Fairness, credibility, and effectiveness in the Copenhagen Accord: an economic assessment

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Abstract

State-of-the-art literature on climate change policies has proposed numerous approaches for the Post-Kyoto agreement. However, in analysing the outcome of negotiations, the feeling is that a huge gap exists between policy makers and scientists. This paper provides a critical analysis of the Copenhagen Accord provisions in comparison with part of the climate-economy literature. It assesses Copenhagen outcome in terms of economic efficiency, environmental effectiveness, and political credibility. Our conclusion suggests that the Copenhagen Accord succeeded in considering some of the climate policy principles, namely credibility, equity, and fairness. First, the change in political leadership indicates a more collaborative mood. Regarding equity and fairness, developing countries obtained an explicit commitment by developed countries for technology, but especially financial transfers, though on a conditional basis. The major limitation of the Accord is the way it addresses the trade-off between fairness, thus implicitly politically viability, and economic and environmental effectiveness. This implies that future negotiations should deal with the eventuality of a global temperature increase above the 2 degrees, even in the presence of successful global mitigation.

Keywords

International climate policy architecture, integrated assessment model, post-Kyoto

JEL Codes

Q54;Q56;Q43

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1. Introduction

Climate change and its effects on the planet are one of the most debated topics at the national and international level. Even though the scientific consensus on climate change is increasingly consolidated, the path towards an international agreement, that should cover the legal and institutional vacuum of the post Kyoto, is slow. The debate on climate policy after 2012, reached its peak last December (7-18 December 2009) in Copenhagen during the 15th Conference of the Parties (COP 15) of the United Nations.

Copenhagen delivered an informal agreement, the Copenhagen Accord (UNFCCC, 2009). It is not legally binding, but it contains a number of important provisions and represents a first step towards a potential successor to the Kyoto Protocol. Reaching an ambitious agreement among a large number of players is not easy. When stakes are high, players seek to maximize benefits while minimizing costs. Therefore, negotiating an agreement among 194 players becomes particularly difficult and almost impossible. International negotiations in other fields such as international trade, prove the complexity of these processes. For example, the Doha Round was launched in 2001, and it is still on the table, after almost ten years of discussion[1].

Having reached an informal agreement is already a good starting point mainly for two reasons. First, the agreement refers to the major elements any climate policy should account for, namely mitigation, finance, technology, deforestation, and adaptation. Second, it provides an important and credible policy signal of change. For the first time, international negotiations witness a change of leadership: the coalition behind the Copenhagen Accord includes key emerging economies and the United States. On the other hand, the Accord presents some limitations. The major is the inability to address the trade-off between political feasibility and environmental effectiveness. Indeed, the weak part is the inconsistency between the bottom-up definition of short-term regional targets and the top-down, long-term goal on global warming, which is based on the precautionary principle. This approach could not guarantee environmental effectiveness. Therefore, future negotiations should take into account the eventuality of a global temperature increase above the 2 degrees, even in the presence of successful global mitigation actions.

This paper examines the economic efficiency, the environmental effectiveness, and the political feasibility of the Copenhagen Accord by relating its main provisions to the state-of-the-art climate-

[1] See http://www.wto.org/english/tratop_e/dda_e/dda_e.htm viewed on January 2010.

economy literature. More specifically, we refer to various studies carried out using the Integrated Assessment Model WITCH[2].

Section 2 introduces the major points of divergences. Section 3 briefly summarises the main provisions of the Accord, emphasising the negotiation position of key players. Section 4 analyses the economic and environmental effectiveness of the proposed emission reduction targets. Section 5 looks into the financial issue and at the role of carbon market. Section 6 concludes with some considerations on possible approaches for the Post-Kyoto architecture.

2. Starting points, points of divergence

Climate change represents one of the most difficult challenges of global governance. Greenhouse gas emissions (GHGs) become uniformly mixed in the atmosphere. Therefore, the induced change in global mean temperature affects the climate in every region, no matter where emissions are produced. Global warming is a one of the greatest global collective action problems (Barrett, 2005) and a global negative externality that is difficult to manage because it can lead to catastrophic and irreversible damages (Stern, 2006). Finally, as pointed out by the International Panel on Climate Change Fourth Assessment Report in 2007 (IPCC, 2007a), climate change is a global problem of unprecedented scale triggered by anthropogenic influences.

Because it is a global challenge, climate change requires full cooperation. However, there are strong incentives to free ride that undermine such cooperation. In particular, the lack of well-defined global property rights justifies the need to establish mechanisms that lead to voluntarily signed agreements by a group of countries sufficiently large to keep climate change under control, making the action effective.

There are three important pillars that every climate agreement should entail. On the one hand, there are asymmetries and different responsibilities that should be acknowledged. This is the dimension of equity. On the other hand, partial action by a limited group of countries would not be sufficiently helpful from the environmental point of view. And this represents the dimension of environmental effectiveness and economic efficiency.

These three principles are a direct implication of the global nature of the problem at stake. First, there is a mismatch between the source of pollution and who bears its impacts, which is exactly

[2] For a detailed description of the WITCH model see Bosetti, et al (2006), Bosetti, Massetti and Tavoni (2007) and Bosetti *et al* (2009f) available at www.witchmode.org.

the definition of negative externality, and gives rise to equity issues. Second, individual incentives to tackle climate change are not commensurate to the size of the problem because each region does not consider global damages. Each country chooses emissions to equalize national marginal benefits and damages. However, emission reduction in one region lowers marginal damages perceived in all countries, inducing an upward revision of their emission strategy. In the climate change literature this effect is also referred to as carbon leakage (Hoel, 1991).

The asymmetric position of various players, characterised by divergent social and economic responsibilities, justifies the application of a differentiated reduction target. Poor countries as a whole argue that action against climate change should come first and foremost from developed countries. The developing countries' position reflects the first pillar of equity. Their primary objective is still eradicating poverty and enhancing economic wellbeing, while developed countries could devote a share of their income to de-carbonize their economies. In addition, developed countries bear a historical responsibility of having built up most of the existing stock of GHGs in the atmosphere.

On the contrary, developed countries' point of view is guided the by the two pillars of economic efficiency and environmental effectiveness. In particular, many industrialized countries insist that emerging economies sign up to binding emission reductions. Their main concern is carbon leakage and exposure to unfair competition from developing countries through the de-localization of carbon intensive industries (Frankel, 2009). Emerging powers, led by China and India, are unwilling to accept such a responsibility, invoking their right to economic growth and emphasising their still low level of per capita emissions.

The history of international agreements on climate change shows how these pillars have influenced its success starting from 1992, when the United Nations Framework Convention on Climate Change (UNFCCC) was established. The Convention has been signed by a large number of countries, essentially because it is rather empty in terms of concrete commitments. This can be explained by the fact that when numbers and targets are put on the plate, reaching an agreement becomes more difficult (Carraro and Siniscalco, 1993; Barret, 1994). The Kyoto Protocol, a major result of the UNFCCC advocacy, represents a first attempt to achieve a world-wide agreement on emission reduction paths. Still, its ratification confirms once more the point just illustrated. When commitments become tougher, countries are less willing to stay in. Developing countries ratified the Protocol mainly because they did not have any binding requirements while the U.S. opted out because of such "uneven" treatment.

In December 2007, the Bali Action Plan, approved under the auspices of the UNFCCC, established a framework for two-year negotiation on the Post-Kyoto global architecture. Compared to the Kyoto Protocol, the Bali Action Plan represents an effort to broaden the scope of future climate agreements to other issues such as adaptation, technology, financing, and the reduction of emissions from deforestation and forest degradation (REDD). It asks developed countries to adopt measurable, reportable, and verifiable mitigation commitments. While, developing countries are required to adopt nationally appropriate mitigation actions (NAMAs), supported and enabled by technology, financing, and capacity building.

These principles have been re-proposed and reinforced at the G8 meeting in L'Aquila in July 2009. The leaders of the Major Economies Forum (including Brazil, India and China) have endorsed the objective to contain global average warming below 2 degrees Celsius above preindustrial levels and they have committed to reduce 50% of global emissions by 2050. In the spirit of the "common but differentiated responsibility" principle, leaders of G8 countries have promised to reduce their GHGs emissions by 80%.

Finally, an important requirement for effective climate policy is long-term credibility, which requires having a domestic constituency supporting the policy (McKibbin, 2006). This explains why at COP15 some key players were not in the position to take action. The US domestic legislation, for instance, slowed down the negotiating process in Copenhagen. Even if President Barack Obama arrived in Copenhagen pledging a specific emission reduction target of 17% compared to the 2005 level by 2020 as part of the US bargaining position[3], the stalemate on the domestic policy has certainly not helped the negotiating process. It was clear from the beginning that an international binding agreement would have come only if the United States had approved its energy and climate package. Until now, this has not happened mainly due to the priority given to two issues, health care and financial reform. The future of the compromise squeezed out in Copenhagen will depend heavily on American domestic politics.

[3] See http://www.whitehouse.gov/the-press-office/president-attend-copenhagen-climate-talks viewed on January 2010.

3. A result achieved: the Copenhagen Accord

The Copenhagen Accord represents the concrete outcome of COP 15. Even if the Accord remains structured in terms of developed and developing countries, its main protagonists have been the United States and emerging economies, namely China, India, Brazil and South Africa. The rest of the countries merely took note of its existence, without formal adoption. The agreement can thus be seen as a letter of intent, opened for signature to all Parties. The Accord has pressured the perception that only the US and China could contribute to shape the course of climate negotiations.

On the one hand, the Accord brings the US back to the central stage. Its structure and key elements have been directly affected by the contribution of the US President and it reflects US domestic political reality. First, the Accord remains cautious about setting a strict set of international rules and it does not mention a firm deadline for signing a binding international agreement, which ensures full national sovereignty (Egenhofer and Georgiev, 2009). Second, it does not set any additional obligations to the US compared to what it plans to do domestically.

On the other hand, Europe, Japan, and other developed countries were largely left to rubber-stamp the deal playing a very limited role at the centre of the negotiations. In particular, the EU demonstrated poor coordination during the negotiations losing its leading position in climate policies. As a result, the Copenhagen Accord neither conceptually nor substantively reflected the EU's original negotiating position (Curtin, 2010). Not satisfied with the full agreement, it may opt for an emission reduction of 20% instead of the more ambitious target of 30%[4].

The Copenhagen Accord, which was supposed to mark the conclusion of the negotiation process started in Bali in 2007, re-proposes the various elements of the Bali Action Plan related to mitigation, in particular deforestation, adaptation, financing, and technology. In addition, it offers two important insights. The first relates to emission reduction commitments that have been informally extended to non-Annex I countries. The second concerns the proposed amount and allocation of financial transfers from developed to developing countries. According to Curtin (2010), the former was designed to galvanise developed countries to action while the latter was designed to bring developing countries to the table.

[4] See http://www.expatica.com/nl/news/local_news/Europe-laments-_lack-of-ambition_-in-climate-deal_58931.html viewed on February 2010.

4. Sharing the burden

Only the first part of the Accord refers to the long-term goals of climate policy (the 2 degrees target), whereas the rest of it focuses on the very short-term (2020) objective. The Accord distinguishes between economy-wide emissions target for Annex I and nationally appropriate mitigation actions for developing countries. Having national mitigation actions is a prerequisite to obtain financial assistance. The only exemption applies to Least Developed Countries (LDCs) and Small Island developing States that are placed in the form of a voluntary mitigation measures and under the support of other countries.

This distinction somehow gives visibility to the emergence of two heterogeneous blocs in the developing world. On the one side, emerging economies such as China, India, South Africa and Brazil, were actively engaged in the negotiation process and in the Copenhagen Accord. On the other side, LDCs, which include the Alliance of Small Island States (AOSIS) and the African group, played a completely diverse role especially in light of their totally different economic growth path and their mild increase in carbon emissions.

With regard to emission reduction targets, both industrialized (Annex I) and non-industrialized countries (Non-Annex I) have submitted their proposals for 2020 (Table 1a and Table 1b).

Table 1a: National emission reduction targets – Annex I Parties

Annex I Parties	Emissions reduction in 2020	Emissions target wrt 1990	GHG emission (GT CO2-eq) excluding LULUCF	Target at 2020	
			1990	Low commitment	High commitment
Australia[1]	5% up to 15-25% wrt 2000	from +13% to -11%	0.42	0.47	0.37
Belarus [2]	5-10% wrt 1990		0.13	0.12	0.12
Canada	17% wrt 2005	+ 2.52%	0.59	0.61	0.61
Croatia	5% wrt 1990	-5%	0.03	0.03	0.03
EU[3]	20-30% wrt 1990	from -20% to -30%	5.56	4.45	3.89
Iceland [4]	30% wrt 1990				
Japan	25 % wrt 1990	-25%	1.27	0.95	0.95
Kazakhstan	15% wrt 1992	--	--		--
Liechtenstein [5]	20-30% wrt 1990				
Monaco	30% wrt 1990				
New Zealand[6]	10-20% wrt 1990	from -10% to -20%	0.06	0.06	0.05
Norway[7]	30-40% wrt 1990	from -30% to -40%	0.05	0.03	0.03
Russia[8]	15-25% wrt 1990	from -15% to -25%	3.32	2.82	2.49
Switzerland[9]	20-30% wrt 1990		0.05	0.04	0.03
Ukraine	20% wrt 1990		0.93	0.74	0.74
U.S.	17% wrt 2005	-3%	6.08	5.88	5.88
Annex I[6]	--	from -12% to -17%	18.50	16.20	15.28

Note:

[1] Australia will move to 25% reduction if the world agrees to an ambitious global deal capable of stabilising levels of greenhouse gases in the atmosphere at 450 ppm CO2-eq or lower. Australia will reduce emissions by 15% if major developing economies commit to substantially restrain emissions and advanced economies take on commitments comparable to Australia's.

[2] Belarus reduction target is premised on its presence of and its access to the Kyoto flexible mechanisms, intensification of technology transfer, capacity building and experience enhancement for Belarus taking into consideration the special conditions of the Parties included in Annex I undergoing the process of transition to a market economy, clarity in the use of new LULUCF rules and modalities.

[3] The EU will move to a 30% reduction if other developed countries commit themselves to comparable emission reductions and if developing countries contribute adequately according to their responsibilities and respective capabilities.

[4] Iceland reduction target in a joint effort with the European Union, as part of a global and comprehensive agreement for the period beyond 2012, provided that other developed countries commit themselves to comparable emissions reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities.

[5] Liechtenstein commits itself to reduce greenhouse gas (GHG) emissions 20% below 1990 levels by 2020. If other developed countries agree to comparable reductions and emerging economies contribute according to their respective capabilities and responsibilities within a framework of a binding agreement, Liechtenstein is prepared to raise its

[3] New Zealand will move to 20% reduction if there is a comprehensive global agreement.

[4] Norway will move to 40% reduction if major emitting Parties agree on emissions reductions in line with the 2 degrees Celsius target.

[5] Russia will move to 25% reduction if major emitting Parties take legally binding commitments to reduce GHG emissions.

[9] As part of a global and comprehensive agreement for the period beyond 2012, Switzerland reiterates its conditional offer to move to a 30% reduction by 2020 compared to the 1990 levels, provided that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities.

[6] Annex I does not include Kazakhstan. As a new member, UNFCCC does not provide its historical data.

Source: UNFCCC GHG Data - Time series - Annex I at http://unfccc.int/ghg_data/ghg_data_unfccc/time_series_annex_i/items/3814.php

UNFCCC "Appendix I - Quantified economy-wide emissions targets for 2020" at http://unfccc.int/home/items/5264.php viewed on 10th May 2010.

Table 1b: National emission reduction targets – Non-Annex I Parties

Non-Annex I Parties	Emissions reduction in 2020
Brazil	36.1-38.9% wrt BaU
Central African Republic	Increase forest area from 11% in 2005 to 25% by 2050
China	Reduced carbon intensity of output by 40-45% wrt 2005
India	Reduced carbon intensity of output by 20-25% wrt 2005
Indonesia	26% wrt BaU
Israel	20% wrt baU
Maldives	Carbon neutrality
Marshall Island	40% wrt 2009
Mexico	30% wrt BaU
Moldova	25% wrt 1990
Singapore	16% wrt BaU
South Africa	34% wrt BaU
South Korea	30% wrt BaU
Togo	Increase forest area from 7% in 2005 to 30% by 2050

Source: UNFCCC "Appendix II - Nationally appropriate mitigation actions of developing country Parties" at http://unfccc.int/home/items/5265.php viewed on 2nd February 2010.

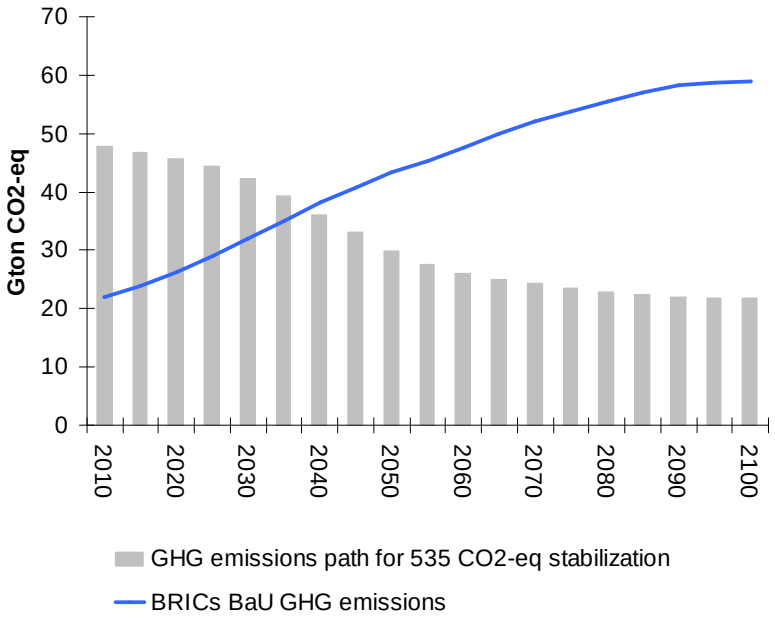
According to UNFCCC GHGs emissions database, if all the Annex I Parties follow their target there will be between 12 and 17% emission reduction with respect to the 1990 level by 2020. This is an expecting result considering that the US's low commitment counterbalances the most ambitious EU target.

The embracement of targets in developing countries displays an important change of direction. Whereas developed countries defined their effort relative to a specific base year (1990, 2000, 2005), the developing countries have taken a more flexible approach by proposing to reduce emissions below the level that they are expected to achieve, without any climate policy in place (Business as Usual - BaU). For instance, Brazil embraced a reduction of about 36-38% compared to the baseline, whereas China and India defined a goal in terms of carbon intensity (the ratio between carbon emissions and GDP), which is to be reduced by 40-45% and 20–25%, respectively. Both targets appear to be non-binding because China and India are expected to achieve them as the consequence of autonomous efficiency improvements triggered by increasing energy prices and long-term technology dynamics rather than any specific policy (See Carraro and Massetti, 2010).

The structure of the proposed targets somehow responds to both the need of global cooperation and equity. Developing countries, especially large and fast-growing economies such as China, India, must be part of the game, mainly for three reasons related to their future emission path, the environmental effectiveness of the climate coalition, and the size of mitigation costs. These three issues are further analysed below.

First, according to the IPCC WG III (2007b), unconstrained, global GHG emissions will continue to grow over the next few decades, driven by the rising demand for cheap fossil fuel-based energy boosted by ongoing economic growth. The lion's share of this increase can be attributed to developing countries, for two reasons. First, their economies will grow faster and, second, they start from a relatively higher carbon intensity of output. For example, baseline emissions of fast-growing regions such as those in the so called BRIC (Brazil, Russia, India, China) would exceed the carbon budget allowed to stabilize GHG concentrations at 535 CO2-eq in 2100 already thirty years from now, in 2040 (see Figure 1).

Figure 1: BRIC countries BaU CO2 emissions and 535 CO2-eq stabilisation path



Source: WITCH model, www.policysimulator.org

Second, the importance of having on board major emitting countries from the developing world is well clarified by the notion of potentially effective coalition (PEC) introduced in Bosetti et al (2009d). A coalition is potentially effective if non-participating regions follow their BaU emissions but still global emissions (from participants plus non-participating countries) make it possible to achieve the stabilisation target (e.g. 550ppm CO2- eq). This can only occur if participant countries emit the lowest level of emissions technically conceivable, that is zero or slightly negative when considering avoided deforestation.

Bosetti et al (2009d) found that only few coalitions could meet the 550ppm CO2-eq target by 2100, even under the very optimistic assumption of zero emissions within the coalition. These few PECs always include both China and India. It follows that, to achieve a meaningful stabilisation target, even if industrialized economies would hypothetically cut their emissions to zero, developing countries would still need to emit less than their BaU scenario.

Sooner or later, effective climate policy will require full cooperation. A prerequisite for being self-enforcing is that full cooperation is economically rational. This means that each cooperating country should be better off than in a non-cooperative situation. Otherwise, they might have an incentive to free ride on the emission reduction of other countries, partly offsetting coalition's effort. Bosetti et al. (2009d) estimated an indicator of free riding incentive, which reflects the interplay between various socio-economic variables. Two important drivers are abatement costs and the benefits of emission reduction, which are implicitly linked to the size and the distribution of damages. Both climate change damages and marginal abatement costs are unequally distributed across world regions. In general, the free riding incentive is negatively correlated with the size of damages and positively correlated with total mitigation costs. China, Middle East and North Africa and Easter Europe would suffer the most from a hypothetical global carbon tax and are indeed those with the highest incentive to free ride. By contrast, developed countries tend to have lower free riding incentives. This result suggests that the opposition of developing countries to join an international agreement with binding targets is justified not only by ethical arguments, but also by economic considerations.

Finally, a global agreement with delayed participation of developing countries would also increase the climate policy bill. Several studies confirmed that a delayed participation of emerging economies could increase the global cost of climate policy, besides inducing lock-in effects in fossil fuel technologies that could make the achievement of long-term emissions reduction targets more difficult. Including developing countries in a global climate agreement would increase its economic

efficiency because they host numerous cheap abatement opportunities. First, starting from a relatively lower level of energy efficiency they offer abatement possibilities that have already been exploited in the developed world. Second, these countries contain the highest level of deforestation recorded. Both elements could contribute to reducing global mitigation costs provided an efficient international carbon market exists, an issue that is discussed in Section 5.

Bosetti, Carraro and Tavoni (2009b) provided a detailed estimation of global cost for the world economic system in the case of a 20-year delayed participation to a global climate agreement by developing countries. With a long-term stabilisation target at 450 ppm CO2, GWP (gross world product) losses would increase by 160% (from 1.3 to 3.4%) in 2030, and by 77% in 2050 (from 3.2 to 5.6%), realigning only at the very end of the century.[5]

The effect on delayed participation has also been at the centre of a modelling comparison exercise coordinated by the Energy Modelling Forum working group 22 (Clarke et al. 2009). Within that group, Bosetti, Carraro and Tavoni (2009a) assessed the additional economic penalty of delaying the participation of BRIC countries to 2030. The size of additional costs depends on the target stringency. The delayed participation of BRICs and their myopic behaviour lock the world energy system in fossil-fuel-based investments, with a penalty on the shadow price of carbon to approximately 150 US$/tCO2 even in the very long-term, when all countries cooperate. That paper also emphasised that countries coming in late could do better if they prepare for the future climate target in advance. In other words, they should start modifying their investment mix before coming into force of the target.

A second modelling comparison using three European models (WITCH, REMIND and IMACLIME-R) showed that postponing global action to 2020 increases discounted global consumption losses from 1.4 to 2% in WITCH, from 0.6 to 1% in REMIND-R and from 0.1 to 0.8% in IMACLIM-R. According to IMACLIM-R and WITCH, an early participation of China and India will also result in significant cost decreases (Edenhofer et al., 2009).

To summarise, sharing the burden between developing and developed countries is important to ensure environmental effectiveness and cost efficiency. However, when the targets at stake are ambitious, it becomes more difficult to address the trade-off between environmental effectiveness and political feasibility. On the on hand, a political feasible agreement would probably fail to be environmental effective. Given the current level of GHG concentration (about

[5] The analysis is based on the WITCH model with a discount rate equal to 3%.

430 ppm CO2-eq), achieving the 2°C target is very unlikely (Carraro and Massetti, 2009). This is even more true considering the time extension asked by developing countries. This view is supported by the work of Bosetti and Frankel (2009), who showed that a politically viable agreement, with delayed entry of developing countries, would lead to a global temperature increase above pre-industrial levels of 2.8 °C. On the other hand, an environmental effective agreement needs to be political viable. It is thus essential to design a system of incentives that make the agreement attractive also for key developing countries. Financial and technology transfers can help to achieve these objectives.

5. Financing and the role of carbon market

Transfers can improve the perspective for broad-based participation. This is probably why the issue of financing was at the top of the agenda during the conference. Carraro, Eyckmans and Finus (2006) provided a thorough assessment of the "full potential of transfers", using a simple theoretical framework and a stylised integrated assessment model. They showed how properly designed transfer schemes, even if financed from outsider countries, can help to achieve a broad, self-enforcing agreement. Countries that remain outside international coalition may still play a role in fostering international cooperation by financing the protection of the global common good in other non-participatory countries, which might eventually find it convenient to join the international coalition. These transfers would be economically rational if the benefits in terms of reduced emissions and damages outweigh the cost of transfers and the cost of domestic emission reduction.

The crucial role of transfers was already recognised in the Kyoto Protocol. Actually, the Clean Development Mechanism (CDM) is the only market instrument in the Protocol where developing countries could participate. However, over the past several years, this mechanism has been subject to a number of critiques. The first relates to the methodologies used for calculating projects emission reduction, the so called additionality issue. The additional abatement for which tradable CERs are issued is computed on the basis of a counter factual baseline which could be questionable. Second, it has been criticized for the length and expensive project approval procedure and the exclusion of many categories of potentially important mitigation activities such as carbon capture and storage (see among others Harvard Project on International Climate Agreements, 2009).

The need for innovative funding mechanisms was also a central conclusion in the Bali Action Plan and the Copenhagen Accord took up this issue again. It includes an explicit commitment by developed countries to provide adequate funding to developing countries. A significant part of these funds will come from the Copenhagen Green Climate Fund, but the Accord seems willing to include as many sources as possible, public and private, multilateral and bilateral.

The Accord envisages a fast-track fund of US$ 10 billion per year from 2010 to 2012, for a total amount of US$ 30 billion. The financial support also requires developing countries to put in place mitigation measures in order to guarantee the allocation of money to carbon-free measures and mitigation policies. Conditional on sufficient and transparent mitigation actions, developed countries have committed to transfer US$ 100 billion dollars a year by 2020.

The Copenhagen Accord does not limit the nature of funding source. It states that the Parties should rely on the use of markets to achieve cost-effective mitigation action. It thus assigns the carbon market a prominent role in attracting private and public investments and in transferring potentially large financial flows from developed to the developing world.

The creation of a market for GHG emissions can be traced back to the 1997 Kyoto Protocol, which promoted the use of an Emissions Trading Scheme (ETS). A global cap-and-trade system sets a cap on emissions and allows countries and industries to exchange allowances “to emit” in the market. These transactions give shape to a real structure of supply and demand of permits, which determine the price of carbon. The carbon price reflects the objectives of stabilisation: the more stringent the stabilisation target, the higher the CO_2 price required to achieve it, and vice versa (Carraro and Favero, 2009). Given the ambition of the stabilisation targets proposed, a potentially high CO2 price could materialise in the future. The increasing price and the growing volume of allowances traded, would amplify the role of the carbon market, which in principle could have the potentialities to make a future climate agreement self-financing (Klein et al. 2008).

Various studies have estimated how large the amount of money transferred through these transactions could be. Most of these assessments share similar assumptions of no transaction costs, global and immediate participation. Jacoby et. al (2008) estimated that the size of north-south side-payments when aiming at global emissions reduction of 50% by 2050. They could amount to US$ 400 billion already in 2020, which is four times the upper bound proposed in Copenhagen. De Cian and Tavoni (2010) computed the financial transfers in the international carbon market from OECD to non-OECD countries, assuming that OECD countries face an emission

reduction target of 90% (compared to 2005). When emission trading begins, in 2020, financial needs are still limited because the initial price of carbon is low. Over time, transferred resources grow substantially driven by the increasing carbon price. Transfers go from amounts comparable to current Official Development Assistance (ODA) flows already in 2025 (US$ 76 Billion, or 0.1% of Gross World Product) to over US$ 1.5 Trillion in 2050. Considering that today's OECD imports of oil (at a price of 70$/bbl) equate roughly US$ 700 Billion, the carbon market resembles that of fossil fuels. In terms of regional GDP, outflows from OECD regions grow up to US$ 1.7 Trillion in 2050, which is more than 2% of OECD GDP (see also Bastianin, Favero and Massetti, 2010).

These estimates only include how much mitigation could cost and they do not consider adaptation financial needs. Comparing these numbers with those coming out from the Copenhagen Accord two considerations can be made. First, the amounts proposed until 2020 seem sufficient for facing the mitigation challenge only. Second, the demand of financial assistance for mitigation is likely to grow significantly over time. On top of that, adaptation will add a demand of about US$ 100 billion in 2050 and of US$ 1 trillion in 2100 (Bosello, Carraro and De Cian, 2010). And this links to another important part of the Accord, the allocation of funds between mitigation and adaptation.

The Accord emphasises an equal balance of the fast-start funds between adaptation and mitigation. However, it seems that funding mitigation is more urgently needed than adaptation, although this conclusion depends on the size of climate change impacts and on their economic evaluation (Bosello, Carraro, and De Cian 2009, 2010). Table 2 shows the allocation of climate change costs between adaptation and mitigation when present and future climate change damages are perceived as moderate[6] and when a 550CO2-eq stabilisation target is implemented. Adaptation needs will become sizable only after 2030. Mitigation starts well in advance compared to adaptation because of the inertia in the climate system and also because of the slow turnover of energy infrastructure. Mitigation options (see also the remaining of this section) such as improvements in energy efficiency, decarbonisation of power generation and the transport sector call for significant upfront investments.

[6] Present and future climate change damages are considered to be moderate if physical impacts are low and if the value attached to the future is low because of a high discount rate (pure rate of time preference 3% declining). On the contrary, present and future climate change damages are considered to be large if physical impacts are high and if the value attached to the future is high because of a low discount rate (pure rate of time preference 0.1% declining).

Table 2: Intertemporal timing of adaptation and mitigation expenditure[7]

Annual Average Costs - WORLD (US$ Billion)	2020	2030	2050	2100
Mitigation expenditure	719	1149	1590	2133
Adaptation expenditure	0.29	6	136	1021

Source: AD-WITCH model (Bosello, Carraro, De Cian, 2010). Mitigation and adaptation expenditure in the presence of a long-term stabilisation target of 550CO2-eq. Mitigation expenditure includes additional investments compared to the baseline in zero carbon technologies for power generation (nuclear, renewables, coal plants with CCS, backstop technology), investments in energy efficiency and backstop R&D, expenditure in biofuels including a backstop technology in the non-electric sector.

The geographic dimension of adaptation is very different from that of mitigation. Whereas the benefits of one abated ton of carbon are global, irrespectively of where abatement takes place, the benefits of adaptation actions advantage primarily the acting community. Developing countries, especially Sub-Saharan Africa, South Asia, and Middle East and North Africa, are more exposed to climatic damages; therefore they are forced to spend more. On an annuitized base computed, climate change adaptation would cost non-OECD countries about US$ 500 Billion (or 0.48% of their GDP) against the US$ 200 Billion (or 0.22% of GDP) of OECD. However, it is quite unlikely that developing countries could afford an expenditure of such size. Hence, this would call for international aid on adaptation, which should promote proactive adaptation strategies and capacity building.

The Copenhagen Accord refers to mitigation actions without giving specific indications on the options that should be prioritised. To achieve the 2°C target, global emissions need to peak before 2015. Such a path requires high effort in all sectors, especially in the energy sector, which represents the primary source of anthropogenic GHG emissions. According to the IPCC WG III (2007b), in a scenario with "no climate policy" CO2 emissions from energy use would increase 40 to 110% between 2000 and 2030. Therefore, what is needed is a remarkable transformation in the way humans produce and consume energy, which has to be supported by profound technological

[7] The estimates reported in Table 2 refer to a case in which present and future climate change damages are perceived as moderate. In a more pessimistic scenario in which current and future damages are larger, adaptation expenditure in 2020 could increase to about US$ 50 billion.

change. Fossil fuels, that have sustained the growth of the economy in the past, are to be replaced by renewable energy with low or zero carbon content. This requires a drastic change in the energy mix which has to be done under different steps but in a short time frame.

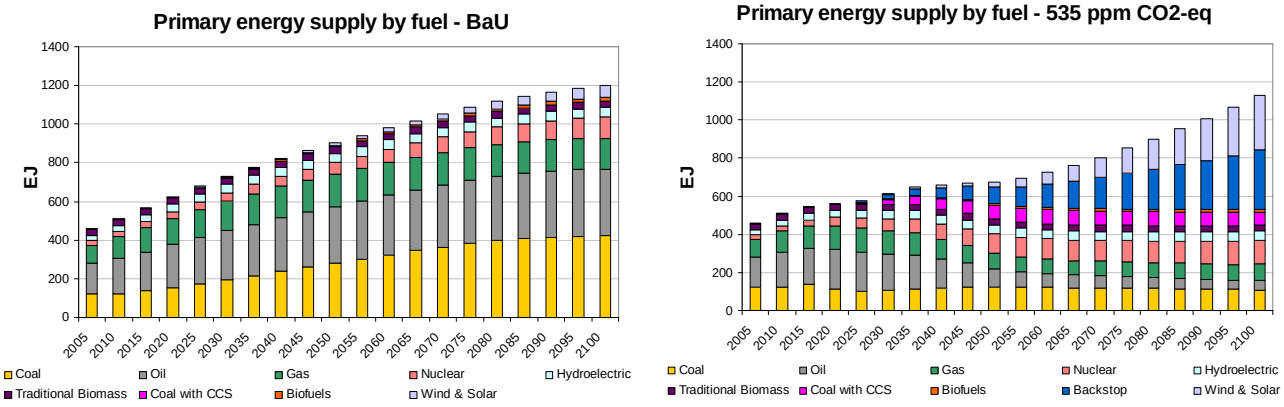
The first option to endorse is energy efficiency improvements beyond the baseline scenario through, for example, measures meant to reduce fossil fuel consumption. This represents one of the cheapest abatement options available at world level, in particular in inefficient countries (see Bosetti et al 2009e).

Power generation is one of the most-cost effective options in achieving a low carbon energy supply for two reasons: its weight on global emissions and the availability of alternative technologies already known or under development. Known technologies include nuclear energy and renewable sources, while the second group (under development) consists of carbon capture and storage (CCS) and backstop technologies. These are technologies not yet available on large scale, but that have the potentialities to be widely deployed, conditional on sufficient R&D investments. Examples are new generation nuclear or solar power. Nuclear power is at the moment the only proven base load generation for large-scale electricity decarbonisation. However, safety or political reasons could limit the use of this energy source in building new plants. Renewables, especially wind and solar power, can also contribute to achieving the stabilisation target. However, some constraints can exist in the penetration of renewable power generation. They have limitations due to low efficiency and grid connectivity problems. Finally, CCS allows the power sector to continue to use fossil fuels, namely coal and gas, at zero emissions.

Finally, the decarbonisation of transport and residential sectors could significantly help in achieving climate stabilisation target.

Figure 2 illustrates this transformation by comparing the energy mix in a baseline scenario (BaU) with a stabilisation scenario consistent with a global temperature increase above pre-industrial levels of 2.5 °C (Stab 535 ppm CO2-eq).

Figure 2: Energy mix. Comparisons of stabilisation policy (Stab 535 CO2-eq) and BaU



Source: WITCH model, www.policysimulator.org

This structural change needs to be supported by a modification in investment priorities. More resources should be directed at increasing energy efficiency and at promoting the deployment of low carbon alternatives. Such radical transformation should occur within the first half of this century to make the 550 ppm CO2-eq scenario feasible but the investments required in monetary terms are manageable. Indeed, the size of overall investments in the baseline and stabilisation scenarios is comparable (see Bastianin, Favero and Massetti, 2010).

These changes can only be achieved through major investments in infrastructure and research and development. R&D investments in energy technologies have been declining since 1980. This tendency should be reverted and more money should bring energy R&D to the 1980 levels, when the oil crisis spurred innovation in renewable and alternative technologies to reach 0.08% of world Gross Domestic Product (Bosetti et al., 2009c). In this regard, the carbon price is a crucial signal and it could have a similar impact as the oil price shock did. According to the WITCH model (see for example Bosetti et al. 2009c), the carbon price induced by a 535 CO2-eq stabilisation policy would induce an optimal increase in energy R&D investments by a factor of six as soon as the climate policy starts. Upfront Investments in research are particularly needed to foster the development and deployment of alternatives in the non-electric sector. In addition, R&D investments could be covered by the revenue from auctioning carbon permits as showed Bastianin, Favero and Massetti (2010).

Not only the energy sector but also deforestation should be on the top of the mitigation options especially considering that deforestation causes 17% of emissions and it occurs mainly in developing countries..

Since the Bali Action Plan in 2007, deforestation has received an increasingly prominent role in climate change negotiations and now it seems closer than any other sector in reaching a comprehensive agreement including both developed countries and emerging economies. Indeed, a point shared by all countries at COP 15 has been the critical role of stopping deforestation. The Accord acknowledges that some funding will be allocated to provide incentives for reducing deforestation and degradation of forests through, for example, the immediate creation of a mechanism for the mobilisation of resources by the industrialised countries. For instance, Reducing Emissions from Deforestation and Forest Degradation (REDD) offers the potential for achieving multiple benefits in the areas of climate change mitigation. Developing countries would reap the many co-benefits that accompany the maintenance of healthy forests, from biodiversity to water services to poverty alleviation and it represents a meaningful incentive for them to undertake mitigation target and thus take part to a future international agreement. On the other hand, developed countries would be more able to manage a smooth transition to a low-carbon economy.

Exploiting GHG emission reduction from avoided deforestation and better land use management could lower mitigation costs. According to Bosetti and Lubowski (2009), its inclusion in the mitigation portfolio reduces costs of a 550 CO2-eq stabilisation policy by 10 to 25%. In addition, Bosetti, Tavoni and Sohngen (2007) estimated that it enables an atmospheric target of 550 CO2e ppmv for the same total cost as a 600 ppmv target without forestry mitigation.

However, the inclusion of REDD in the carbon market could have a downward effect on the carbon price. According to Bosetti, Tavoni and Sohngen (2007) the price of carbon could decrease by 40% by 2050. In addition, it could delay low carbon technologies development due to the elimination price incentives and undermine incentives to invest in reducing emissions internally.

However, the last COP 15 has reinforced the idea of tapping carbon markets to finance reductions in emissions from deforestation. To date, a range of market and non-market measures have been

identified to encourage mitigation in forestry, including direct liability or involvement in a national emissions trading scheme.[8]

6. Conclusion and discussion

Climate change and its effects on the planet and humans are one of the most debated topics at the national and international level. The question on climate policy after 2012 reached its climax in the 15th Conference of the Parties in Copenhagen last December. The result of the negotiation process started in Bali in 2007 and stopped in Copenhagen was not a legally-binding agreement, but a letter of intent. However, such intents will be a good starting point if kept in the following negotiations.

The parties involved have to consider the issue of addressing the post-Kyoto successor as an opportunity to transform the architecture of the international agreement. The new agreement should build upon three essential principles: fairness, political credibility and effectiveness.

Fairness and equity can be achieved through a differentiated treatment of industrialised countries, which should be the first to adopt reduction targets, and the developing ones. What emerged during COP 15 is the important role of negotiations in giving a credible sign of change. This credible signal has to be given *in primis* by the highest emitters. If the US and China are not prepared to deliver legally-binding commitments, half of the Earth's emissions will not be covered by a legal agreement. Additionally, within the developing countries bloc there are substantial differences that cannot be ignored by a global treaty. Targets have to be introduced gradually in emerging countries on the basis of individual socio-economic indicators defined *ex ante* (see among others Olmstead and Stavins 2009, Bosetti and Frankel 2009, and Cao 2008). In general, when the targets at stake are ambitious, it becomes more difficult to address the trade-off between credibility, fairness, and environmental effectiveness. A politically viable agreement is likely to miss the 2 degree target and therefore policy makers should consider the need to adapt to a warmer climate, despite the successful implementation of global mitigation actions.

[8] There are already some carbon markets that allow forestry credits to be used as offsets follow the project-based approach: the Australian New South Wales carbon market, the voluntary United States Chicago Climate Exchange (CCX) and the New Zealand cap-and-trade scheme. Other trading systems may eventually allow for the inclusion of forestry carbon credits through project-based approaches.

Credibility requires some certainty, if possible, about future climate policy. Certainty could be provided with the introduction of sufficiently long-term global reduction targets shared among countries, on the basis of past and future responsibilities. This could be associated with the introduction of a carbon tax or a global emission trading scheme. Although this second option does not appear feasible yet, linking national emission trading schemes already in act or proposed could pave the way towards a global integrated market (see for example Tuerk et al. 2009, Jaffe and Stavins 2008, and Flachsland, Marschinski and Edenhofer 2008). Credibility would provide a strong and reliable signal, stimulating investment in low-zero emission technologies and motivating domestic abatement. A new fund could also help to support the deployment of low carbon technologies in major emitter developing countries and promote international cooperation on low GHG research, development, and demonstration (Gallagher, 2009).

Economic and environmental effectiveness requires the agreement being shared by all parties. To be economically effective, part of the game has to be played in developing world, for several reasons. First, their thirst for economic growth will translate into increased demand for energy. Therefore, technological innovation should not be confined to developed countries and mechanisms that promote technology transfer will play a key role. Second, poor countries still suffer the negative consequences of the climate change caused by past pollution by the richest countries. Thus, international cooperation on adaptation is also needed.

Copenhagen is only a first step in the complex process of negotiation, but at least in the right direction.

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