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FAIRNESS, CREDIBILITY, AND EFFECTIVENESS IN THE COPENHAGEN ACCORD: AN ECONOMIC ASSESSMENT

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SUMMARY 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 tries to bridge this gap by providing a critical and comparative analysis of the Copenhagen Accord provisions, linking them to a 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 politically viability, thus implicitly fairness, and economic and environmental effectiveness. Therefore, 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: Q54, Q56, Q43

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 is slow towards an international agreement that covers the legal and institutional vacuum of the post Kyoto. The debate on climate policy after 2012, reached its peak in 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 the 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 finance, technology, deforestation, and adaptation. Second, it provides an important and credible policy signal of change. Given the very long-time horizon of climate policy, signing a binding agreement in 2010 or 2011 would not have major consequences. In addition, the change of leadership sends important political signals. For the first time in international negotiations, the coalition includes key emerging markets led by the United States (Koch-Weser, 2010). Probably, the major limitation of the Accord is the inability to acknowledge the existence of a trade-off between political feasibility and environmental effectiveness. The weak part of the Copenhagen Accord is related to the bottom-up definition of regional targets and the long-term goal on global warming. This kind of approach does not guarantee environmental effectiveness. Therefore, future negotiations should also deal with the eventuality of a global temperature increase

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

above the 2 degrees, even in the presence of successful global mitigation.

This paper examines the economic efficiency, the environmental effectiveness, and the political feasibility of the Copenhagen Accord by linking its main provisions to the state-of-the-art climate-economy literature. 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) have 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 global negative externality that is difficult to manage because it can lead to catastrophic and irreversible damages (Stern, 2006). It is indeed one of the greatest global collective action problems (Barrett, 2005). 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, when property rights are not clearly defined, there are strong incentives to free ride that undermine co-operation. This makes it increasingly difficult to reach effective and widely accepted agreements. 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.

The history of international agreements on climate change dates back to 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

[2] See Bosetti, et al (2006), Bosetti, Massetti and Tavoni (2007) and Bosetti *et al* (2009f) for a detailed description of the WITCH model.

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-years 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. 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 an objective of containing an average warming to 2 degrees Celsius above preindustrial levels and committed to reduce global emissions by 50% by 2050. In the spirit of the "common but differentiated responsibility" principle that governs global action against global warming, leaders of G8 countries have promised to reduce GHGs emissions by 80%.

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 is 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 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 balance 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.

A final and 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

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

financial reform. Whether this will occur in 2010 is difficult to predict, because of midterm elections and because of the newly elected Senator, Scott Brown. The future of the compromise squeezed out in Copenhagen will depend heavily on American domestic politics.

3. A result achieved: the Copenhagen Accord

The Copenhagen Accord, proposed on December 18, 2009, represents the real result produced by COP 15. Even if the Accord remains structured in terms of developed and developing countries, its main protagonists are 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 the 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. 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). According to Guérin and Wemaere (2009), this Accord represents indeed a victory for the US. First, it does not set any additional obligations to the US compared to what it plans to do domestically. Second, its international target for reducing emissions will be the mirror of its domestic legislation. Finally, it obtains the verification of developing countries actions, particularly China, through international consultations and analysis, which is one of the main open issues in the negotiation process.

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]. In addition, of the amount pledged to fast-start finance, the EU has the highest share

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

with the US contribution equal to one third of the European one (Guérin and Wemaere, 2009).

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 targets 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), emissions reduction commitments were designed to galvanise developed countries to action while, the agreement on financing was designed to bring developing countries to the table. The next two sections deal with these two elements, starting with emissions reduction targets.

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) objectives. 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 of developing countries. From one side, the BASIC group comprising China, India, South Africa and Brazil, was 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 show a completely different economic growth path and mild increase in carbon emissions.

Emission reduction targets are to be finalized by the end of January 2010, when both industrialized (Annex I) and non-industrialized countries (Non-Annex I) should present their measures for 2020. Even if this deadline has been defined as “soft” by United Nations climate chief Yvo De Boer[5], who did not expect a submission by each Party, many developed and developing countries have already submitted their specific targets (Table 1).

[5] See http://www.guardian.co.uk/environment/2010/jan/20/copenhagen-accord-deadline-climate-change viewed on February 2010.

Table 1: National emission reduction targets

Annex I Parties	Emissions reduction in 2020	Emissions target wrt 1990	GHG emission (GT CO2-eq) excluding LULUCF	
			1990	2020
Australia[1]	5% up to 15-25% wrt 2000	from +13% to -11%	0.42	0.47 – 0.37
Canada	17% wrt 2005	+ 2.52%	0.59	0.61
Croatia	5% wrt 1990	- 5%	0.03	0.03
EU[2]	20-30% wrt 1990	From -20% to - 30%	5.56	4.45 – 3.89
Japan	25 % wrt 1990	-25%	1.27	0.95
Kazakhstan	15% wrt 1992	--	--	--
New Zealand[3]	10-20% wrt 1990	From -10% to 20%	0.06	0.06 – 0.05
Norway[4]	30-40% wrt 1990	From -30% to 40%	0.05	0.03 – 0.03
Russia[5]	15-25% wrt 1990	From -15% to -25%	3.32	2.82 – 2.49
U.S.	17% wrt 2005	-3%	6.08	5.88
Annex I[6]	--	-15%	17.39	14.80

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] 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.

[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.

[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 2nd February 2010.

Non-Annex I Parties	Emissions reduction in 2020
Brazil	36.1-38.9% wrt BaU
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
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.	

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).

Japan proposed about a reduction of 25% compared to 1990, the US of 4%. According to UNFCCC GHGs emissions database, if all the Annex I Parties follow their target there will be a 15% emission reduction with respect to the 1990 level by 2020. This is a reasonable result considering that US and EU targets have the highest weight in the Annex I effort.

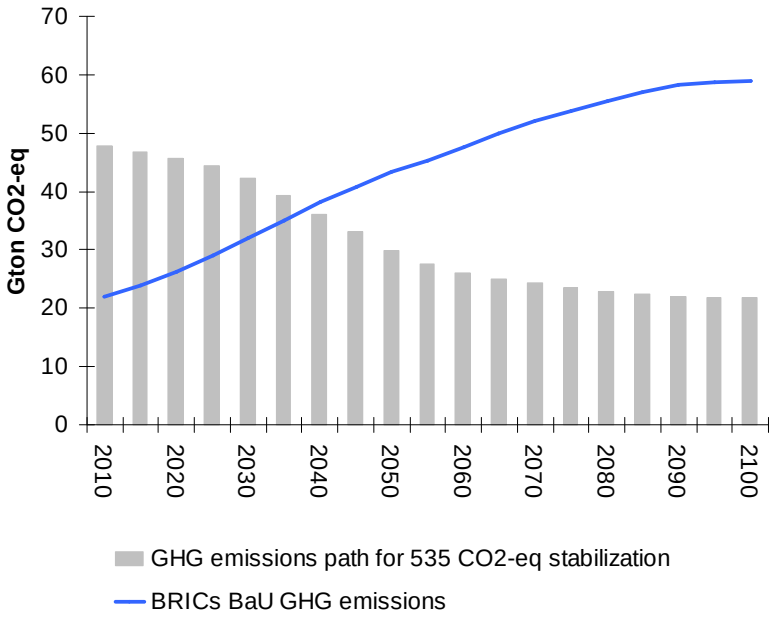
Regarding developing countries, the UNFCCC does not provide historical data. However, we collect their proposals. For instance, Brazil embraced a reduction of about 38% compared to the baseline, whereas China and India defined a goal in terms of carbon intensity (the ratio between carbon emissions and GDP), which is to be reduced by 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 long-term price and technology dynamics more 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 must be part of the game, mainly for two reasons: future emission path and mitigation costs. This is especially true for large and fast-growing economies such as China, India, and other major emitters.

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 (Bosetti et al.2006, 2009f)

The abundance of cheap abatement opportunities in developing countries is also a reason for their inclusion in a global agreement on climate mitigation. First, starting from a relatively lower level of energy efficiency they offer abatement possibilities that have already been exploited in the developed world and are therefore easy to transfer. Second, these countries contain the highest level of deforestation recorded. Both of these issues will be discussed in Section 5.

The importance of involving major emitting countries from the developing world is well clarified by the notion of potentially effective coalition (PEC) introduced in Bosetti et al (2009d). Given a stabilisation target at the 550 CO2-eq ppm, a coalition is potentially effective if it meets two conditions. First, participants emit the lowest level of emissions that is technically conceivable (zero), while non-participating regions follow their BaU emissions. Second, emissions from the coalition, added to those of non-participating countries, make it possible to achieve the stabilisation target. 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, determined by the interactions among several socio-economic variables. Two important drivers are abatement costs and the benefits of emission reduction, which is 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 (e.g. according to that study China would suffer low damages) and positively correlated with mitigation costs. China, Africa, 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 the lowest free riding incentives. This result suggests that the opposition of developing countries to join an international agreement with binding targets could be explained not only by an ethical ground, but also by some economic considerations.

Besides failing to meet long-term ambitious targets, 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. In particular, such costs have been measured in terms of global consumption losses, carbon prices, or gross world product losses.

According to Edmonds et al. (2007), the effect of delaying the entry of non-Annex I countries to 2020 into the coalition of countries actively engaged in mitigation roughly doubles the price of carbon when the CO2 concentration is limited to 550 ppm. When the target is fixed to 450 ppm, a delay until 2050 renders the limit infeasible. Even delays until 2035 lead to a carbon price that spikes at more than $2500 per ton of carbon before declining subsequent to the entry of the largest emitting non-Annex I regions.[6] This result suggests that greater delay in accession would lower the efficiency of the market. 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.[7]

The effect on delayed participation has recently been analysed within a modelling comparison exercise coordinated by Energy Modelling Forum working group 22 (Clarke et al. 2009). Within this 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

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

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.

Another modelling comparison has been produced with three European models (WITCH, REMIND and IMACLIME-R). It showed that delaying global mitigation action until 2020 still makes it possible to stabilize at 450 ppm CO2 by 2100, but discounted global consumption losses increase 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. With a rising number of regions taking early action by 2010, global costs of stabilisation decrease. The participation of big Annex I countries such as China and India is particularly relevant for the magnitude of mitigation costs (Edenhofer et al., 2009).

To summarise, involving developing 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. First, given that current GHG concentration is 430 ppm CO2-eq, in the absence of technologies that can reduce the stock of GHG emissions in the atmosphere, the 2°C target could be achieved with a median likelihood only if emissions, all over the world, were immediately (starting from 2012) cut to zero. This is clearly unrealistic and even more complicated by the demand of a time extension by developing countries (Carraro and Massetti, 2009). Second, Bosetti and Frankel (2009) showed that a politically viable agreement, with delayed entry of developing countries, would not succeed to stabilise CO2 concentrations (only) below 460 ppm, leading to a global temperature increase of 2.8 °C. It is essential to design a system of incentives that make the agreement on emission reduction attractive also for key developing countries. Financial and technology transfers can help complying with this task. They make it possible to stick to ambitious stabilisation targets while keeping global stabilisation costs moderate.

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 very simple theoretical framework of analysis and a stylised integrated assessment model of climate policy. 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 become active members of the international coalition. These transfers would be economically rational if the benefits in terms of reduced emissions and damages outweigh the cost of both transfers and domestic emission reduction.

The crucial role of transfers was already recognised in the Kyoto Protocol. Multilateral financial transfers take place under the so-called Global Environment Facility (GEF) program, whereas flexible mechanisms allow for bilateral relationships. These flexible mechanisms, namely Clean Development Mechanism (CDM) and Joint Implementation (JI), allow member countries to acquire emissions credits in foreign countries.

The GEF finances programs and projects to protect the global environment in six focal areas: climate change (mitigation and adaptation), biodiversity, international waters, persistent organic pollutants, ozone depletion, and land degradation (desertification and deforestation). The GEF Trust Fund received US$ 3.13 billion for the period of 2006 to 2010 (Doornbosch and Knight, 2008). As this funding is too small to invest in large demonstration projects, the GEF focuses on removing market barriers to replicating demonstration projects, and creating enabling environments. A positive feature of the GEF's funding policy is that it covers the incremental costs for projects that would not otherwise receive private sector finance (Doornbosch and Knight, 2008).

Compared to the GEF, which collects public resources from the governments of Annex I Parties, CDM can involve not only governments, but also private agents. Companies in Annex I Parties can use the credits generated by the CDM projects (Clean Emission Reductions – CERs) to comply with national climate policy obligations. In this way, CDMs have the potential to give additional support to mitigation policies with resources coming from Annex I reductions.

The need for innovative funding mechanisms was also a central conclusion in the Bali Action Plan. The relevant body of UNFCCC for negotiations so-called "Ad Hoc Working

Group on Long-Term Cooperative Action under the Convention"(AWG-LCA) strongly supported financial resources and investment to carry action on mitigation adaptation and technology cooperation (UNFCCC, 2007). 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. These figures, however, do not reflect what had been demanded by developing countries who wanted much more.

Are the proposed transfers sufficient to finance ambitious mitigation and adaptation? Financing ambitious mitigation, though not ambitious enough to achieve the 2 degrees target, is likely to require much larger financial resources. Carraro and Massetti (2010) found a similar conclusion. They found that if all the Copenhagen Green Climate Fund were used to finance mitigation actions in developing countries, emissions could peak before 2020. This would make it possible to limit temperature increase to about 2.5°C, still well above the 2°C threshold. To this purpose additional funding would be needed.

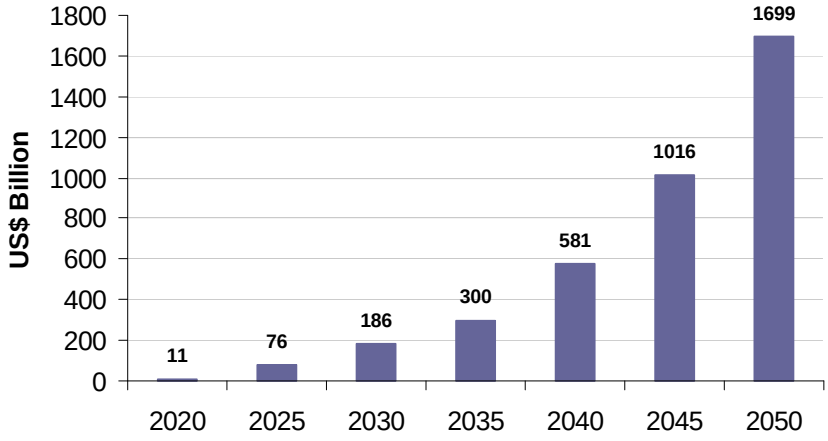
The Copenhagen Accord does not limit the nature of funding source. It states that the Parties should pursue opportunities to use markets to achieve cost-effective mitigation action emphasising the role of the carbon market as a key player in both attracting both private and public investments and moving huge financial flows from developed countries to the developing world.

The creation of a market for GHG emissions can be traced back to the 1997 Kyoto Protocol, which identified the Emissions Trading Scheme (ETS) as environmental policy instruments. The ETS is often associated with a cap-and-trade system that sets a cap on emissions and allows countries and industries to exchange allowances "to emit" in the market, thus giving shape to a real structure of supply and demand permits, which determines the price of carbon. In a hypothetical context of global cap-and-trade, the carbon price will be influenced by 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). Considering that the present CO2 concentration is around 380 ppm, to avoid a 2°C temperature increase, a strict policy with a high CO2 price is required. The increasing price value and volume of allowances traded will increase the value and the role of the market. In principle, the carbon market has the potentialities to make a future climate agreement self-financing, increasing financial flows to developing countries (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 the size of north-south side-payments when aiming at global emissions reduction of 50% by 2050. Compensating mitigation costs in developing countries would require 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 from OECD to non-OECD countries going through an international carbon market. When OECD faces an emission reduction target of 90% (compared to 2005), non-OECD countries must remain 47% below their projected baseline. Global emission trading starts only in 2020. Financial needs are initially low (Figure 2), because the price of carbon rises gradually over time, but then grows rapidly, driven by the convex path of 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.

Figure 2: Financial transfers mobilised through the international carbon market



Source: WITCH model (De Cian and Tavoni, 2010)

These estimates only review how much mitigation will cost and do not include financing for adaptation. 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[8] 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

[8] 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).

infrastructure and the technology inertia. 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.

Table 2: Intertemporal timing of adaptation and mitigation expenditure

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. Mitigation brings global benefits, whereas adaptation benefits are perceived at the scale of the impacted system, which is regional at best, but mostly local. As a consequence, the benefits of one abated ton of carbon are global, irrespectively of where abatement takes place. Differently, 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. It is quite unlikely that developing countries could afford an expenditure of such size and this would call for international aid on adaptation as well. Therefore, there is room for international cooperation also on adaptation, which should promote especially anticipatory adaptation strategies and capacity building. These options are not immediately effective, but they contribute to building up a stock of defensive capital that will be effective when future damages occur.

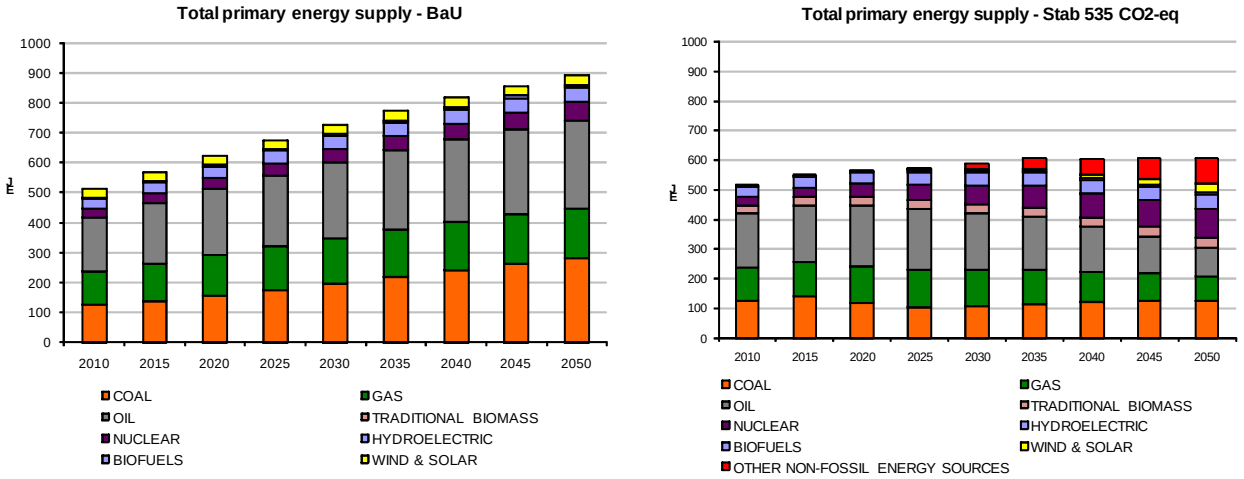
Although fast-start investments, until 2012, should address mitigation needs only, already between 2012 and 2020 about half of the budget (US$ 50 billion) could go to preventive adaptation strategies, depending on the size of the damages faced. The estimates reported in Table 2 refer to a case

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.

The Copenhagen Accord refers to mitigation actions without giving specific indications on the options that should be prioritised. The energy sector is on top of the list, together with deforestation, which is explicitly mentioned. 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. Fossil fuels, that have supported the growth of the economy in the past, are to be replaced by renewable energy with low or zero carbon content. This requires a profound technological change. First through the use of technologies that are already available but not yet widely adopted. Second new products and techniques need to be developed.

In particular, emission reductions can be achieved mainly by increasing energy efficiency and by reducing carbon intensity. This requires a drastic change in the energy mix which has to be done under different steps but in a short time frame. Such change is illustrated in Figure 3, which compares the BaU scenario with a 535 ppm CO2-eq stabilisation, which would lead to a global temperature increase of 2.5 degrees above pre-industrial levels.

Figure 3: Energy mix. Comparisons of stabilisation policy (535 CO2-eq) and BaU



Source: WITCH model (Bosetti et al.2006, 2009f)

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

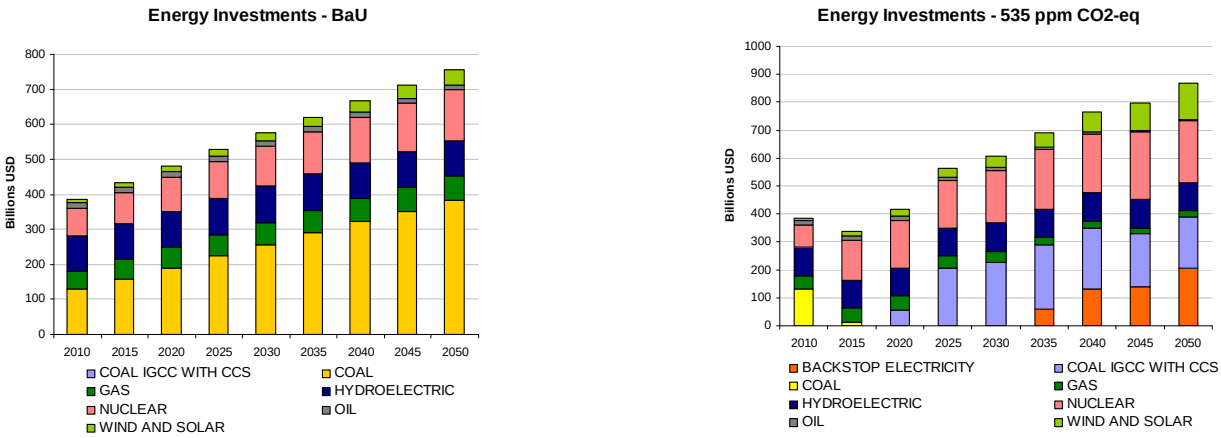
Power generation is one of the most-cost effective options in achieving a low carbon energy supply for two reasons: its weight on global emissions and the availability of alternative technologies already known or under development. Known technologies include nuclear energy and renewable sources, while the second group (under development) consists of carbon capture and sequestration (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. Also renewables, especially wind and solar power, can contribute in 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.

The carbon market plays an important role in fostering and directing the required change in the energy mix. The higher the carbon price, the greater the incentive to use less polluting energy sources, such as nuclear and renewable. At the same time, it provides incentives to decline the use of fossil fuels such as coal, gas, and especially oil. Once widely available, plants with CCS would allow continuing the use of fossil fuels to produce energy without incurring the cost associated with emissions of pollutants.

Regarding the future energy mix, investments directed at increasing energy efficiency and deploying new technology as well as low carbon alternatives in the energy sector are required to achieve the stabilisation target. Figure 4 shows that such radical transformation has to be done in the next years but the investments required in monetary terms are manageable. Bastianin, Favero and Massetti (2010) found similar results for a slightly loosen target, 550 ppm CO2-eq.

Figure 4: Total investment in energy 2010-2050, by production technology (BaU and 535 CO2-eq)

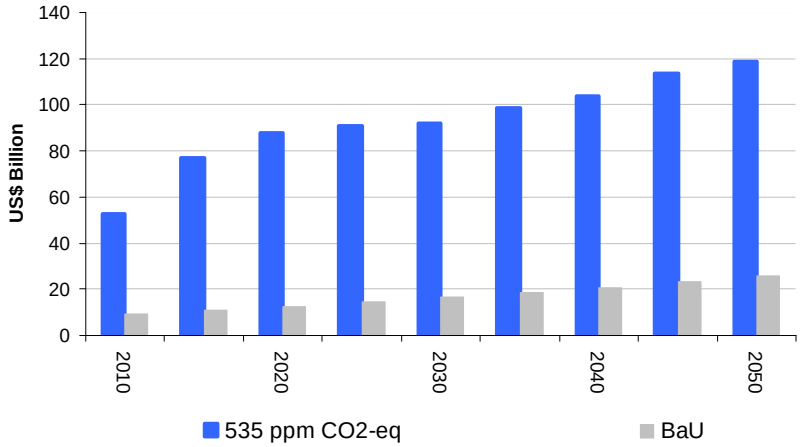


Source: WITCH model (Bosetti et al.2006, 2009f)

Although this is a gradual process, it needs to be implemented immediately because of the long life-time horizon of energy investments and of the slow turnover of the energy infrastructure. These changes can only be achieved through major investments in infrastructure and research and development. This tendency should be reverted and more money should flow to energy R&D, to return to the levels of the '80s, 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 (Figure 5). Upfront Investments in research are particularly needed to foster the development and deployment of alternatives in the non-electric sector. The nature of investments in these technologies attracts a lot of investments at the beginning, when marginal returns are still high. Bastianin, Favero and Massetti (2010) showed that a fraction of the revenues from auctioning carbon permits would be sufficient to cover R&D investments.

Figure 5: Energy R&D Investments in the baseline (BaU) and policy scenario (535 C02-eq)



Source: WITCH model (Bosetti et al.2006, 2009f)

Even if during the centuries land use change emissions have greatly contributed to GHG concentrations, it has some challenges that have not been addressed yet by climate change negotiations, at least until the Bali Action Plan. Since 2007, times have changed and forestry now seems closer than any other sector in reaching a comprehensive agreement including both developed countries and emerging economies. One point in common for every country in the 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. 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. Avoiding deforestation is indeed one of the cheapest options for reducing global GHG emissions, especially considering that deforestation causes 17% of emissions and it occurs mainly in developing countries. 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%. 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. Finally, they also found that forest sinks could contribute to one-third of total abatement by 2050.

In this context, it will be important to design appropriate and feasible incentive mechanisms to address such goal. According to Bellassen et al. (2008), there are three main possibilities to be considered: a tax-based fund, the use of auctions revenues, and the issuance of tradable credits. Regarding the first option, some examples are already being put into place. For instance, the World Bank Forest Carbon Partnership Facility (FCPF)[9] aims to develop capacity building and to catalyse financial flows comprising two mechanisms: one readiness fund and a carbon fund. Both the US House and Senate bill - *the American Clean Energy and Security Act and the Clean Energy Jobs and American Power Act* respectively - include three interlinked programs to help developing nations prevent tropical deforestation. These bills provide funding to help developing countries reduce deforestation. Once a developing country develops a robust avoided deforestation program, it can begin to sell qualified tons into the US cap-and-trade system as offsets (National Wildlife Federation, 2010).

However, given the magnitude of funding required, a system that separates forests from the carbon market and finances a reduction in forest emissions solely through funds would be highly unlikely to reach the required level of funding. This drawback leaves a room for the third option: including

[9] See http://www.forestcarbonpartnership.org/fcp/node/12 viewed on February 2010.

REDD in the carbon market. This has, however, some disadvantages. For instance, the inclusion of cheap emission reductions in a market system will 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.[10]

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. The 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: political credibility, effectiveness, and fairness.

Credibility requires some certainty, if possible, about future climate policy. Certainty could be provided with the introduction of a short, but especially long-term global reduction target 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. Even if this second option is not feasible at the beginning it could be achieved through the linking of national emission trading scheme already in act or proposed (see for example Tuerk et al. 2009, Jaffe and Stavins 2008, and Flachsland, Marschinski and Edenhofer 2008). In both cases, it would provide a strong, reliable, and immediate signal for both countries and market agents, stimulating investment in

[10] 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.

low-zero emissions technologies and motivating internal abatement. In this regard, also a new fund could help support low carbon technology deployment in major emitter developing countries, international cooperation on low GHG research, development, and demonstration (Gallagher, 2009).

Economic and environmental effectiveness require the agreement being shared by all parties. To achieve an effective accord in terms of the environment, part of the game has to be played by developing countries, 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. Innovative mechanisms to promote technology transfer will play a key role. Second, many poor countries are still suffering the negative effects of climate change, partly caused by past pollution of the richest countries. Financial aid and technological adaptation measures are also needed. Copenhagen is only a first step in the complex process of negotiation, but at least in the right direction.

Fairness and equity can be achieved through a differentiated treatment of industrialised countries, which would 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 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 will be difficult in limiting global temperature increase below 2°C, unless carbon-absorbing technologies become widely available. Therefore, policy makers should consider the need to adapt to a warmer climate, despite the successful implementation of global mitigation actions.

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