "common but differentiated responsibility" in response to climate change. Here again, the principle of differentiation of the degree of responsibility depending on countries' level of development is incontrovertible. The UNFCCC provides a binary interpretation of this, set in stone by the Kyoto Protocol, the Convention's main application text, that divides the world between high-income countries fully responsibility for climate change and others exempted (for how long?) from participating in reducing emissions and even from transparently filing their emissions with the UNFCCC.

This bipolar view of the world, already questionable in 1992, is totally out of step with contemporary reality, where emerging economies have shifted the centre of gravity of the

international economy by becoming the main driver of the increase in emissions. Nor does it take account of the geopolitics of energy, with the importance of the bloc of oil producers and exporters, without whose participation no serious climate agreement can be achieved. These basic geopolitical facts are confirmed by the figures: of the top ten emitters of CO_2 from energy production, totalling about 80% of global emissions, four are emerging countries, four are industrialized countries and two hydrocarbon exporting countries.[8] The following table shows the top fourteen global emitters of energy CO_2. Taking into account the emissions of CO_2 from deforestation and other greenhouse gases would place Brazil and Indonesia significantly higher in the rankings.

Table 1 – Emissions by country

	1990	2011	
Main emitters	**Emissions (gigatonnes of CO_2)**	**Emissions (gigatonnes of CO_2)**	**Cumulative emissions (%)**
China	2.43	8.67	27.8
United States	4.86	5.31	44.8
EU-27	4.13	3.59	56.3
India	0.59	1.81	62.1
Russia	2.34	1.74	67.6
Japan	1.07	1.19	71.4
Korea	0.24	0.61	73.4
Iran	0.19	0.52	75.1
Canada	0.42	0.47	76.6
Mexico	0.29	0.45	78.0
South Africa	0.29	0.45	79.5
Saudi Arabia	0.14	0.44	80.9
Brazil	0.21	0.42	82.2
Indonesia	0.15	0.41	83.5

Source: International Energy Agency

The UNFCCC introduces international governance, based on various technical bodies for the measurement, verification and management of the instruments set up by the treaties. It also makes climate negotiations an on-going process, with annual meetings of the supreme body of the treaty, the Conference of Parties (COP), which is required to take its decisions by consensus of the 193 countries that have ratified the Convention. An ambitious climate agreement needs to forge a new coalition between major emitters by going beyond the binary interpretation of the principle of common but differentiated responsibility.

A brief history of the negotiations: Kyoto, Copenhagen…Paris

Three cities symbolize the key stages of international climate negotiation with the objective of concluding an international agreement.

Kyoto (1997). Three years after the ratification of the UNFCCC, the COP conference at Kyoto in December led to the signing of the Kyoto Protocol, the main application text of the Convention. The Protocol resulted in two important changes in international life: it committed, in a "legally binding" way, the industrialized countries to reduce their emissions by 5% between 1990 and 2008-12; and it linked this commitment to a cap-and-trade system enabling these countries to trade emission rights, with a view to giving rise to an international carbon price. A further feature of the system is the Clean Development Mechanism, which valorises emissions reductions achieved by the countries of the South, otherwise exempted from commitments in the protocol architecture.

The promoters of the protocol originally intended extending it beyond 2012, by gradually incorporating other countries into the system. On realizing the impossibility of such a process, strongly advocated by the European Union, another type of political agreement was found in 2009 at the Copenhagen conference.

Copenhagen (2009). For the first time the emerging economies and the United States committed themselves at Copenhagen to reduce emissions. But this major breakthrough on the extension of the geographical coverage was accompanied by a weakening of the follow-up system: under the Copenhagen architecture, the UNFCCC secretariat becomes a mere rubber stamp, recording the voluntary commitments submitted by countries, without any homogenization of methods or a monitoring, reporting and verification (MRV) system to ensure their implementation. Such an "à la carte" system has hardly any chance of setting emission trajectories in line with the 2°C objective. In terms of economic instruments, the Copenhagen Accord is also a step back compared to the architecture of the Kyoto Protocol. It simply records the financial transfer commitments from North to South ($30 billion a year from 2010 to 1012 and $100 billion a year from 2020), which have little real impact, as neither the origin nor the destination are specified, nor even the use of funds raised.

Paris (2015). In accordance with the customary procedure for climate negotiators, the Durban (2011) conference set the deadline of December 2015 to find a universal new climate agreement coming into operation in 2020. In view of the number of topics up for discussion, observers may be forgiven a degree of perplexity. The key issue of the Paris conference,

however, can conveniently be summarized on the basis of the three pillars of climate policy presented by William Nordhaus in *The Climate Casino* (2013).

The first pillar: preventive adaptation strategies strengthening the resilience of actors faced with climate change. These actions, implemented in a decentralized way, bring local benefits. International coordination here involves developing cooperative approaches to strengthen the adaptation capacity of the most vulnerable countries. There is no need for an international treaty to do this. On the other hand, the development of such approaches, and their funding by the high-income countries, can facilitate the adherence of developing countries to a universal agreement.

The second pillar: recourse, as a last resort, to so-called "geo-engineering" strategies consisting of artificially changing the climate regulation system if the combination of adaptation and mitigation strategies fails: for example, seeding the sea with iron sulphate to increase its capacity to absorb atmospheric CO_2 or introducing aerosols into the upper atmosphere to reduce solar radiation. Such an approach raises numerous questions (see the UK Royal Society (2009)) that it is better to anticipate by imposing very stringent international rules. For this, a treaty is required – but a new treaty lying outside the framework of the UNFCCC, since it extends beyond its purview.

The real issue for the Paris conference concerns the third pillar, climate change mitigation, which involves acting with regard to greenhouse gas emissions. An ambitious agreement in Paris would involve a system that goes further than the one-legged Kyoto Protocol or self-service system introduced in Copenhagen, where everyone can nibble at what suits them. Like the Montreal Protocol for the protection of the ozone layer, such an agreement must be based on three pillars: strong political commitment by governments; rigorous and independent MRV; and powerful economic instruments based on carbon pricing.

Possible forms of an "ideal" agreement

Let us now try and outline the contours of the "ideal" agreement, in which a carbon price applies to every tonne of greenhouse gas regardless of where in the world it is emitted. In 2013, global emissions of greenhouse gases are estimated at about 50 billion tonnes of CO_2 equivalent, or 6.5 tonnes per capita. At a price of $25 per tonne, this would generate some $1250 worldwide. This figure represents a new rent: the environmental rent associated with the scarcity of the atmosphere in its climate regulation function. But at $1250 billion, impressive though it is, this figure would still only represent half the amount of oil rent for the same year. How might this sum be distributed in the global economy?

At the international level, the distributional effects of a single carbon price have for twenty years been the real stumbling block in climate negotiations. As Graciela Chichilnisky and David Heal (1998) have emphasized, the differences in wealth between countries are such that the establishment of a uniform carbon price (whether in the form of a tax or an emissions trading scheme) seems impossible: a carbon price appropriate for the North will always be too high for the South and one appropriate for the South will be too low for the North. If this issue is to be addressed without proceeding along the inefficient path of carbon prices differentiated by zones, it will be necessary to make massive resource transfers from North to South in order to guide the decisions of all economic actors under the right conditions.

On paper, the introduction of an international carbon price can be easily combined with such lump sum redistribution. Imagine that carbon pricing is introduced by means of a flat tax, the proceeds of which would be distributed in an egalitarian way to each country on the basis of the number of inhabitants. In distributive terms, such a mechanism is equivalent to a global cap-and-trade system based on an equal distribution of emission rights per capita. With unchanged emissions, such carbon pricing generates massive income transfers from industrialized to developing countries: a global flow of about $250 billion a year, twice total public development aid. With a contribution of $115 billion, the United States would be the main loser, while India would be the main beneficiary, with an inflow of $135 billion. Such a system would be overwhelmingly approved by those developing countries most reluctant to join a climate agreement, such as India.

In actual fact it is the high-income countries that oppose such a route, in which the introduction of a single international carbon price would be accompanied by massive redistribution. These countries prefer to rely on the so-called “grandfathering” formula, in which recognized historical emission rights are capped and then reduced over time. Such a formula, used in the framework of the Kyoto Protocol, by implication leaves the developing countries on the periphery of the agreement, with the Clean Development Mechanism as a consolation prize. This architecture makes it very tricky to extend the original core of the coalition of high-income countries based on the acknowledgement of historical emission rights.

Various combinations of these two methods for allocating rights can be conceived, which would redistribute winners and losers in the carbon pricing game. In fact there are numerous options for the distribution of rights (Müller (1998)). Each of these options involves redistribution among countries and determines which countries pay and which benefit (Jouvet and Rotillon (2012)). From an economic standpoint, this is the Gordian knot of climate

negotiations, that under the auspices of the United Nations have been conducted continuously since 1992.

To avoid these difficulties, it is tempting to envisage alternative systems. Thomas Courchene and John Allen (2008) have proposed introducing carbon pricing in the form of a tax imposed on the carbon content of goods and services consumed, along the lines of VAT. Such a system deployed on the economy downstream is attractive because it neutralizes the risks of the undesirable competitive effects arising with progressive introduction and falls mainly on the consumption of high-income countries. Concretely, its implementation would mean that carbon flows are tracked in the economy through microeconomic accounting, a distant prospect. The same applies to the proposal by de Perthuis (2010) to introduce carbon pricing though controlling emissions entirely upstream, by capping the rights of fossil energy producers according to the reserves of coal mines and oil or gas deposits. Such a system could incorporate fossil energy producing countries into a coalition, but its implementation comes up against the problem of estimating the reserves available underground. In both cases, these routes are not likely to result in mechanisms that can be deployed on a large scale within the time frame required by the scheduling of international negotiations. For this reason, we recommend dual track carbon pricing to give credibility to a future universal climate agreement (de Perthuis et al. (2015)).

A carbon price and rebate[1] system for integrating developing countries into a global agreement

Despite the entry into force of the UNFCCC, there is no clear and consistent MRV system for greenhouse gas emissions applying to all countries. The technical basis of such a system, through national inventories and the work of the IPCC on emission factors, is available and already covers the emissions of the Convention's Annex I countries (developed countries and those in transition to a market economy). However, information on most other countries' emissions remains very sketchy. These, then, are the political obstacles that must be overcome, with the help of ad hoc incentives, if all countries are to be included in a common MRV system.

The experience of the Kyoto Protocol has shown the difficulty, if not the impossibility, of making an international carbon price emerge by means of an allowances trading system between states. Indeed, it is not the role of governments to engage in trading. To encourage

[1] A price and rebate system corresponds to the so-called « bonus-malus » in french.

governments to act in concert, it is essential to work toward a different system of carbon pricing that is both straightforward and transparent. A price and rebate mechanism, which simultaneously defines the price to pay for emissions above a certain threshold and the use that the money raised should be put to, seems appropriate. In such a system, any country exceeding the average level of emissions per capita would pay a specified amount on every tonne emitted above the threshold. Symmetrically, countries that emit less than this benchmark level would receive compensation calculated on the number of tonnes saved compared to the world average. By construction, this mechanism would balance from year to year. It would initially benefit countries with the lowest per capita emissions that in general coincide with the group of least developed countries. Once it is fully operational, the price and rebate system would encourage all countries to reduce their per capita emissions, in order to reduce the gap between the payments and the rebates.

As with the introduction of a carbon tax at national level, there then arises the question of the rate used to calculate the payments and the rebates. The cost-benefit or cost-effectiveness methods presented in the previous chapter give fairly wide ranges of about 50 to 140 dollars per tonne of CO_2 equivalent in 2020. With the exception of Sweden, the low end of the range has not been attained in any of the countries that have introduced a domestic carbon price. There is very little chance that a negotiated consensus on these levels can be achieved. It is therefore necessary to aim for a more modest level by negotiating on the basis of two considerations.

- If solely the objective of including developing countries in the common MRV framework is retained, a rate of one to two dollars per tonne, generative of $14 to $28 billion on 2011 emission figures, would fund the deployment of an ambitious MRV system in developing countries.

- To make the “carrot” really tempting for low-income countries, a second objective needs to be added to the price and rebate system, namely making credible the pledge made in Copenhagen of $100 billion of financial transfers, which remains a permanent point of contention between the high-income and low-income countries in the framework of the negotiations. A rate of $7-8 per tonne of CO_2 equivalent would release sufficient resources to transfer $100 billion a year to countries with low emissions per capita. The form of the transfers generated depend on the reference year and scale of emissions adopted.

Of that $100 billion, a little over $60 billion would come from Western countries and Japan, and just under $20 billion would come from hydrocarbon-exporting countries (Russia

and Saudi Arabia in particular) and Asian countries whose economies have taken off (China and Korea in particular). The introduction of a price and rebate system would thus generate redistribution among countries in conformity with the principle of common but differentiated responsibility, while getting away from its binary interpretation which for more than a decade has prevented any serious progress in international climate negotiations.

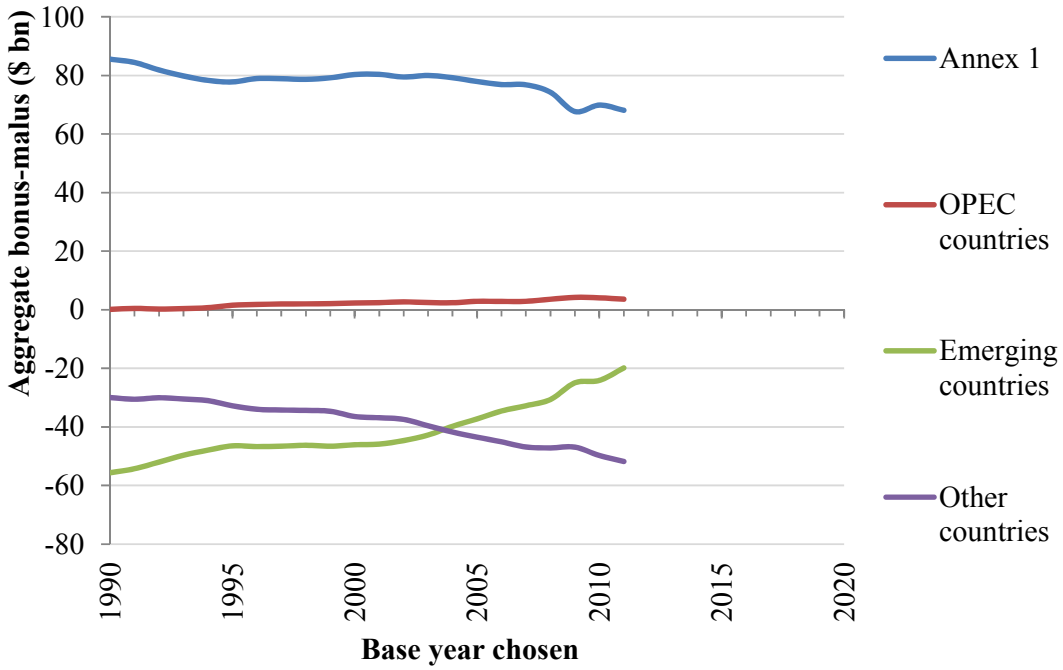
Table 2 – Redistribution effects of a price and rebate system (excluding forests and agriculture) on the basis of a $100 billon transfer or $7.5 per tonne of CO_2 (2011emissions)

	Total emissions ($MtCO_2$ eq.)	Population (million)	Emissions per capita (tCO_2 eq.)	Transfers ($ million)
Contributors				
United States	6,550	312	21.0	34,428
China	10,553	1,344	7.9	15,742
Russia	2,374	143	16.6	11,064
EU-28	4,541	503	9.0	10,325
Japan	1,307	128	10.2	3,776
Canada	716	34	20.9	3,752
Australia	563	22	25.2	3,172
South Korea	688	50	13.8	2,810
Saudi Arabia	533	28	19.2	2,687
Iran	716	75	9.5	1,809
Others	4,495	399	11.3	14,889
Total of contributors	*33,036*	*3,038*	*10.9*	*104,454*
World	**43,413**	**6,903**	**6.3**	**0**
Beneficiaries				
India	2,486	1,221	2.0	-38,955
Bangladesh	129	153	0.8	-6,244
Pakistan	308	176	1.8	-5,997
Nigeria	325	164	2.0	-5,311
Indonesia	835	244	3.4	-5,241
Philippines	150	95	1.6	-3,362
Ethiopia	125	89	1.4	-3,282
Vietnam	274	88	3.1	-2,087
Rep. Dem. Congo	172	64	2.7	-1,727
Tanzania	73	46	1.6	-1,639
Others	5,501	1,524	3.6	-30,609

Source: Climate Economics Chair based on World Resources Institute data (2014).

This combination of price and rebate promotes both efficiency and fairness. It promotes efficiency since every nation faces the same incentives at the margin to reduce emissions. It promotes fairness because the rebate received will be larger, the lower are a nation's per-capita emissions, and nations with especially low per-capita emissions will end up receiving rebates larger than their payments. The main obstacle to be surmounted in getting the system under way is to convince the governments of donor countries to pay their contribution, a sum that in fact is very modest compared to the size of their economies. The transfers are also very sensitive to the base year chosen, as the graph below shows.

Figure: Effect of the base year for the price and rebate system (1990-2011) [9]



Source: Climate Economics Chair based on World Resources Institute data (2014).

A second economic instrument could greatly help them: the establishment of a transcontinental carbon market supported by ambitious emissions reduction trajectories that would allow them to raise funds through the auctioning of emission allowances.

A coalition of three to launch the transcontinental carbon market

A price and rebate system would encourage developing countries to join a universal agreement as a result of the redistribution it generates. On the other hand, it would not directly

introduce into the economic system a carbon price signal capable of changing patterns of production and consumption. Yet the credibility of trajectories massively reducing emissions is based on introducing the value of the climate into the price system.

To move from an "ideal" agreement to an "effective" agreement that allows an international carbon price to be introduced into the economy, the number of players at the outset needs to be drastically reduced. From among the 193 countries involved in the UNFCCC, it is necessary to form a coalition of major emitters agreeing to combine their emissions reduction with a cap-and-trade mechanism that makes an international carbon price emerge. The two criteria for selecting the actors forming the initial coalition are size and their experience curve with regard to carbon pricing.

The size criterion shows that with just fourteen actors almost 85% of global emissions are covered and that with just the top three – China, the United States and the European Union – as much as 56%. A basic reality principle favours targeting the strength of the coalition rather than its extension to a larger number of players. Such a dilemma between numbers and strength is standard in the quest for environmental agreements (see Brousseau et al. (2012)). In the case of a future climate accord, because of the concentration of emissions among a small number of countries, it would be most effective to build a solid core with a relatively small number of players, which could later be expanded.

The experience curve criterion leads to the selection of three players, all of them unilaterally committed to the carbon pricing route. The European Union was the first to implement carbon pricing on a large scale, but is struggling to find a second wind in its solo race. The United States introduced a cap-and-trade scheme to regulate federal SO_2 emissions in the 1990s and thus has the longest experience curve for this type of instrument. Because of the hostility of the Senate, such a scheme could not be developed at the national level for CO_2, but the government is in a position to learn from the experience of individual U.S. states in this respect. Since 2012, China has been experimenting with regional carbon markets on the scale of municipalities and provinces, covering some 250 million people. As shown by the work of Wen Wang (2012), the design of these markets is often inspired by the European experience. Based on these experiments, the next stage of China's policy will, as from 2015, be to establish national regulation of greenhouse gas emissions together with a widening of carbon pricing.

Even though there are major differences between the various markets (see Quemin and Wang (2014)), the kernel of a future climate agreement might involve constructing a set of common emissions reduction goals from 2015 to 2020 by the three main emitters, with a

long-term trajectory and a transcontinental carbon market, developed from the existing prototypes in these three groupings. Such a prototype of the international carbon market should, for practical reasons, initially cover only energy CO_2 emissions and construct a system of governance that takes on board all the lessons from the problems encountered to date by each of these main emitters for creating a carbon price. The very limited number of players may at first sight seem surprising. Yet it goes beyond a simple bilateral agreement between the United States and China, the route recommended in 2003 by Stewart and Wiener following the evident shortcomings of the Kyoto Protocol (Stewart and Wiener (2003)). The success of this initial coalition will be measured by its ability to build a system open to other emitters, which should be encouraged to join it and thus consolidate it.

Countries not belonging to the initial coalition should of course file their commitments with the UNFCCC, in accordance with MRV rules, which the introduction of a price and rebate system would enable to be generalized. But these objectives will not be initially shared in the emission rights trading system, though they will be in the following stages when the countries concerned successively join the original coalition on the basis of the twin criteria of size and their experience curve. If the size criterion is predominant, the most likely candidates are India, Russia, Japan and Korea. But the experience curve criterion for carbon pricing should not be underestimated, since a country may not join the coalition unless it has already internally established the infrastructure needed for such pricing. From this standpoint, a country such as Korea, which is preparing to launch a carbon market system in 2015 covering its industrial emissions, is much more advanced than other large emitters such as India and Russia. How can such countries be encouraged to join the original three-member group? Generally speaking, the incentive will be all the stronger, since the global climate agreement will simultaneously have mapped out positive pathways for the international coordination of action to address climate risks.

The value of a "solutions agenda"

The final parameter capable of changing the game at the climate conference in Paris, 2015: the construction of a "solutions agenda" emphasizing the co-benefits that may accrue to those acting early to reduce greenhouse gas emissions. The most important of these co-benefits is the reduction of local pollution and the damage to health associated with the use of coal. This consideration is clearly one of main motivations underlying China's climate strategy, a nation that has become the key player in climate negotiations. The construction of

a positive agenda is likely to reveal various other co-benefits encouraging governments to reach a universal agreement.

Over the years, the agenda for climate conferences has tackled new issues, even though the negotiations may have been at a standstill or even backsliding in terms of coordinating actions to reduce greenhouse gas emissions. New topics, such as climate change adaptation, the transfer of low-carbon technology and innovative financial mechanisms, have been introduced through ad hoc working groups, but without really opening up new perspectives. The march toward increased cooperation in reducing emissions will be facilitated if these general categories are linked to specific issues by offering the actors concerned concrete action programs that generate solutions. By selecting one or two priorities in each area, there would be a gain in effectiveness and a shift from a strategic vision of substitution to one of complementarity. Let us provide a few examples to illustrate the point.

Regarding questions of adaptation to climate change, the IPCC Fifth Assessment Report upwardly revised its projections for the rise in sea levels and emphasized the vulnerability of delta areas, the most populous of which are located in Asia and Africa. A programme focused on defence strategies against this risk, with funding targeted to areas of highest vulnerability and the sharing of experience of the most innovative countries in finding solutions, would be more effective than general disquisitions on the respective merits of adaptation and mitigation.

Another topic emphasized in the IPCC Fifth Assessment Report is the vulnerability of food production in developing countries to anticipated climate disruption. Technically, an important way for farmers to adapt is to have living material (seeds and livestock) that can withstand changing climatic conditions. In its time, the “green revolution” contributed to major agricultural progress in these countries by initiating research programmes around gene selection aimed at agriculture in the global South. Is it not the moment to launch a new programme of this kind, under the auspices of the United Nations, to increase the response capacity of farmers in developing countries to climate disturbances?

With regard to technology transfers, much of the discussion introduced within the UNFCCC has focused on the question of patents and property rights, that would risk hampering the transfer of low-carbon technology to the South. Though very important for the distribution of drugs for treating AIDS, this issue is not relevant for low-carbon technologies, the transfer of which can be very rapid, as shown by the relocation to China of companies producing solar panels. On the other hand, the deployment of carbon capture and storage (CCS) technologies faces many barriers. Yet the IPCC scenarios show that emission

trajectories limiting the risk of global warming to 2°C require the large-scale deployment of these technologies. Rather than discussing patents, would it not be better to organize an international program of technological cooperation around CCS, drawing as much as possible on the lessons learned from pilot plants that could be installed in different parts of the world?

Are innovations likely to generate new funding? As the prospect of the rapid spread of carbon pricing recedes, proposals have multiplied for raising additional financing and finding ways to mobilize the $100 billion pledged at Copenhagen. We can certainly count on financiers to compete in devising unconventional products. Thus formulated, this question of funding makes little sense. If a climate agreement leads to a genuine prospect of pricing carbon, we will immediately see a variety of new forms of financing emerge for guiding the economy towards low carbon. The United States has revolutionized its energy production system over the last decade by exploiting unconventional hydrocarbons without encountering the slightest difficulty raising hundred of billions of additional dollars. Developing an Australian natural gas production, transportation and distribution chain destined for Japan involved an investment of around $50 billion that the major energy operators had no difficulty in finding. If their pricing system is changed by correctly setting the price of carbon, such investments will be redirected towards an energy transition compatible with the protection of the climate.

Bibliography

105th Congress, 1st Session, Report N°105-54, GPO, July 1997

Boden, T. and B. Andres, CDIAC, Oak Ridge National Laboratory, US Department of Energy, July 2014.

Brousseau, E. Dedeurwaerdere, T., PA. Jouvet and M. Willinger, *Global Environmental Commons, Analytical and Political Challenges in Building Governance Mechanisms*, Oxford University Press, 2012.

Courchene T. and J. Allen, *Climate Change: the Case for a Carbon Tariff/Tax*, March Policy Options 59, 2008.

de Perthuis, Ch., PA. Jouvet, R. Trotignon, B. Solier, B. Meurisse and S. Quemin, *Les instruments économiques et la conférence Paris-climat 2015: le catalyseur de la tarification du carbone,* Climate Economics Chair, Policy Brief N°2014-05, October 2015.

Global Climate Change Impacts in the United States, third edition, May 2014.

IPCC, WGIII AR5, April 2014

Jouvet PA and G. Rotillon, Capital Allocation and International Equilibrium with Pollution Permits, *Modern Economy*, 3, 2012.

Müller, B., "Justice in Global Warning Negotiations. How to Obtain a Procedurally Fair Compromise," Oxford Institute for Energy Studies, EV26, 1998.

Nordhaus, W., 2013, *The Climate Casino, Risk, Uncertainty and Economics for a Warming World*, Yale University Press.

Olson M., 1965, *The Logic of Collective Action*, Cambridge, MA: Harvard University Press. Sandler, T. (2004), Global Collective Action, West Nyack, NY, USA: Cambridge University Press.

Quemin, S. and W. Wang, "Overview of climate change policies and development of emissions trading in China". Climate Economics Chair, Information and Debates Series No. 30, March 2014

Stewart R.S.et J. B. Wiener, *Reconstructing Climate Policy: Beyond Kyoto*, The American Enterprises Institute, 2003.

(The) UK Royal Society*, Geo-engineering the Climate: Science, Governance and Uncertainty*, September 2009.

Wen Wang, "Overview of climate change policies and prospects for carbon markets in China"*, Cahiers of the Climate Economics Chair*, Informations & Débats series, July 2012, n° 18.

[1] Chlorofluorocarbons or CFCs are a subclass of fluorinated gas mainly used, up until they were banned, in the refrigeration industry, air conditioning and atomizers.
[2] The resolution proposed by Senators Byrd and Hagel (a Republican and a Democrat) was passed unanimously by the Senate 95-0 on 25 July 1997, a few months before the climate conference where the Kyoto Protocol was signed. This resolution in fact sought to prevent the adherence of the United States to any climate agreement, so constraining were the conditions for ratification laid down by the Senators. See: *105th Congress, 1st Session, Report N°105-54, GPO.*
[3] The figures presented in the IPCC Fifth Assessment Report regarding the six greenhouse gases covered by climate change agreements are unequivocal: their average annual growth rate rose from 1.3% between 1970 and 2000 to 2.2% between 2000 and 2010. See: *IPCC, WGIII AR5, April 2014*. Statistics on CO_2 emissions from energy sources compiled by the International Energy Agency and the Oak Ridge National Laboratory, United States Department of Energy, lead to the same conclusions. See: *Global CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2010,* Tom Boden and Bob Andres, CDIAC, Oak Ridge National Laboratory, US Department of Energy, July 2014.
[4] The substitutable strategies viewpoint implies that each player believes he can benefit from other players' strategies without making any effort, whereas a complementary viewpoint implies that each player believes that his strategy will become more effective if it coincides with that of other players. These two outlooks define different attitudes as to free-riding behaviour.
[5] The IPCC was established in 1987 under the auspices of two UN agencies: the World Meteorological Organization and the United Nations Program for the Environment. The IPCC is not an additional research centre, but a network linking up scientists around the world. The First Assessment Report published in 1990 played a key role in the signing of the 1992 Convention on Climate Change. The final conclusions of the Fifth IPCC Report were made public in October 2014 and provide support for the COP 21, due to be held in Paris in December 2015. As well as its assessment function, the IPCC plays a role important in setting standards for the calculation and accounting of greenhouse gas emissions.
[6] The third edition of *Global Climate Change Impacts in the United States* was published in May 2014. The report, placed under the authority of the National Science and Technology Council, was supervised by more than three hundred American scientists, many of whom also participate in the work of the IPCC. It is intended for Congress and the President of the United States, with numerous illustrations and summaries designed to facilitate understanding by non-climatologist policy makers and elected officials.
[7] Founded in 1956 in the UK by Samuel Shenton, the Flat Earth Society had several thousand members in the 1960s. According to its promoters, who continue to maintain a website, it still numbers a few hundred in 2014.
[8] We here count the European Union as a single country, since it negotiates with one voice at the United Nations. The following table shows the top fourteen global energy CO_2 emitters. Taking into account CO_2 emissions associated with deforestation and other greenhouse gas emissions would put Brazil and Indonesia much higher in the ranking.

Table: Energy CO_2 emissions

	1990	2011	
	Gigatonnes	Gigatonnes	Cumulative global emissions
China	2.43	8.67	27.8%
USA	4.86	5.31	44.8%
EU-27	4.13	3.59	56.3%
India	0.59	1.81	62.1%
Russia	2.34	1.74	67.6%
Japan	1.07	1.19	71.4%
Korea	0.24	0.61	73.4%
Iran	0.19	0.52	75.1%
Canada	0.42	0.47	76.6%
Mexico	0.29	0.45	78.0%
South Africa	0.29	0.45	79.5%

Saudi Arabia	0.14	0.44	80.9%
Brazil	0.21	0.42	82.2%
Indonesia	0.15	0.41	83.5%

Source: International Energy Agency

[9] **Annex 1:** Australia, Belarus, Canada, USA, EU-28, Iceland, Japan, Norway, New Zealand, Russia, Switzerland, Ukraine. **OPEC countries:** Algeria, Angola, Saudi Arabia, Ecuador, United Arab Emirates, Iraq, Iran, Kuwait, Libya, Nigeria, Qatar, Venezuela. **Emerging countries:** South Africa, Argentina, Brazil, China, South Korea, India, Mexico, Singapore, Turkey.