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LIMITS – LOW CLIMATE IMPACT SCENARIOS AND THE IMPLICATION OF REQUIRED TIGHT EMISSION CONTROL STRATEGIES
PROJECT NO 282846

DELIVERABLE NO. 2.5

Report that assesses the institutional needs for dealing with policies and financing - The economics and management of climate-related financial flows

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1. Introduction

Transitioning to a low-carbon global economic system will require a significant amount of investment in 'green' sectors[1], notably in energy production and energy efficiency, in both high-income and developing countries (Ceres 2014; IEA 2012; McCollum et al. 2014; WEF 2013). However, the exact time and geographical profile of low-carbon investment depends on a large number of variables, including several political ones.

Tackling climate change requires reaching an agreement among countries that differ in their stages of development, prospective climate damages, costs of mitigation and adaptation, ability to pay and perceived historical responsibility. Furthermore, climate change is a strongly asymmetric problem, in that damages from climate change are likely to be harsher for countries with low levels of income[2] and, as will be shown in section 4, in the absence of compensating transfers, a cost-minimising distribution of mitigation costs would impose a higher proportional burden on the shoulders of emerging economies (Tavoni et al. 2014).

This unequal distribution of climate mitigation costs at the expense of developing countries is likely to act as a major obstacle holding back the attainment of a common agreement on emissions reduction, and calls for the implementation of more equitable mechanisms of financing investment for green growth. For example, the United Nations Framework Convention on Climate Change (UNFCCC) has adopted the 'Common but Differentiated Responsibilities' principle - later used as an attribution scheme in the Kyoto Protocol - according to which national obligations are decided according to a mix of responsibility and capacity to pay. The concept was reaffirmed at the 15th Conference of Parties (COP) held in Copenhagen in 2009, where it was agreed that high-income countries would scale up financial flows to developing countries for climate-change mitigation and adaptation, with the objective of reaching an amount of US$100 billion per year by 2020 (UNFCCC 2009).

The aim of the paper is two-fold. First, we analyse the current state of international climate finance. In particular, we describe and assess different sources of climate finance currently operating Official Development Assistance (ODA), climate funds, development banks, carbon markets and Foreign Direct Investment (FDI). For each of them, we present the latest data available, discuss strengths and weaknesses, and examine their possible evolution in the future.

Second, we consider the magnitude of the international climate finance flows likely to be needed in the future. In order to do that, we employ the results of the Integrated Assessment Models

[1] 'Green' investment indicates here investment in all productive sectors that helps to improve the environmental sustainability of the economic system: production of energy from renewable sources, improvement of energy efficiency in buildings and transportation, management of natural capital, waste management, water management, sustainable agriculture, and others. Despite the fact that 'low-carbon' investment comprises a smaller set of investments – in activities that help to reduce the amount of greenhouse gas emissions – we will employ these two terms interchangeably.

[2] The evidence about the distribution of the impacts of climate change is summarised in the contribution of Working Group II to the Fifth Assessment Report of the IPCC (IPCC 2014).

(IAMs) involved in the LIMITS project (Low climate IMpact scenarios and the Implications of required Tight emission control Strategies), an inter-model comparison exercise with the objective of studying the feasibility of keeping the global temperature increase from pre-industrial times below 2°C (Kriegler et al. 2014).

In particular, we analyse two scenarios in which, on top of respecting the 2°C limit in global temperature increase, a global carbon market is created, allowing regions to trade emissions allowances among themselves. Allowances are allocated at the beginning of each period according to two burden-sharing rules. The first is a 'per capita' rule in which allowances are allocated according to an equalised value of GHG emissions per capita across regions and the convergence towards this value takes place during the period from 2020 to 2050. The second is an 'equal effort' rule, in which abatement efforts, rather than emissions, are equalised across regions. This means that, from 2025/2030 onwards, all regions incur the same policy costs as the global average. A more detailed description of these scenarios can be found in Tavoni et al. (2014).

The carbon markets resulting from these allocation mechanisms are quite large (see section 4). In particular, we calculate the amount of financial resources flowing from high-income to emerging economies, which reach $500 billion per year in the 'per capita' scenario, and more than $1 trillion per year in the 'equal effort' one. Not only a large gap between 'optimal' North-South financial flows and current ones is therefore present, but even the $100 billion promised by high-income countries would not be sufficient to equalise efforts across regions. This could pose a serious threat to the achievement of global climate agreement.

Finally, some considerations must be developed regarding the appropriate governance arrangements for future North-South finance flows. Large inflows as the ones resulting from LIMITS models may cause more damages than benefits if not properly managed. This is especially true for developing countries, where immature financial intermediation systems and unstable public institutions are often an obstacle to effective spending in low-carbon sectors.

The paper is thus structured as follows. Section 2 presents estimates of global 'climate finance', with a particular focus on low-carbon investment taking place in emerging economies thanks to financial resources originating in high-income countries. Section 3 discusses the most relevant sources of North-South climate finance, describing the role of each of them in providing capital to support low-carbon and climate-resilient investment. Section 4 employs the results of the LIMITS project to calculate the effects of allowing for a global market of carbon allowances and the 'optimal' North-South financial transfers. Section 5 discusses some macroeconomic aspects of the management of climate finance. Finally, section 6 concludes.

2. Climate finance: Outlook and prospects

The aim of this section is to provide an overview of international climate finance. First, we discuss the concept of 'climate finance' and present various global estimates. We then focus on the climate-related investment taking place in emerging economies, with a particular interest in those financed by finance flows originating in high-income regions. This sets the context for section 3, in which the different sources of North-South climate finance are discussed in detail.

2.1 Definition and sources of climate finance

A clear, internationally agreed, definition of 'climate finance' is still missing. In fact, there are many different interpretations of what exactly climate finance means and how it should be classified.

A first source of confusion is related to the geographical scope of climate finance. The term has often been employed in recent years to indicate the international climate-related financial flows taking place between high-income and developing countries. This was the meaning given to climate finance by UN (2010), among others. However, the term can also be used in a broader sense – as, for instance, in CPI (2013) – to indicate all the financial resources employed in climate-related activities, whether cross-border or purely domestic. The latter meaning is, in our view, the most helpful. However, using it does not entirely eliminate ambiguity, as the term does not make clear to what stage in the chain of financial intermediation from saving from income to spending by the ultimate investor on physical capital and other productive inputs the user of the term is referring.

A possible taxonomy is shown in Figure 1. The foundation of the investment financing process lies in the existence of financial resources (at the left end of the chart). Financial flows can be generated by a range of different actors: private banks, other non-bank private investors, companies with retained earnings, governments and others. These entities are not the ones carrying out the real investment, but they may be willing to lend to someone who is able to do so. Financial resources thus flow to the economic agents who are actually going to spend them on investment goods and services: project developers, energy utilities, companies, households and others. There is a certain degree of overlap between these two categories (lenders and entrepreneurs) as the same entity can play both roles, but it is useful to keep them conceptually separate. Finally, at the end of the process, end-borrowers allocate financial resources to support specific economic activities. Possible destinations are, for instance, large projects for renewable energy production, the creation of small distributed energy production capacity, green technology R&D and others.

[Figure 1 ABOUT HERE]

The exercises aiming to track climate finance classify finance flows according to a mix of categories at varying stages of the chain of financial intermediation, depending on research interests and, more often, availability of data. In this paper, we focus on two of the most comprehensive tracking initiatives, developed by Bloomberg New Energy Finance (BNEF) and

the Climate Policy Initiative (CPI). The two organisations employ different measurement methods[3], which lead to different estimates of 'clean energy investment' (US$244 billion in 2012, according to FS-UNEP and BNEF 2013) and 'climate finance' (US$359 billion in 2012, according to CPI 2013). They do agree, however, in indicating a slowdown in global climate investment in 2012[4], which reflected both a substantial reduction in clean energy technology costs and the impact of increased policy uncertainty among investors[5].

The two initiatives adopt different taxonomies. BNEF divides total investment into two main categories: projects and companies[6]. Projects attract the large majority of finance. They can be further classified as 'large infrastructure projects' ('asset finance', US$149 billion) and small distributed capacity (US$80 billion). Companies can be financed through venture capital, private equity or, in the case of listed companies, public markets. These forms of finance in 2012 raised just US$7 billion. Using the classification presented in Figure 1, the BNEF taxonomy focuses on finance flows close to the end investments.

The classification of climate finance by CPI (2013), on the other hand, focuses further upstream in the flow of intermediated finance. Four main categories of climate finance are considered:

- Public sources. This category includes direct public spending on climate-related activities, typically by ministries and other government agencies.
- Public intermediaries. In this case, public money is not spent directly by governments but intermediated by development financial institutions[7] (DFIs) or climate funds. Although their finance is classified as public, DFIs also raise private finance from capital markets through the issuance of 'green bonds' and other debt instruments.
- Private sources. These include project developers, corporate actors, households, energy utilities and other private entities investing in climate-related activities. Even though some of them are fully or partially owned by the public sector, they are all classified here as private actors because of their common profit-driven orientation.

[3] Estimates by BNEF include all energy sector investments but have only a partial coverage of energy efficiency upgrades, industry process improvements and sustainable transport. The investment universe covered by CPI is larger. It includes energy efficiency measures on the demand side and in transmission, investment in agriculture, forestry, land use, livestock management, process emissions in industry, and capacity-building projects, among others. CPI also covers investment directed towards adaptation activities.

[4] The declining trend also continued in 2013 according to BNEF (2014).

[5] Many governments are currently retreating from providing support to the sector, partly because of the stress posed by the economic crisis. In some instances, they have gone so far as to introduce retroactive adjustments – as in the recent Spanish case – potentially damaging government credibility among possible investors for years to come (FS-UNEP and BNEF 2013).

[6] A third category also exists in FS-UNEP and BNEF (2013): R&D. Corporate R&D and Government R&D raised US$5 billion each in 2012.

[7] Development financial institutions – or development banks – are financial institutions, with a strong public component, charged with the objective of promoting national, regional or global economic development. See de Luna-Martinez and Vicente (2012).

- Private intermediaries. This category includes private financial institutions such as commercial banks, pension funds, insurance companies and other asset management funds.

[Figure 2 ABOUT HERE]

Figure 2 shows the relative contribution of the four categories to the total amount of climate finance in 2012. Private sources are predominant, accounting for 56% of climate finance. Among them, private developers represent 20% of total finance, corporate actors 16%, and households 9%. Public intermediaries are also very important, especially national and multilateral development banks (19% and 11% of total finance, respectively). Neither public sources nor private intermediaries, on the other hand, seem to contribute to a large extent to overall green finance.

Results would be different if the approach moved further upstream in the process shown in Figure 1, getting closer to the ultimate origins of lending flows. In this case, credit originated in the private banking system (and used by the private agents included under 'private sources') would probably account for a much larger share of total climate finance. Bank lending is in fact the most common instrument of external finance for firms, especially for small enterprises and in emerging markets (Bank of England 2014; ECB 2012; Eickmeier et al. 2013). However, despite its relevance, reliable data about the amount of credit originating in private banks is still not publicly available (CPI 2013). Firms can also finance investment through retained profits (internal finance).

2.2 Climate finance in developing countries

Of the overall amount of climate investment, an increasing proportion is being carried out in low-income and emerging economies[8]. This is shown in Figure 3, which reports data from FS-UNEP and BNEF (2013). Low-carbon investment in many emerging-market economies of the developing world has been steadily increasing since 2004, while investment in high-income economies fell back in 2012 and 2013 (BNEF 2014). Key reasons for this shift are the reduction of renewable-energy subsidies in Europe and the USA, and the increasing attractiveness of emerging markets with rising demands for electric power and extensive renewable energy resources. China was the dominant leader among the non-OECD countries, raising its investment by 22%, due to the rapid growth of its solar energy market. Other developing regions deploying significant amounts of renewable energy are the Middle East and Africa – especially South Africa and Morocco – and Latin American countries such as Brazil, Mexico and Chile (BNEF 2014).

[Figure 3 ABOUT HERE]

Figure 4 is instead based on data from CPI (2013). The left pie chart confirms the current relevance of developing economies, in which about 51% of global climate investment was carried out in 2012. The majority of it was financed from domestic sources, while the remaining part (28%

[8] In this report, the high-income/emerging economies (or North/South) dichotomy reflects, unless otherwise specified, the OECD/non-OECD one.

of the total) benefited from financial resources flowing from OECD countries. This is shown in the central pie chart of Figure 4, and highlights the relevance of the domestic investment dynamics of emerging economies in driving the gradual shift of 'green' finance towards the developing world. Finally, the right pie chart of Figure 4 shows the different origins of North-South flows, which will be discussed later in this report.

[Figure 4 ABOUT HERE]

In terms of absolute amounts, CPI (2013) estimates the amount of North-South climate investment to have been in the range of US$39-62 billion in 2012. North-South climate finance flows have also been assessed by Clapp et al. (2012), who estimate aggregate flows in the 2009-2010 period to have been in the range of US$ 70 to 120 billion each year. The differences between the two studies can be explained by the different reporting period used, the intrinsic uncertainties involved in the data gathered and in the method used to calculate private climate flows[9]. FS-UNEP and BNEF (2013) reports only the North-South flows in renewable energy asset finance, which is around US$8 billion, a much lower value compared with the US$33 billion of North-North cross-border investment.

As indicated by the ranges estimating the North-South flows, there are large uncertainties in these figures for two main reasons. First, large data gaps exist in the available data used. In particular, the gaps are relevant particularly noticeable for specific sectors such as the private sector which is subject to confidentiality concerns as well as to different incentives to report than public flows (Stadelmann and Michaelowa 2013). On the public sector data gaps are also found, such as such those encountered in Other Official Flows (OOF) within the multilateral public actors, which do not track yet climate-related activities comprehensively (Clapp et al. 2012). Additionally, databases do not always show the source and destination countries of the different climate-flows making very difficult to estimate North-South flows. Secondly, due to the lack of harmonized methodology, data can be reported in many various ways and using several different kinds of monetary and qualitative metrics, not always systematic. Moreover, there is no internationally-agreed description of what climate finance is and what exactly is "additional" and "mobilized", neither a methodological approach to avoid double counting across several sources. Thus, estimating climate flows, and in particular those from developed to developing regions, is not an easy task and international and a homogenized methodology and rules are needed to overcome the current difficulties.

Despite the issues related to tracking flows, the financing of low-carbon investment in the developing world has been a key topic in recent international climate negotiations, which have been more protracted because of the stark disagreements on how, in principle, the costs of the low-carbon transition should be distributed.. The idea that wealthier nations should bear a higher proportion of the costs of climate change, embodied in the text of the original UNFCCC, is now

[9] For the lower estimate of private flows, CPI (2013) uses data from the BNEF database while Clapp et al. (2012) uses UNCTAD data for 2010. The higher estimate of private funds in CPI (2013) comes from North-South FDI data for Alternative/Renewable Energy for 2012 whereas Clapp et al. (2012) uses BNEF data for 2010. For more information on the different methods used, the reader is referred to both reports.

frequently accepted[10]. The UNFCCC, for instance, has officially adopted the 'Common but Differentiated Responsibilities' principle, implemented in the Kyoto Protocol through the identification of a group of 'Annex I' countries to which most of the mitigation effort was assigned.

More recently, during the fifteenth Conference of the Parties (COP15) of the United Nations Framework of Climate change (UNFCCC) in 2009, developed countries collectively pledged US$30 billion per year to support mitigation and adaptation efforts in developing regions (UNFCCC 2009). After this 'fast start' finance period ended in 2012, Parties pledged to scale up the yearly sum to US$100 billion by 2020, using as a primary tool a new 'Green Climate Fund'[11] established under the UNFCCC framework at the 16th Conference of the Parties at Cancun. Although developed countries reported that they delivered more than US$33 billion in fast-start climate finance between 2010 and 2012, questions have been raised by developing countries about how new and additional this support was, as well as about how the money has been spent (Nakhooda et al. 2013).

Tracking the public and private financial flows that may contribute to the US$100 billion Copenhagen commitment is proving challenging. The best available overviews currently available are the report of the High-Level Advisory Group on Climate Change Financing (UN 2010) and CPI (2013). The High-Level Advisory Group report concluded that it is "challenging but feasible" to mobilize US$100 billion annually for climate actions in developing countries by 2020.

[10] Article 3.1 of the UNFCCC states that "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." Article 4.3 states that "The developed country Parties and other developed Parties included in Annex II… shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures… The implementation of these commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among the developed country Parties."

[11] The Green Climate Fund is a multilateral fund designed to move financial resources from developed to developing regions in order to support projects, programmes, policies related to climate adaptation and mitigation.

3. Sources of North-South climate finance

This section discusses the most relevant sources of climate finance flowing to developing economies, describing the role of each of them in providing capital to support low-carbon and climate-resilient investment:

- Official Development Assistance (ODA);
- Climate funds;
- Bilateral and multilateral development banks;
- Carbon markets;
- Foreign direct investment (FDI);

Table 1 gives an overview of the types of climate finance for developing countries that are here discussed: the size of the climate flows and the sources of databases where the data can be found. As it has been mentioned in the previous section, the estimation of climate finance it is not an easy task and even less is to determine N-S financing flows accurately. Because of this, the table also summarized the most important strengths and deficiencies of the available databases to track N-S flows. For a further discussion on the available sources and their pros and cons, see Clapp (2012).

[Table 1 ABOUT HERE]

3.1 Official Development Assistance (ODA)

The main objective of ODA[12] is to support economic development and reduce poverty in developing countries, in particular by achieving the Millennium Development Goals[13]. Recently, great attention has been given to the existing and potential role for ODA to support mitigation and adaptation activities, largely because of the extensive overlap between these activities and various macroeconomic variables related to growth and poverty reduction. ODA can be broadly divided into bilateral aid, in which assistance is given directly to developing countries, and multilateral aid, which provides assistance through international organisations. Both of them can be in the form of technical assistance for human capacity building or financial assistance, typically consisting of grants and concessional loans.

In the period 2010-11,t otal ODA bilateral assistance principally or significantly related to climate reached US$ 21.2 billion, which was 16% of total ODA and more than four times as high as in

[12] ODA is defined as the flows to multilateral development institutions and countries that appear on the list of ODA recipients of the OECD Development Assistance Committee (OECD-DAC), on the condition that: (i) assistance is provided by official agencies, including state and local governments, or by their executing agencies; (ii) each transaction is administered with the promotion of economic development and welfare of developing countries as its main objective; and (iii) assistance is concessional in character and carries a grant element of at least 25%.
[13] See www.un.org/millenniumgoals.

2006-07 (Figure 5). For about 60% of these activities, mitigation or adaptation was the 'principal' objective, meaning that mitigation or adaptation would not have been funded but for that objective. For the remainder 40%, climate mitigation or adaptation was a 'significant' objective, meaning that other prime objectives have been formulated or adjusted to help meet climate concerns (OECD DAC 2013). The latter is typically the case for adaptation projects, for which funds are not directed purely to achieve adaptation targets but instead mainstreamed into activities driven by other development objectives.

[Figure 5 about here]

Mitigation-related aid accounted in 2010-11 for most of the US$21.2 billion of total climate-related aid (76%). Three crucial economic infrastructure sectors – energy, water and transport – received more than half of total mitigation-related aid. Other areas such as forestry and environmental protection received large capacity-building support and technical assistance. Three quarters of total mitigation-related aid in 2010-11 was provided by five DAC members (Japan, Germany, France, EU institutions and Norway). Looking at the mitigation-related ODA recipients, Asia was the region that received the largest share (47%), mainly due to support to India, Indonesia and China. Africa followed– largely driven by sub-Saharan countries – with 21% of overall mitigation-related aid. A high share of the mitigation-related aid was committed as concessional loans (58%), because these may encourage stronger engagement of the private sector in middle-income countries, where there are significant mitigation opportunities. Grants comprised 42% of total mitigation-related aid (OECD DAC 2014b).

Of the total climate-related aid in 2010-11, 24% targeted adaptation-related activities. The sectors that received most of the support were: environmental-related capacity building; water; agriculture; forestry and fishing and rural development and disaster risk reduction and response. The two top providers of adaptation-related flows were Japan and Germany, followed by EU Institutions, the UK and Australia. The recipients of the greatest amount of adaptation-related aid in absolute terms were the middle-income countries, although not to the same extent as with mitigation-related aid.. This is because Least Developed Countries (LDCs) and other Low Income Countries received a higher share of total adaptation-related support (25%) compared with their share of total mitigation-related aid (14%). The top ten recipients were Vietnam, Indonesia, Kenya, Iraq, India, Bangladesh, Ethiopia, Peru, Pakistan and China. Adaptation-related support was given in the form of grants (69%) and loans (31%). However, the share of loans was smaller than in mitigation-related aid because grants are more important for LDCs and there has been a greater focus on adaptation-related objectives in these countries (OECD DAC 2014a).

A study of climate-related ODA (Kalirajan et al. 2011) drew the following conclusions:

- Empirical results suggest that the involvement of the private sector is essential where ODA is directed towards mitigation-related objectives in order to ensure that ODA directed towards other important objectives, such as hitting the MDGs, is not reduced. In this context, Japan's example, providing ODA and funding for official collaboration with the private sector, is a good model for other developed economies to follow.

- ODA is not effective in all countries and it can only work in those regions where there is a good policy environment. In this sense, countries with good-quality institutions and policies are in a better position to receive climate-related ODA than those that do not have a stable and robust policy context.
- The lack of coordination between donor agencies and national governments in promoting climate-change activities has often been reported to be a major obstacle. However, it seems that coordination improved after this problem had been identified and discussed.
- Climate-related ODA can play a key role in the provision of crop price insurance in the period of adjustment and adaptation to new climatic conditions in agriculture. Insurance companies currently rarely offer insurance to vulnerable groups (e.g. the peasantry in an Indian village) and those who do offer insurance to these groups, such as microfinance institutions, cannot pool risk sufficiently. ODA can facilitate reinsurance and risk pooling across borders.

3.2 Climate funds

There are a growing number of climate funds initiatives designed to help developing countries address the challenges of climate change. Table 1 shows the most important climate funds currently operating. The list contains 15 multilateral and 5 national climate funds, managing financial resources raised by multilateral development institutions and national governments[14].

Several fall under the aegis of the Global Environment Facility (GEF), which manages various funds with environmental objectives. The GEF was established in October 1991 as a US$1 billion pilot programme to assist in the protection of the global environment and to promote environmental sustainable development. The GEF was to provide new and additional grants and concessional funding to cover the additional costs associated with transforming a project with national benefits into one with global environmental benefits. The United Nations Development Programme, the United Nations Environment Program, and the World Bank were the three initial partners implementing GEF projects, which later included climate-related projects. In 1994, the GEF was restructured and moved out of the World Bank system to become a permanent, separate institution, enhancing the involvement of developing countries in the decision-making process and in implementation of the projects. However, the World Bank has served as the Trustee of the GEF Trust Fund and provided administrative services.

In 2012, climate funds spent around US$1.6 billion, which represents 10% growth from the amount managed through climate funds in the previous year (CPI 2013). 63% went toward mitigation projects and 37% to adaptation projects. Climate funds channelled their funds to projects in the form of grants (66%) and low-cost debt (33%).

[Table 1 ABOUT HERE]

With respect to national climate funds, Irawan et al. (2012) argue that governments need to be clear about national climate funds' strategic role, their political feasibility, the institutional and

[14] On the Climate Funds Update Website, several more (relatively new) climate funds can be found but they are not presented in the table here because they do not provide robust data on project approvals.

human resource capacity available to support their operation, and issues of time and cost-effectiveness.

The establishment of the Green Climate Fund (GCF) is expected to reshape the global architecture of climate change financing and promote its growth. The latest GCF meeting, held in Bali in 2014, made some progress towards resource mobilisation. The parameters and guidelines for allocating funds during the GCF's initial phase were addressed. These include:

- Equally balancing mitigation and adaptation funding over time;
- Allocating 50% of adaptation-related funds to vulnerable countries (e.g. LDCs), small island developing states (SIDS) and African countries and;
- Maximising engagement with the private sector and providing incentives to economic agents to switch more towards low-carbon development (IISD 2014).

The Board also discussed the requirements for initial resource mobilisation such as risk management, investment frameworks to support mitigation and adaptation activities and the structure of the Private Sector Facility, among others.

3.3 Bilateral and multilateral development banks

Development financial institutions (DFIs) are playing an increasingly crucial role in delivering finance to low-carbon investment in developing countries. DFIs can be classified as:

- National development banks. Historically, these financial institutions were created by national governments to support the process of national economic development. Examples of national development banks include KfW in Germany, BNDES in Brazil and the China Development Bank, among many others.
- Multilateral development banks (MDBs). Development banks can also be established as international institutions and be supported by several countries. The European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), the Asian Development Bank, the African Development and the Inter-American Development Bank are examples of multilateral development banks.
- Bilateral financial institutions (BFIs). These financial institutions are created by national governments for the purpose of delivering aid and financial resources to developing economies. Examples of bilateral financial institutions are the French Agency for Development, the Japan International Cooperation Agency (JICA) and the North American Development Bank.

All these types of development financial institutions currently have a prominent role in providing climate finance in developing countries. In 2012, DFIs committed US$121 billion of climate finance, which represented around a third of the overall total[15] (CPI 2013) and in the 2007-12

[15] The majority of DFIs' commitments were in the form of low-cost loans (56%), and focused on European countries (37%), East Asia and Pacific (26%) and the Latin American region.

period at least US$425 billion were provided by development banks to projects for renewable energy production, energy efficiency and other environment-related activities (BNEF 2013). However, most of the US$121 billion were invested domestically, with only 15-22 US$ billion are international North-South flows.

MDBs and BFIs have become increasingly important in managing the international financial flows between OECD and non-OECD countries. According to CPI (2013) data, shown in Figure 4, around 65% of total North-South climate finance was delivered by them. In particular MDBs – although limited by their smaller budgets compared with the national ones – have been vigorously involved in financing the green economy. During 2011, for instance, the European Investment Bank invested approximately €18 billion – a third of total lending – in activities related to climate change (EIB 2012). The European Bank for Reconstruction and Development since 2006 has invested approximately €10 billion just in the energy sector (EBRD 2012).

Multilateral development banks have also been the most active promoters of the diffusion of 'green bonds', which have a strong potential for driving financial resources towards low-carbon sectors, especially if issued in large amounts and in a standardised fashion. Typically, the funds raised by the issuance of 'green bonds' are ring-fenced for specific environmental objectives but benefit in the same way as traditional bonds from the financial standing of the issuer and offer similar risks and returns to financial investors. They can be attractive to financial investors who wish to meet political objectives, portfolio diversification goals or related corporate responsibility objectives. The pioneer issuers of this type of debt instrument have been the World Bank and its sister organisation, the International Finance Corporation, with their 'Green Bonds', and the European Investment Bank, with their 'Climate Awareness Bonds'. The market is in a phase of rapid expansion, and the outstanding amount of green bonds is now around $346 billion[16](CBI 2013).

These institutions, in addition to controlling dedicated funds to support climate-related projects, can also play a role in 'carbon financing' (i.e. buying emission reduction certificates from the Clean Development Mechanism and Joint Implementation markets on behalf of Annex 1 parties with an obligation). MDBs have also played a role as implementing agents of the UNFCCC's Global Environment Facility (GEF).

3.4 Carbon markets

Carbon markets develop where nations, businesses or individuals have the obligation or willingness to reduce greenhouse gas emissions (GHGs). In these markets, emission allowances are tradable assets, allowing participants to meet their mitigation targets through efforts or investments undertaken by others. The rationale behind international carbon mechanisms is that climate change is a global problem and, as emissions are mixed in the atmosphere irrespective of their origin, it does not matter where the mitigation activity takes place as long as global emission

[16] This amount includes not only bonds issued by multilateral and similar institutions, but also corporate and government bonds with a climate component. For instance, bonds issued by the Chinese Ministry of Railways for the construction of high-speed rail account for US$117 billion out of the US$346 billion total.

levels are reduced. By trading emissions, participants can accomplish their commitment more cost-effectively because emissions reductions occur where mitigation costs are lowest.

Under the Kyoto Protocol, domestic mitigation actions by nations may be complemented by emission reductions achieved internationally. There are three main market approaches established by the Kyoto Protocol: International Emission Trading between countries with emission targets (a mechanism based on a cap-and-trade approach[17]), and two project-based mechanisms following a baseline-and-credit approach[18]: the Joint Implementation (JI) and the Clean Development Mechanism (CDM). The latter is directed at trades involving developed and developing countries and is the most relevant mechanism up to now for attracting climate investment in developing countries.

Under the CDM mechanism, countries with quantitative mitigation obligations (Annex I) may partly achieve their targets by acquiring emission reductions from mitigation projects implemented in developing countries without such reduction obligations (Non-Annex I). The CDM has the dual objective of reducing the costs of mitigation for entities in developed countries and promoting sustainable development in CDM host countries (developing countries). Mitigation costs are often lower in developing countries, thus CDM projects allow developed countries to meet their emission reduction targets at a lower cost.

A project under the CDM needs to demonstrate that the emission reductions are 'additional' in order to be eligible. This means that: 1) the project (and therefore, the emission reductions) would not have been implemented without the extra revenue gained from selling offsets from the project and 2) emissions are lower than under the baseline scenario. Definition of the baseline of a particular project must follow methods approved by the UNFCCC and be assessed by a third party validator (so- called a Designated Operational Entity).

CDM project activities in developing countries generate Certified Emission Reductions (CERs), which represent the reduction of one metric tonne of CO_2 equivalent. CERs are purchased by developed country entities to meet a portion of their emission reduction commitments. There are many different sorts of CER purchasers in the public and the private sectors. Typical buyers are energy intensive companies, banks, government programmes and institutional and private hedge funds. Buyers can choose to approach the selling party directly or to operate through dedicated carbon brokers. The sellers often prefer the latter option since it allows them to access a wider

[17] Under a cap-and-trade system, an emission cap for a group of emitters under a defined jurisdiction is set. Emissions allowances are then distributed or auctioned off to the participating emitters. These allowances represent the maximum amount of GHG emissions each participant has the right to emit. Added together, the allowances are equal to the overall 'cap' of the trading system. Participants can sell excess allowances to others if they do not need to use them all themselves or buy allowances if their actual emissions exceed their allocated amounts. In theory, each participant will implement emission reduction measures internally for as long as the marginal abatement costs are below the market price for allowances.

[18] Under the baseline-and-credit approach, carbon credits are created by direct investment in a mitigation activity. Here, there is no overall cap and no allocation of allowances, but carbon credits are generated if they represent verified emissions reductions in compared to the baseline pathway and they have followed recognized standards and procedures. Participation in a baseline-and-credit scheme is voluntary but only works if there is a demand for credits.

market of potential carbon credit buyers. Sellers are often the project owners and project developers (e.g. farms, factories, energy companies) in the developing country where the mitigation project takes place.

There are different type of costs incurred during the CDM project cycle related to the planning phase, the construction phase and the operating phase. A CDM project can be financed in various ways during the planning and construction phase (Subbarao 2011; UNEP and Ecosecurities 2007):

i. Multilateral, government and private carbon funds: Industrial-country governments, companies and multilateral organisations contribute to a common Carbon Fund to provide technology and finance and agree to buy the CERs generated. Some of the most important Carbon Funds so far have been the World Bank Prototype Carbon Fund, the European Carbon Fund and the Asia Pacific Carbon Fund.

ii. Emission Reduction Purchase Agreement (ERPA): This is a typical forward contract where an Annex I investor provides project development services in return for receiving the CERs generated by the project. The price of the CER purchased is set within the ERPA. CER payments might be structured as upfront payments. The CER buyer often sells the purchased CER to a secondary buyer.

iii. Full or partial equity or debt: Under the equity scheme, the Annex I investor finances all or partly the CDM project in return for full or shared financial returns and CERs. Local investors might wish to co-invest in the project and have a share of the CERs generated to be able to sell the credits later. Under the debt scheme, the Annex I investor provides a loan at concessional rates in return for the CERs.

iv. Project hosts[19]: Hosts may provide their own internal funds to finance small projects.

v. Equipment suppliers: These might provide assets on lease or credit.

In 2013, it was estimated that the CDM had supported 6,556 carbon market projects and US$356 billion in investments in emission reductions since its inception in 2005 (Purvis et al. 2013). Another estimate by Clapp et.al (2012) tracked the financial flows related to CDM in a much lower range (US$ 2.2-2.3 billion in 2010). To date, the CDM is widely recognised as having played a key role in accelerating climate action not only by mobilising large private sector investments but also by encouraging economic development and helping to alleviate poverty. However, it has also been criticised for various failings, such as channeling windfall profits to project owners for projects that fail the additionality test, benefiting polluting or unsustainable industries (e.g. emitters of industrial gases, coal plants and large hydropower projects) and creating a slow and opaque approval process subject to possible conflicts of interest (Purvis 2013).

[19] The project host is the entity providing the land or facilities required to carry out the CDM project in the developing country. There may be more than one project host for one single project (e.g. one providing the land and another providing the resources). Project hosts may be individuals, companies, or government institutions.

Currently the CDM is not working very well, as indicated by the collapse in the carbon prices achievable. The economic crisis in Europe, the biggest market for CDM credits, has caused emissions to be lower than expected because of a decrease in manufacturing, which, together with a suspected over-supply of credits, has resulted in the price falling. Currently CER prices have been pushed below 0.20€/tCO_2e (US$ 0.28) from over 20€/tCO_2e (US$ 28) five years ago. This has caused demand for CDM credits to drop significantly. Despite these failures and crises, the CDM market has generated considerable benefits as a pioneering mechanism and has left an important legacy for the new carbon markets that are emerging in many countries and that are incorporating the lessons learned from the CDM in their particular schemes.

In addition to the CDM, there are a handful of other regional, regional and subnational markets in operation or under development, as shown in Figure 6. While some of these markets were inspired by the emissions trading systems underpinned by the Kyoto Protocol, such as the EU ETS, others are independent of the Kyoto Protocol and have their own credit schemes. The regional carbon markets that are currently under operation are:

- The EU ETS: this is the largest emissions trading system in the world. It was implemented by the European Union in 2005 to meet its emission reduction targets under the Kyoto Protocol where a cap was set on the largest carbon emitters in key high-carbon sectors, covering 40-45% of the total GHG emissions of all member states.
- The California AB32 Cap and Trade System: this set a cap on state-wide greenhouse gas emissions at 1990 levels to be achieved by 2020, representing a real reduction of roughly 25% from 2008 levels. After years of preparation, California's cap-and-trade programme started its first compliance period in January 2013. The major entities in the California carbon market are power companies and some industrial groups.
- Kazakhstan's Emissions Trading Scheme: this is a mandatory trading scheme since 2013 that covers CO_2 emissions. The scheme covers facilities emitting above 20,000 tCO_2e/y in agriculture, transport, oil and gas, mining and metallurgy, the chemical sector and the power sector.
- The New Zealand Emission Trading Scheme (NZ ETS): this allocates allowances to economic actors, creating incentives to reduce emissions in the long term. The NZ ETS aims to target most sectors of the economy in the long run, but different sectors will only gradually be included in the scheme. The forestry sector was the first to join in 2008, and has been followed by the liquid fuels, energy and industrial waste sectors.
- Australia's Carbon Pollution Reduction Scheme (CPRS): this was proposed as a main element in Australia's emission reduction strategy. The scheme was abandoned due to a lack of political support. However, Australia's lower house passed federal climate legislation in October 2011, which was subsequently passed by the Senate in November 2011, which mandates a carbon tax initially, to be replaced in due course by a full cap-and-trade system, covering 60% of Australia's emissions. The current Australian government is committed to repealing this legislation.

- The Regional Greenhouse Gas Initiative (RGGI): this is a mandatory cap-and-trade programme in place since 2008, imposed exclusively in the power sector in ten states of the USA.
- The Western Climate Initiative: this is a joint programme of several US states and Canadian provinces, primarily in the West, who have agreed to coordinate climate policies and establish a joint cap-and-trade programme. The target is to reduce GHGs 15% below 2005 levels by 2020.
- The Quebec Cap-and-Trade Scheme: this was launched in January 2013 and aims to achieve a reduction in emissions of 20% from 1990 levels. As of January 2014, it is being linked to the AB32 programme in California.
- Japan's Voluntary Emission Trading Scheme (JVTS): this is a non-mandatory emission trading scheme established to create incentives for voluntary emission reductions and to gather experience for future mandatory schemes. In addition, the city of Tokyo operates the first cap-and-trade scheme in the world for commercial buildings. In March 2011, the Japanese Ministry of Environment furthermore initiated a Bilateral Offset Credit Mechanism between Japan and developing countries, which exists alongside the CDM and allows the government to fund GHG reductions in other countries to offset Japanese obligations.

[Figure 6 ABOUT HERE]

Although the number of carbon markets around the world is growing, these schemes will on the whole operate domestically and therefore will not involve international trade (and resulting investments) between developed and developing countries. Today, of the existing markets, only Europe and Japan are buying significant quantities of international credits. Japan, however, may switch to purchasing credits through its own national carbon market in the near future. Other emerging carbon markets such those being implemented in China, India, South Korea and Brazil and potential schemes to be developed in Chile, Costa Rica, Mexico, Turkey and Ukraine do not plan to allow international credits either. However, what is clear is that the CDM has helped developing countries discovering their own potential to mitigate emissions at a lower cost and has stimulated the creation of ambitious climate policies in these nations. China, the largest CDM project supplier hosting investments worth US$220 billion, is one of the best examples. Chinese companies have gained significant experience with clean technologies and China has now more wind capacity than any other country. Additionally, by taxing Chinese CDM projects, the Chinese government raised around US$1.5 billion by the end of 2011 – revenues used to develop domestic climate policies. The government, based on the knowledge it gained of the CDM, has launched several domestic trial emission trading schemes.

Under the World Bank's Partnership for Market Readiness (PMR), established in 2010, a growing number of countries are exploring the use of market-based mechanisms. The PMR is a grant-based global partnership that supports the assessment, design, and implementation of carbon pricing instruments. The PMR is made up of a dozen contributing participants that have pledged

about US$115 million to the PMR Trust Fund and 16 implementing countries, of which Chile, China, Mexico, and Costa Rica are the most advanced in their designs.

Another innovative mechanism conceived at COP 16 that is gaining importance in stimulating climate investments in developing countries is the formulation of so-called NAMAs (Nationally Appropriate Mitigation Actions). Unlike the CDM projects, NAMAs can be policies, programmes or projects that help developing countries to make progress in reducing their own domestic GHG emissions with financial and technological support from the international community. Going beyond the CDM's project-by-project focus, NAMAs are expected to support and enhance the scale of activity from a sectoral level. NAMAs are implemented at the national, regional, or local levels and can be structured with two different ways of funding: (i) domestically supported NAMAs, called 'unilateral NAMAs'; and (ii) internationally supported NAMAs, called 'supported NAMAs'. 'Credited NAMAs' have also been discussed, whereby a developing country earns credits that can be sold in the global carbon market by reducing emissions below an agreed crediting baseline. A robust international framework for NAMAs is still in the making; but recent initiatives, such as the NAMAs registry[20], demonstrate a 'learning-by-doing' approach to NAMA development. Mali, Ethiopia and Uruguay have made submissions seeking support for preparation of a NAMA. Chile and Uruguay have also made submissions for NAMAs seeking support for implementation. A NAMA database has been established (hosted by Ecofys), which provides a collection of publicly available information. According to the NAMA database, there is a wider involvement in NAMA development, with 95 NAMAs and 37 feasibility studies in 35 countries.

3.5 Foreign direct investment (FDI)

Foreign direct investment (FDI) is defined as the net inflows of investment into production or business in a country by an individual or company of another country to acquire a lasting management interest (10% or more). 'Green' or 'low-carbon' FDI refer to those investments that lead to a reduction of GHG emissions in compared with a 'business-as-usual' scenario.

FDI is the sum of equity capital, reinvestment of earnings, other long-term capital and short-term capital. The most important actors providing private investment are: private companies, local, commercial banks, non-bank financial institutions, leasing companies, private equity investors and institutional investors.

The latest estimates for FDI flows from developed to developing countries are in the range of US$ 4 - 13 billion (CPI 2013) for 2012.

FDI has been considered an important source of technology spillover, efficiency improvement and growth for low-carbon development. Before the financial and economic crisis in 2008, FDI was growing steadily. However, as the global crisis hit countries, it is estimated that FDI decreased by almost 15% from 2007 levels (UNCTAD 2009). Nevertheless, despite the global declining trend in FDI, an interesting change in direction of financial investment flows was

[20] See www4.unfccc.int/sites/nama/SitePages/Home.aspx.

observed. While FDI investments decreased in developed countries, they were growing in developing and transition economies. For the first time in 2010, developed countries received less than the half of global FDI inflows while China received more than US$ 100 billion of FDI, becoming the world's second-largest recipient of FDI. All the BRIC countries were members of the top 15 recipients of FDI flows. Up to now, FDI inflows into developing countries have been concentrated in a few leading Southeast Asian and Latin American economies. The changing direction of flows can be explained by the significant improvements of 'doing business' indicators[21] in developing countries, especially in BRIC countries, and a stabilisation of these indicators in developed countries (Bayraktar 2013). Another factor is the growing share of FDI from developing country-based investors.

Yet, many developing countries, including developing economies, may still encounter difficulties in attracting low-carbon FDI due to legal and institutional difficulties (e.g. insufficient incentives and regulation, legal protection and lack of transparency) and socioeconomic/financial challenges (e.g. lack of skills, expertise or training). It is, therefore, essential for governments of low-income countries to develop robust investment promotion strategies and the knowledge needed about the most competitive low-carbon subsectors in their jurisdiction. These governments can, for example create policy measures to attract low-carbon investments such as the implementation of feed-in tariffs, emission standards, promotion of technology transfer through links with domestic firms and policies to encourage the disclosure of GHG emissions data for energy use in production operations. For a further discussion on the main barriers for catalyse low-carbon FDI in developing countries and the financial, policy and technical support needed to overcome these, see UNCTAD (2013) and IFC (2011).

Another precondition that needs to be satisfied if private capital flows are to be catalysed for low-carbon and climate-resilient investment is to have appropriate financial instruments available. A private sector project, in its simplest form, could be financed on the company's balance sheet which itself will comprise shareholder's equity and short- and long-term debt. Additional equity finance may be provided by private equity funds, or raised through capital markets through share issues. Debt can be either raised through capital markets by borrowing from a bank or through the issuance of innovative instruments such as green bonds. The emerging market for green bonds may in due course be used more to raise finance for private-sector projects. The most important potential sources are the funds raised by MDBs from pension funds and institutional investors. The International Finance Corporation reports that from the total funds raised by issuing climate bonds (US$12 billion), around US$ 3.8 billion were raised by MDBs for projects in developing countries (IFC 2011).

[21] 'Doing business' indicators include: (i)*'Starting a business' indicators* (e.g. Number of procedures, time, cost, minimum capital); (ii) 'Closing a business' indicators (e.g. Recovery rate, time, cost); (iii)'Getting credit' indicators (e.g. Strength of legal rights index, depth of credit information index, public registry coverage); (iv) 'Protecting investors' indicators (e.g. Extent of disclosure index, extent of director liability index, ease of shareholder suits index, strength of investor protection index).

4. The desired level of international climate finance flows through time

The previous section discusses the current state of climate-related financial flows from high-income to emerging economies. The aim of this section is instead to analyse the required amount of financial resources needed to achieve a stabilisation of global temperatures below the 2°C increase threshold in the most cost-effective way. That will allow us to identify the gap between current and desired future climate finance.

In order to obtain estimates for desired climate financial flows, we employ results from the LIMITS project – 'Low climate IMpact scenarios and the Implications of required Tight emission control Strategies' (Kriegler et al. 2014). The policy options considered by the models are restricted to the implementation of a global carbon tax/market, but their results are still able to offer a good indication of the size and directions of desired climate-related financial flows during the rest of this century.

4.1 The LIMITS project and efficient mitigation

The aim of the LIMITS project is to study the feasibility of limiting the global temperature increase since pre-industrial times to less than 2°C and to assess a number of possible mitigation policies (Kriegler et al. 2014). It involves seven Integrated Assessment Models (IAMs), large-scale numerical models aimed at simulating the dynamics connecting the economy, climate and the energy system. A short description of the models involved is presented in Table 3.

The models use a harmonised group of geographical regions, the details of which can be found in Table 4. All models except AIM-Enduse cover the time period until 2100.

[Table 3 ABOUT HERE]

[Table 4 ABOUT HERE]

The models involved represent a diversified range of modelling techniques and assumptions. In some of them, the dynamics are driven by the maximisation of a welfare function based on consumption, while in others the objective is to minimise the energy costs. Some assume perfect foresight and are thus based on an intertemporal optimisation method, while others prefer to adopt a recursive dynamic solution instead, where results are calculated for each time step (this reduces the role for forward-looking behaviour). This variety makes the inter-model comparison exercise interesting and capable of reflecting features of the uncertainty around future physical and economic trajectories.

All the models run the same set of scenarios. Four of them are particularly relevant for the purposes of this paper and are presented in Table 5: a reference scenario without stringent climate policies (RefPol); a climate policy scenario (RefPol-450); and two climate policy scenarios with emissions trading (RefPol-450-PC and RefPol-450-EE). A complete list of the LIMITS scenarios can be found in Kriegler et al. (2014).

[Table 5 ABOUT HERE]

The Reference Policy (RefPol) scenario assumes that individual regions implement climate and technology policies consistent with the emissions reduction targets included in the Copenhagen pledges but no more. Examples include targets on greenhouse gas emissions reduction, GHG intensity reduction, nuclear power and renewable energy. The resulting carbon prices are therefore relatively low and diversified across regions, leading by the end of the century to an increase in global temperatures higher than 2°C.

The RefPol-450 scenario, by contrast, is the central climate-change mitigation scenario. It assumes that the Reference Policy is applied until 2020, and from the following period (2025 or 2030 depending on the models) a globally uniform carbon price is introduced so as to achieve a concentration target of 450 parts per million of CO_2 equivalent by 2100.[22] This could be thought as a carbon tax applied in all regions on all GHGs covered by the Kyoto Protocol.

The RefPol-450 scenario delivers efficient climate-change mitigation, capable of respecting the 2°C ceiling while maximising welfare (or minimising the costs of the energy system). However, the costs of mitigation policies are distributed unequally among regions. Figure 7 reports the regional costs[23] associated with climate-change policies in RefPol-450 as a proportion of global average policy costs.[24]

It can be seen that high-income regions (Europe, Pacific OECD and North America) bear a very small proportion of the overall policy costs, while low-income regions (Africa, India and others) and energy-exporting countries (Reforming Economies and Middle East) suffer policy costs well above the global average. These results – consistent across models, with the exception of Middle East – are due to a variety of reasons, including different abatement possibilities, regional emissions paths, energy intensities and energy exports (Tavoni et al. 2014).

[Figure 7 ABOUT HERE]

4.2 Trade in emissions allowances and optimal carbon markets

In order to examine the conflict between efficiency and equity along abatement paths, two additional scenarios are introduced (RefPol-450-PC and RefPol-450-EE) in which regions are allowed to trade freely emissions allowances allocated according to some burden-sharing mechanism.

In the RefPol-450-PC scenario (where PC stands for 'Per Capita'), emissions permits are allocated according to an equalised value of GHG emissions per capita across regions. The convergence towards this value takes place during the period from 2020 to 2050. In the case of

[22] Temporary overshoot of targets is allowed.

[23] Similarly to Tavoni et al. (2014), we computed regional policy costs using: GDP losses for models with a macro-economic component (MESSAGE, REMIND and WITCH); abatement costs for AIM-Enduse, IMAGE and GCAM; energy system costs for TIAM-ECN.

[24] Comparing regional policy costs with global policy costs helps to control for the 'structural' differences in policy costs across models, which tend to be quite pronounced, ranging from 0.51% of global GDP (IMAGE and GCAM) to 5.84% (WITCH).

the RefPol-450-EE scenario (where EE stands for 'Equal Effort'), abatement efforts – rather than emissions – are equalised across regions. This means that, from 2025/2030 onwards, all regions incur the same policy costs as the global average. A more detailed description of these scenarios can be found in Tavoni et al. (2014).

[Figure 8 ABOUT HERE]

Figure 8 shows the resulting carbon markets in terms of the amount of emissions allowances exchanged. In the RefPol-450-PC scenario, most of the models remain in the range of 2-6 gigatonnes of CO_2 equivalent per year for the whole century. Some of them (IMAGE and TIAM-ECN) foresee a peak in trade around the middle of the century and a subsequent decrease. In others (MESSAGE and REMIND), the opposite happens, with the carbon market expanding its size only after 2050. The exception is GCAM, which shows a much larger carbon market than the rest of the models, both at the beginning and at the end of the century.

In the RefPol-450-EE scenario, the optimal size of carbon markets resulting from trade of emissions allowances are slightly smaller. In GCAM and IMAGE, carbon markets experience an expansion during the first half of the century and then gradually decline. In WITCH and MESSAGE, the declining trend lasts for the whole century, but the initial size of the markets is larger. TIAM-ECN shows a very limited market, below one gigatonne of CO_2 equivalent per year, while REMIND shows the largest one, above 5 gigatonnes for most of the century.

In Figure 9, the amount of allowances exchanged is multiplied by each model's carbon price to show the economic value associated with the trade in the global carbon market. On average, the per-capita allocation scenario delivers much larger carbon market values than the equal-effort one. In the case of WITCH, the carbon market in RefPol-450-EE reaches almost 10% of global GDP. These results are highly dependent on the underlying carbon prices, shown in Figure 10, the dynamics of which are very different across models.

[Figure 9 ABOUT HERE]

[Figure 10 ABOUT HERE]

4.3 The direction of carbon market financial flows

Figure 11 and Figure 12 focus on the direction of the carbon market financial flows, cumulated over the 2020-2050 period and as a percentage of regional GDP. The results once again highlight the economic relevance of the flows resulting from the implementation of a global carbon market aimed at respecting the 2°C ceiling.

In the RefPol-450-PC scenario, shown inFigure 11, some regions need to buy emissions allowances according to all models (this is reflected in the negative financial flows in the figure). These include high-income regions (North America, Pacific OECD, Europe), the Middle East and China, which in the case of WITCH has to buy permits for as much as 5% of its GDP. The remaining regions show a higher degree of variability across models, but they all, except for the Reforming Economies, appear to be net sellers of allowances. This is particularly true for Africa, which receives financial inflows up to 15% of its GDP according to WITCH and GCAM.

[Figure 11 ABOUT HERE]

The financial flows in Refpol-450-EE scenario, shown in Figure 12, reveal a rather different picture. High-income regions are still purchasing permits, although the amount of the outflows in terms of their domestic GDP is now higher (and more diverse across models). India and Latin America also appear to be net buyers of allowances according to most models. The remaining regions are sellers. In particular, the Reforming Economies and the Middle East receive substantial financial inflows. This is because they bear a large proportion of the policy costs in the optimal scenario without trade, so an equalisation of efforts as required in scenario RefPol-450-EE makes them much better off.

[Figure 12 ABOUT HERE]

Finally, Figure 13 and Figure 14 show the amount of annual financial transfers for RefPol-450-PC and RefPol-450-EE in the 2020-2050 period from high-income to emerging economies.[25] For all the models considered, the amount of financial transfers in the case of an allocation based on equal mitigation costs tend to be higher than those generated by a per-capita allocation. For both scenarios, REMIND and, especially, WITCH are the models that involve the largest 'North-South' financial transfers, while TIAM-ECN is the one involving the smallest ones. The WITCH result for the RefPol-450-EE scenario is particularly high, reaching almost US$1,500 billion of financial flows already in 2030.

[Figure 13 ABOUT HERE]

[Figure 14 ABOUT HERE]

4.4 The fiscal sustainability of energy supply investment

Text In Bowen et al. (2014) the projected receipts from a carbon tax (or, equivalently in deterministic models, revenuers from auctioning all emissions quotas) – which can be interpreted as a flow of carbon revenues – was compared with the optimal investment in energy supply in order to test whether the fiscal revenues stemming from carbon taxation would be enough to pay for the energy investment required.

In this section we develop a similar exercise, focusing on international carbon market financial flows instead of domestic carbon tax revenues. The aim is to investigate the changes in energy investment financing produced by selling or purchasing emissions allowances.

Figure 15 shows the amount of optimal energy supply investment in RefPol-450 as a percentage of regional GDP in the 2020-50 period.[26] The high-income and emerging economies are clearly differentiated. In the cases of North America, Europe and Pacific OECD, all models tend to agree on the low amount of energy supply investment required (below 1% of GDP).

[25] High-income economies include North America, Europe and Pacific OECD (plus Rest of the World for WITCH and REMIND). Emerging Economies include Africa, China+, India+, Latin America, Middle East, Reforming Economies and Rest of Asia.

[26] In these figures, we exclude the results for AIM-Enduse and GCAM, which does not report energy supply investment. TIAM-ECN results are calculated using only CO_2 emissions instead of Kyoto gases emissions.

Emerging economies, on the other hand, need larger investments. The results, however, are much more diverse across models. In general, WITCH and IMAGE tend to exhibit lower values compared with REMIND, MESSAGE and TIAM-ECN. The variability is particularly strong in the case of Africa, for which the estimated energy supply investment required varies from 1% (WITCH) to 5% (REMIND) of regional GDP.

[Figure 15 ABOUT HERE]

Energy supply investments are then compared with the financial flows generated from emissions allowances trade. The resulting values indicate the overall financing requirement, which is lower than the energy supply financing requirement if positive financial flows enter the region as a consequence of selling allowances, or higher if finance leaves the region because of the purchase of allowances. When the value is lower than zero, the region is able to finance the entire amount of energy supply investment using financial flows from abroad.

Figure 16 reports the results for the RefPol-450-PC case. There are only a few regions that are able to finance investment through carbon market revenues: India (according to IMAGE and TIAM-ECN), Africa (TIAM-ECN and WITCH), Latin America and Rest of Asia (WITCH). In some cases, incoming financial flows would be so large that regions would retain a significant financial resource after having invested in energy supply, a resource that could be used for a variety of other purposes. On the other hand, some regions increase their financing requirements, having to purchase a large number of allowances as well as paying for their energy supply investment. This is, for instance, the case of Reforming Economies, where the financing requirement jumps to 10% of GDP according to TIAM-ECN.

[Figure 16 ABOUT HERE]

Finally, Figure 17 shows the results in the case of the Equal Effort scenario. As already noted in the previous subsection, the real 'winners' in this case are the Middle East and the Reforming Economies, the mitigation efforts of which in the scenario without trade are proportionally very large as a consequence of their fossil fuel endowments and exports. When efforts are equalised, their financing requirement are sharply reduced, reaching, according to WITCH and REMIND, strongly negative values. The only other region capable of financing its energy investment through carbon market financial flows is Africa in the WITCH model.

[Figure 17 ABOUT HERE]

5. Economic aspects of climate finance

The sections above discuss the need for climate finance, the evidence about current financial flows from developed to developing countries and the scale of the future global challenge if the 2°C ceiling for the global temperature change is not to be breached. High-income countries have agreed to scale up the flow of finance to developing countries for climate-change mitigation and adaptation, to US$100 billion per year by 2020. This is a large number. It can be compared with total net Official Development Assistance for all uses (according to the OECD) of US$134.8 billion in 2013 (of which perhaps around one fifth is for climate-related purposes). Although ODA does not include private finance flows, it is much more likely than private finance to comprise net transfers rather than competitively remunerated gross flows. There is some evidence that public and private finance flows have already increased since the UNFCCC Copenhagen Conference of the Parties in 2009, along with real investment in the low-carbon transition. However, North-South finance flows do not yet match the scale of the needs for adaptation and mitigation in developing countries, the flows have been directed through several different channels in a haphazard fashion and the principles that should govern future flows have not yet been agreed, despite the focus on this issue in the UNFCCC COP process. Important issues such as whether and how commercial private finance flows should be counted towards the Copenhagen finance goal and how the spending financed by these flows should be monitored, if at all, have not been resolved.

Ultimately, these questions will have to be answered via political discussion but a more analytical perspective may help to clarify the key issues at stake. In particular, the appropriate governance arrangements for future finance flows ought to be related to the arguments advanced for North-South transfers in the first place. The next sub-section considers these briefly. Then the principles that might govern public and private finance flows are discussed. Finally, some more macroeconomic aspects of climate finance are highlighted.

5.1 What should determine the magnitude of North-South transfers?

Discussions of the appropriate magnitudes of and modalities for governing North-South transfers turn on ethical considerations of equity, sovereign rights and historical responsibility for the build-up of greenhouse gases in the atmosphere. There is an extensive literature on the implications of different ethical perspectives for burden-sharing with respect to the costs of adaptation to and mitigation of climate change.[27] Considering the utilitarian perspective that guides traditional neoclassical economics and its implications for policy, Bowen et al. (2014) note the advantages for the efficient allocation of resources (across activities today and in the future) of using carbon pricing to internalise the greenhouse gas externality. But they also point out that there has to be a possibility of using lump-sum transfers to compensate losers if the introduction of emissions pricing is to be unambiguously welfare-enhancing across all individuals and generations (a 'Pareto improvement' in the jargon of welfare economics). Only in these

[27] See, inter alia, Torvanger and Ringius (2002), Kverndokk and Rose (2008), Campiglio (2012) and Stern (2013b, 2013a).

circumstances can considerations of equity and efficiency be separated. Thus applying the standard tools of traditional welfare economics, a concern with the distribution of income among policy-makers is likely to entail net cross-border flows of transfers to poorer countries given their disproportionate share of cheap mitigation opportunities, their greater vulnerability to climate change and their relatively low per capita incomes.[28]

From this perspective, tying individual financial flows (for example, from specific revenue-raising instruments or climate funds) to specific mitigation or adaptation spending is not warranted by the general equity arguments – for example, the flows might be needed to compensate the poor in developing countries for higher fuel costs resulting not from climate change per se but from carbon pricing. Also, there is no reason why cross-border revenues from a particular earmarked source should automatically equal the incremental costs borne period by period or in total. From this perspective, governance arrangements could be very simple. Net aggregate transfers would be related to a developing country's exploitation of cost-effective mitigation opportunities, its vulnerability to climate change and its average per capita income (or some other measure of income distribution allowing for differences in income distribution across countries). Only these macro-level variables would need to be monitored for compliance. Individual financial flows would not need to be earmarked or hypothecated to particular narrowly defined purposes, given that their ultimate purpose would be compensating for the inequity of the distribution of current expenses of cost-effective action on climate change.

Bowen et al. (2014) show that the incremental costs of keeping temperatures under the 2°C ceiling, in the sense of the incremental loss to GDP or aggregate consumption from implementing changes in the energy supply system, are likely to be considerably higher than the net incremental investment costs. Incremental investment costs measure the direct reduction in consumption necessary to finance investment but not the additional indirect, or 'general equilibrium,' costs. Some integrated assessment models do differentiate among incremental investment costs, GDP costs and consumption costs but few allow for all the potentially important feedback channels, such as the possibility of reduced labour supply in the face of higher real relative energy costs for households. Although the LIMITS models suggest that the net incremental investment costs of transforming energy supply will be modest (and perhaps even negative because of improvements in energy efficiency and lower investment in capital-intensive fossil-fuel-based power generation), the models that allow for general equilibrium effects point to substantial GDP and consumption losses in developing countries in the absence of transfers. If decarbonisation of other sectors of developing economies were to be included in the calculations, together with an allowance for the transitional costs of structural change, Bowen et al. (2014) suggest that the incremental costs to developing countries are likely to be well in excess of US$100 billion by 2020 and rising for many years afterwards.

[28] Fairness may also entail the current generation passing on a smaller stock of manufactured capital to its descendants in return for bequeathing a lower stock of greenhouse gases in the atmosphere. However, the current generation may be willing to bear some of the costs of additional investment today so that future generations reap higher returns from a world with a lower average temperature than they would otherwise have to suffer. In the jargon of neoclassical economics, societies may not insist on climate-change policies being Pareto-improving.

However, the LIMITS projections show that there is considerable uncertainty about the magnitude of net costs and the extent to which they are reflected in investment costs, even given the broadly similar modelling approaches adopted. Also, further analysis is needed of the incremental costs of investment in improving energy efficiency and reducing the carbon content of production outside the energy supply sector. Finally, the projections may not capture all the possible offsets to mitigation costs ('co-benefits') that might arise if well-designed 'green growth' policies are put into place.

In practice, international negotiators have 'short circuited' the need for explicit agreement on the appropriate ethical perspective(s) to take by agreeing on the 'Copenhagen US$100 billion by 2020' target. In the light of the discussion above, this figure does not appear to meet the UNFCCC rubric about high-income countries meeting the full incremental costs of developing countries' actions on climate change. Nevertheless, the figure is substantially higher than the existing level of financial flows. If it is taken to represent the UNFCCC negotiators' considered compromise on the demands of equity, it should be additional to any other aid flows not related to climate change (as it should reflect an increment associated specifically with climate change) and should comprise transfers, not commercially remunerated financial investments. As far as private financial flows are concerned, only the value of the cost reduction on concessionary loans relative to commercial terms should be included in the calculation of the total 'Copenhagen flows,' as suggested in UN (2010)[29]. The key demands for governance according to this perspective are:

i. Reporting and verification of financial flows from high-income countries to developing countries for climate-change actions;

ii. Measurement of the concessionary element of private, public and mixed public-private finance flows;

iii. Reporting and verification of the costs of the aggregate of actions to mitigate and adapt in recipient developing countries;

iv. Distribution of finance across developing countries in a pattern broadly reflecting each country's spending on cost-effective mitigation opportunities, its vulnerability to climate change and its average per capita income (or some other measure of income distribution allowing for differences in income distribution across countries).

The inadequacy of the US$100 billion target for transfers may reflect a lack of commitment to the principle of meeting full incremental costs, in which case a more pragmatic approach to governance may be necessary, relating it to the varying political requirements of high-income and developing countries. Even so, economic principles may have a role to play in informing governance arrangements, as outlined in the next sub-section.

[29] Where non-marginal increases in investment are financed, commercially remunerated finance flows may generate a significant consumer surplus and therefore still contribute a net benefit. Where the commercial terms are more advantageous than would be available if the developing country recipient had to finance the investment from domestic saving, there would also be a net benefit, so there is some justification for including some small fraction of commercial private finance flows in the Copenhagen total.

5.2 Economic principles

Economic analysis can help guide efforts to raise finance for climate action in developing countries. Four key points emerge from this perspective (Bowen 2011). First, public finance is warranted by a range of market – and policy – failures associated with climate change and its mitigation. In practice, the problem of GHG externalities is compounded by several other market failures, particularly in the areas of innovation, network economies, provision of infrastructure public goods, information asymmetries and fragility of financial intermediaries. These generally need to be tackled by public policy (where the public sector has sufficient information, well-designed policy instruments at its disposal and is reasonably robust in the face of rent-seeking), including in some cases financial subsidies. There are also public policy failures, such as the lack of credibility of the policy framework that can arise when governments cannot bind their successors. This can be remedied in part by developed-country policy-makers investing in their reputations by committing resources to announced policies and accepting increased costs of reneging on these policies, thus building credibility and strengthening the impact of incentives to alter private-sector behaviour. As Bowen (2011) argues, "Policy commitments that include financial or reputational incentives for all participating governments to achieve the announced outcomes can enhance the credibility of the policies and help to align the interests of policy-makers more closely with those of private agents. Thus, public support for developing-country actions, especially through multilateral frameworks endorsed collectively by all participating governments, can help to strengthen actions by the private sector."

Second, there is an important role for private finance, which can bring in a much wider range of economic agents to assess mitigation and adaptation opportunities and costs and to monitor the performance of individual projects. However, two types of public action are very desirable in both high-income and developing countries if private finance is to be generated at the appropriate scale and if privately financed projects are to be distributed across countries in a cost-effective way: pricing carbon and building a consensus about what a country's prospective mitigation and adaptation needs will be. To provide the right incentives for private investment and innovation, there should be pervasive carbon pricing across countries and economic sectors at a broadly similar level, with policies developing the expectation among financial intermediaries that carbon price levels will rise over time. By contrast, fossil-fuel subsidies discourage private investment in low-carbon technologies and the absence of emissions pricing can encourage funding for investments that result in 'carbon leakage' from countries that do impose a carbon price.

There is a role for policy-makers in stimulating private finance, by reducing the uncertainty facing private agents (e.g. by the use of emissions reduction targets or by indicating the government's expectations about the future carbon price through contracts), not least because it partly reflects uncertainty about policy-makers' future behaviour. Thus, private finance flows will be encouraged if the international policy framework and the rules and regulation of carbon markets are settled, clear and credible for the long term. The design of such markets should also discourage price volatility (e.g. by allowing banking and borrowing in emissions trading schemes and ensuring liquidity and competition in carbon markets). Public finance can also help to reduce the risks facing the private sector and thus leverage private finance. In countries with more sophisticated financial sectors, this might include grants, interest-rate subsidies for private-sector

project finance, loan guarantees and insurance premia to help manage the risks unique to investments related to climate change, equity co-investment and the issuance of indexed bonds that pay more when carbon prices fall, hence allowing carbon market participants to hedge their risks more easily.

Third, as Bowen (2011) discusses, raising tax revenues is preferable to borrowing as a means of raising public finance for North-South transfers, if, from the perspective of high-income countries, the justification for the transfers is equity across countries generation by generation. But in general the message from the public finance literature is that the source of the funding does not matter much. Economic theory advocates taxing 'bads', a number of which have escaped the tax base in most countries so far (including some cross-border pollution). However, economic theory discourages earmarking or hypothecation of specific revenue streams to particular uses, except when setting a user charge to cover the marginal costs of a publicly provided good (McCleary 1991; OECD 1996). With the latter exception, there is no reason why the revenue generated by the appropriate tax rate on one activity (e.g. global financial transactions) should equal the appropriate spending on another activity (e.g. public support for developing countries' climate policies). Even if tax rates and spending are initially set so as to bring about the equality needed, there is no guarantee that this will remain the case over time. Thus much of the effort devoted to designing new instruments and taxes for industrial countries to earmark for climate finance is misplaced. International collaboration between high-income countries' governments is desirable in delivering promises about public finance flows taken on in the context of international negotiations or where economies of scale in monitoring, verification and reporting are important. However, this does not imply that coordination of revenue sources is necessary. Governments may agree about the appropriate uses of funds without agreeing about appropriate sources.

Fourth, how much could or should be raised by the many specific proposals for finance for climate action in developing countries is often uncertain. How multiple schemes would interact is also a matter for further study. Several of the schemes that have been suggested could have the presumably unintended effect of depressing carbon prices and thus undermining incentives facing the private sector. Some others entail high monitoring costs.

Bowen (2011) reviews in the light of these points a range of proposals - including those discussed in UN (2010) - for generating new North-South financial flows. As well as increasing commitments to the Green Climate Fund by high-income countries, two sets of proposals appear particularly attractive: (i) expanding the scale and scope of the Clean Development Mechanism (CDM) and (ii) expanding the use of the balance sheets of the international financial institutions (IFIs), including the use of Special Drawing Rights. The first would require moving away from a purely project-based approach but could be tailored to developing countries' emerging commitments to Nationally Appropriate Mitigation Actions (NAMAs). It would encourage private flows of finance. The second would require reform of the governance arrangements for IFIs to win the agreement of developing countries to the conditionality imposed on the resulting public finance flows. This report argues that the main condition should be that recipient countries take appropriate overall action on mitigation and adaptation. Public finance flows should be targeted more towards the countries with more serious adaptation needs, more opportunities for low-cost

mitigation and more poverty. Subject to that criterion being satisfied, the use of particular payments for narrowly defined climate-related purposes may not warrant close supervision and developing countries should be entitled to use essentially compensatory payments as they see fit.

There is still some way to go before climate finance can be said to meet the principles outlined here. Nakhooda (2014) draws three main lessons from the ODI's studies of the UNFCCC's initiative on Fast Start Finance – the attempt to increase climate finance quickly in advance of full agreement on long-term arrangements and objectives:

i. Not all of the finance provided was new. Some sources have proved unreliable: experiments with raising revenues through carbon markets have collapsed alongside the global price for carbon. In times of austerity, there is a need to strengthen political commitment to support developing countries to act on climate change.

ii. Finance was weakly targeted to emissions and vulnerability. Mitigation finance was not strongly focused on countries where there was substantial potential for GHG emission reduction. Similarly, adaptation finance did not always expressly target vulnerability.

iii. Improved transparency on climate finance in both developed and developing countries will promote understanding of whether countries are meeting their commitments, and whether funding is being used effectively. Reporting on climate finance has improved. But it is still not clear whether the world community is succeeding in shifting global investments as a whole away from business as usual towards climate compatible solutions.

5.3 Some macroeconomic aspects of the management of climate finance

The governance of climate finance flows also needs to take into account some possible adverse macroeconomic consequences. Bowen et al. (2014) point out that, for some developing countries, especially in sub-Saharan Africa, there is a risk of inflicting a 'resource curse' because the flows of finance warranted by most burden-sharing rules are large. The concept of a 'resource curse' is discussed in Collier (2010) and Frankel (2010) among others.[30] Potential problems include appreciation of the recipient countries' exchange rates, the crowding out of employment-creating activities, especially outside the sectors transitioning to low-carbon technologies, rent-seeking and the undermining of fiscal discipline. Adverse consequences are more likely if the flows of finance are volatile, which is a potential problem if a permit-trading-based regime is used to regulate greenhouse gas emissions, to the extent that European experience with the EU Emissions Trading System is a guide. The danger of currency appreciation in the recipient countries is lower if it is accompanied by flows of real resources or if the recipients build up their stocks of foreign currency. The issue is discussed further in Strand (2009), who argues that "the macroeconomic implications of such flows are manageable in the short run, but the larger

[30] A related threat is the 'Dutch disease' analysed initially by Corden and Neary (1982), wherein the effort to spend the finance domestically pushes up the relative price of non-tradables and the real wage rate in the recipient country, with adverse consequences for the traded sector.

revenues resulting from global emissions schemes could overwhelm this capacity and lead to a number of potential macroeconomic management problems."

The results of the LIMITS scenario runs described here and in Bowen et al. (2014) can be compared with those of Jakob et al. (2012), who use the integrated assessment model REMIND-R to explore potential finance flows in a range of scenarios and who also discuss the resource curse implications. In their projections, Africa and the 'rest of Asia' also do well out of the 'per capita convergence' burden-sharing rule. The projected outcome across regions is more mixed across scenarios and models under 'equal burden-sharing,' although the Middle East is generally expected to benefit. Without inward flows of climate mitigation finance, the Middle East would be faced with the reverse of the resource curse. EBRD (2011) suggests that this would also be a problem for countries of the Former Soviet Union. Having structured their economies around high levels of revenues from the sale of fossil fuels internationally, they may suffer a sharp deterioration in their terms of trade. On top of that, they tend to have carbon-intensive economies themselves, so are likely to have abnormally large incremental investment requirements given the need to restructure production more widely.

The resource curse is not an inevitable consequence of large inward finance flows. Frankel (2010), for example, contrasts the experience of Norway, Chile and Botswana with that of Nigeria, Bolivia and Congo. The former have managed the flows more effectively. Climate finance flows may be easier to manage than payments for resource exports. Under an international agreement governing the aggregate magnitude of flows, the flows would for example be more or less exogenous to the policies adopted by the recipients. The parallels with the resource curse suggest that more attention needs to be given to:

i. Boosting the flow of goods and services to the recipient countries, particularly (although not necessarily exclusively) for use in emissions-reducing projects (unless there is involuntary unemployment due to aggregate demand deficiency)

ii. Avoiding an induced appreciation in the real exchange rate

iii. Establishing domestic governance arrangements to ensure transparency and debate about the use of the finance flows

One important aspect of domestic governance arrangements is the promotion, regulation and supervision of financial intermediation in recipient countries to ensure the efficient allocation of credit generated by the inflows. This is in any case likely to be important for middle-income developing countries with effective domestic financial intermediation in the event that high-income countries do not fully meet the obligations that they have undertaken. Bowen et al. (2014) argue that emerging-market economies would be able to finance the low-carbon transformation of their energy supply systems reasonably easily from domestic saving flows if necessary, particularly if they use carbon pricing and utilise the revenues raised to finance investment in capital embodying low-carbon technologies. The main challenge is to ensure that government revenues are complemented by investment in the appropriate sectors. Historical experience suggests that incremental aggregate investment (and saving) needs are well within the range of past variation in emerging-market economies' investment/GDP and saving/GDP ratios. Such countries have tended to finance their domestic investment booms from domestic resources and could do so in

future, too, if necessary. Several emerging-market economies, including India and China, have experienced large increases of investment and domestic saving in a very short space of time. In the light of the continuing debate over precisely what the obligations of the advanced industrial nations are, and when nations should cease to be classified as 'developing,' today's developing countries would be well advised to consider how to improve domestic incentives to direct domestic funds, for investment and compensatory income support, to the appropriate sectors of their economies.

6. Conclusions

Climate-related international financial flows are likely to rise significantly if countries act on their commitment to a ceiling of 2°C on the global temperature increase. This will reflect the rise in the climate-related investment needed in energy supply and energy efficiency across all sectors of economies, together with the uneven distribution across countries of cost-effective ways of reducing greenhouse gas emissions and the uneven distribution of saving rates. Considerations of fairness, equity and historical responsibility have led policy-makers to focus in particular on the financial flows appropriate between high-income countries (the global 'North') and developing countries (the global 'South'). Arguments for abating greenhouse gases where the resource cost of so doing is least and setting a global carbon price to provide the right incentives lose much of their appeal if the world's poor have to bear a disproportionate burden of the abatement costs. As a result, the UNFCCC recognises the need for North-South transfers. Countries agreed at Copenhagen to aim for a flow of US$100 billion per year by 2020.

Of the overall amount of climate-related investment, an increasing proportion is being carried out in low-income and emerging economies. The majority of it appears to be financed from domestic sources, particularly in the large emerging-market economies with developed domestic financial intermediation such as China, not by financial resources flowing from OECD countries. However, tracking the public and private financial flows that may count towards the US$100 billion Copenhagen commitment is proving challenging. Along with the basic problem of collecting data, there are questions about the additionality of finance flows, the displacement of other development aid and the status of private flows. Most of the flows so far have been from the public sector – Official Development Aid and financing by the multilateral development banks. Private flows have also been generated but they have been held back by the weakness of carbon markets and the Kyoto Clean Development Mechanism, the very limited implementation of carbon pricing around the world and uncertainty about the prospective evolution of national and international policies on climate change. Various dedicated climate funds have been set up, including the Green Climate Fund mandated by the UNFCCC members, but their ultimate ambition and objectives are not always clear and there are debates about their governance. It does not appear that high-income countries are yet close to bearing the full incremental costs of agreed action on climate change by developing countries.

This problem is illustrated clearly by the LIMITS scenarios. These show that high-income regions (Europe, Pacific OECD and North America) are likely to bear a very small proportion of the overall costs of strong mitigation consistent with the 2°C ceiling, while low-income regions (Africa, India and others) and energy-exporting countries (Reforming Economies and Middle East) are likely to suffer policy costs well above the global average. These results – consistent across models, with the exception of Middle East – are due to a variety of reasons, including different abatement possibilities, regional emissions paths, energy intensities and energy exports.

The LIMITS projections include a strong abatement scenario where emissions permits are allocated strictly in proportion to population by 2050, thus equalising each region's target emissions per capita. In a second strong abatement scenario, abatement efforts per head – rather than emissions – are equalised across regions, so that, from 2025/2030 onwards, all

regions incur the same policy costs per head as the global average. (Neither of these rules corresponds exactly to a strict interpretation of high-income countries paying the full incremental costs of climate change policies in developing economies.)

The different models differ in their projections for carbon prices and flows of traded quotas, but the projected size of carbon markets under these two scenarios is large in nearly all of them, rising to over 2% of global world product towards the end of the century. The 'per capita equalisation' rule tends to be associated with larger carbon markets than the 'equal effort' burden-sharing rule. Under the former rule, high-income regions, the Middle East and China, have to buy quotas. The remaining regions show a higher degree of variability across models, but they all, except for the Reforming Economies, appear to be net sellers of allowances. This is particularly true for Africa, which will receive financial inflows of up to 15% of its GDP according to two models. The financial flows under equalisation of effort reveal a rather different picture. High-income regions are still purchasing permits net and the amount of outflows in terms of their domestic GDP is higher (and more diverse across models). India and Latin America also appear to be net buyers of allowances according to most models. The remaining regions are sellers. In particular, the Reforming Economies and the Middle East receive substantial financial inflows. This is because they bear a large proportion of the policy costs in the optimal scenario without trade in allowances.

In the light of these findings, it is helpful to go back to first principles and consider what should determine the extent of North-South transfers and to what type of conditionality they should be subject. According to projections from the models in the LIMITS consortium, the incremental costs of keeping temperatures under the 2°C ceiling, in the sense of the incremental loss to GDP or aggregate consumption from implementing changes in the energy supply system, are likely to be considerably higher than the net incremental investment costs – and considerably higher than the Copenhagen target of US$100 billion per year by 2020. To the extent that these flows are warranted on grounds of equity between rich and poor countries, the key demands for governance according to this perspective are:

i. Reporting and verification of financial flows from high-income countries to developing countries for climate-change actions;

ii. Measurement of the concessionary element of private, public and mixed public-private finance flows;

iii. Reporting and verification of the costs of the aggregate of actions to mitigate and adapt in recipient developing countries;

iv. Distribution of finance across developing countries in a pattern broadly reflecting each country's spending on cost-effective mitigation opportunities, its vulnerability to climate change and its average per capita income (or some other measure of income distribution allowing for differences in income distribution across countries).

The source of finance for North-South flows should not be a central issue and earmarking particular revenue streams to climate-change actions in developing countries would not be particularly helpful (just as finance ministries are generally well advised not to hypothecate

revenue streams at a high level of disaggregation). Three sets of financing proposals appear particularly attractive according to criteria of good public finance:

i. increasing commitments to the Green Climate Fund by high-income countries:

ii. expanding the scale and scope of the Clean Development Mechanism (CDM), lessening the role of project-based monitoring, reporting, and verification; and

iii. expanding the use of the balance sheets of the international financial institutions (IFIs), including the use of Special Drawing Rights, while reforming IFI governance.

Governance of climate finance flows by developing countries also needs to encompass a policy framework for macroeconomic policies that would:

i. Guard against the emergence of a new 'resource curse' associated with inward flows of finance;

ii. Avoid a large appreciation of the real exchange rate; and

iii. Establish domestic governance arrangements to ensure monitoring, transparency and debate about the use of the finance flows.

Also, developing countries should continue to improve the efficiency and regulation of domestic financial intermediation, not only to make best use of financial inflows from high-income countries but also as a precaution against the failure of the latter to reach the Copenhagen 2020 target.

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8. Tables

Table 1 North-South climate finance information sources (adapted from Clapp 2012 and CPI 2013)

Type and channel of climate finance (size and year)	Key data sources	Pros and cons of data source
Public funds		
ODA (USD 21.2 US$ billion, 2010-2011)	OECD DAC-CRS Rio markers	The most comprehensive system for tracking aid flows related to climate change. Following a review of reported data, high quality data on project level are made publicly available. The CSR system is a statistical system to analyse flows to ODA-eligible countries, with a particular focus on aid allocations and trends. Using the 'Rio Marker' DAC has monitored climate change-related aid flows. It covers only a small part of all N-S flows. The Rio markers have so far mainly been applied to ODA only, with a limited amount of other official flows (OOF) covered The Rio markers have so far mainly been applied to ODA only, with a limited amount of other official flows (OOF) covered
Climate funds (USD 1.6 US$ billion, 2012)	Climate Funds Update	It provides independent information and analysis on bilateral and multilateral climate change funding initiatives and gives a good aggrega picture of N-S climate financial flows through 26 dedicated climate funds. It is an open source data that allows assessment of funds by funder and the allocation of support across themes, regions, and countries. Data is collected from very different sources using different methods and makes comparability between data difficult. Data have been found not always up to date
Bilateral and Multilateral Development Banks (USD 15-22 US$ billion, 2012)	Joint MDB Reporting (for Multilateral finance) and climate commitments (for Bilateral finance)	Harmonized reporting method of activities across MDBs. Only aggregated results have been presented in the 2012 and 2013 reports without the list of projects that has been classified as climate finance
Private funds		
CDM and specialized carbon markets (USD 2.3 US$ billion, 2010)	UNEP-RISO CDM Database	It does not have statistical data on value of CERs, CDM project investments or even price of CERs.
	Thomson Reuter Point Carbon can provide data on carbon market prices	Thomson Reuter provides in a routine manner some commercial information. Estimates of CDM project investment have been constructe by analysts The estimates are derived from proxy data. It focuses on clean energy technology only and there is no agreed methods for what or how to track finance flows related to CDM
FDI and other private finance (USD 4-13 US$ billion, 2012-2013)	UNCTAD FDI Statistics	This source has broad country coverage for inflows and outflows Database does not allow tracking of both the source and destination of the flows; neither sectoral detail by country.
	OECD FDI Statistics	This source has higher quality data than UNCTAD, and it allows tracking of source or first counterparty recipient by sector. Only covers OECD countries as "reporting" countries. FDI data is published on a country and sectoral level, the company-level data are not public. Difficulties to see which flows are climate-related.
	BNEF	Comprehensive commercial data sources on some specific subsets of private climate finance. BNEF provides a detailed project-level database for energy sector investments. It is a commercial database accessible only on a fee basis. The database do no track country of origin of the capital flows, thus makes N-S tracking difficult. Also, data presented by BNEF comes from open sources that can be found on internet and lacks, therefore, a fully comprehensive view and is not verified by the investors themselves. Poor coverage beyond renewable energies.

Table 2: Overview and characteristics of available climate funds in 2012 (Source: CPI 2013; Climate Funds Update 2014)

Climate Funds	Administrating organization	Targeted objective	Funds in 2012 (US$ million)
Adaptation Fund	World Bank (interim trustee)/UNFCCC	Adaptation	69
Clean Technology Fund	World Bank	Mitigation	413
Congo Basin Forest Fund	African Development Bank	Mitigation (REDD)	21
Forest Carbon Partnership - Readiness Fund	Mitigation (REDD)	Mitigation (REDD)	7
Forest Investment Program	World Bank	Mitigation (REDD)	18
Global Environmental Facility Trust Fund	Global Environment Facility (GEF) with World Bank as Trustee	Mitigation	238
Global Climate Change Alliance	European Commission - Directorate-General for Development and Cooperation - EuropeAid	Adaptation	48
Global Energy Efficiency and Renewable Energy Fund	European Investment Bank	Mitigation	13
Least Developed Countries Fund	Global Environment Facility (GEF) with World Bank as Trustee	Adaptation	167
MDG Achievement Fund	UNDP MDTF	Adaptation /Mitigation	4
Multilateral Fund of the Montreal Protocol	Executive Committee of the Fund	Mitigation	118
Pilot Program for Climate Resilience	World Bank	Adaptation	192
Special Climate Change Fund	Global Environment Facility (GEF) with World Bank as Trustee	Adaptation /Mitigation	
Scaling up Renewable Energy Program	World Bank	Mitigation	28
Special Climate Change Fund	Global Environment Facility (GEF) with World Bank as Trustee	Adaptation /Mitigation	41
UN-REDD	UNDP	Mitigation (REDD)	12
Amazon Fund	Brazilian Development Bank	Mitigation (REDD)	89
Guyana REDD Investment Fund	Steering Committee of the fund with the World Bank as Trustee	Mitigation (REDD)	12
Bangladesh Climate Change Resilience Fund	Government of Bangladesh and World Bank	Adaptation	54
Indonesia Climate Change Trust Fund	Indonesia's National Development Planning Agency with UNDP as Trustee	Adaptation /Mitigation	8.5
Bangladesh Climate Change Trust Fund	Minister for Environment and Forests of Bangladesh	Adaptation /Mitigation	66
Total			**1610**

Table 3 Models participating to the LIMITS Project (adapted from Kriegler et al. 2014)

Model name	Institution	Equilibrium	Method	References
AIM-Enduse	National Institute for Environmental Studies (Japan)	Partial	Recursive dynamic	Hibino et al. (2003)
GCAM	Pacific Northwest National Laboratory (USA)	Partial	Recursive dynamic	Kim et al. (2006)
IMAGE/TIMER	Netherlands Environmental Assessment Agency (PBL)	Partial	Recursive dynamic	Bouwman et al. (2006)
MESSAGE-MACRO	International Institute for Applied Systems Analysis (IIASA)	General	Perfect foresight	Riahi et al. (2011)
REMIND	Potsdam Institute for Climate Impact Research (PIK)	General	Perfect foresight	Leimbach et al. (2010)
TIAM-ECN	Energy Research Centre of the Netherlands (ECN)	Partial	Perfect foresight	Keppo and van der Zwaan (2012)
WITCH	Fondazione ENI Enrico Mattei (FEEM)	General	Perfect foresight	Bosetti et al. (2009)

Table 4 Regional disaggregation (adapted from Tavoni et al., 2014)

Region	Description
Africa	Countries of Sub-Saharan Africa; some models also include North African countries.
China+	Countries of centrally planned Asia; primarily China.
Europe	EU27 countries; some models also include Turkey.
India+	Countries of South Asia; primarily India.
Latin America	Countries of Latin America and the Caribbean.
Middle East	Countries of the Middle East; some models also include North African countries.
North America	Countries of North America; primarily the United States of America and Canada
Pacific OECD	Countries of the Pacific OECD; primarily includes Japan, Australia, and New Zealand.
Reforming Economies	Countries from the Reforming Economies of Eastern Europe and the Former Soviet Union.
Rest of Asia	Other countries of Asia; South Korea, Malaysia, Philippines, Singapore, Thailand, Indonesia, and others
Rest of the World	This category only exists for REMIND and WITCH and includes countries that are not categorised elsewhere (Australia, South Africa and others).

Table 5 LIMITS scenarios summary

Scenario	CO_2eq Concentration target (in 2100)	Policy before 2020	Policy after 2020	Burden sharing rule
RefPol	/	Weak policy		/
RefPol-450	450 ppm	Weak policy	Global GHG tax	/
RefPol-450-PC	450 ppm	Weak policy	Global GHG tax	Per capita convergence
RefPol-450-EE	450 ppm	Weak policy	Global GHG tax	Equal mitigation costs

9. Figures

Figure 1 The investment financing process

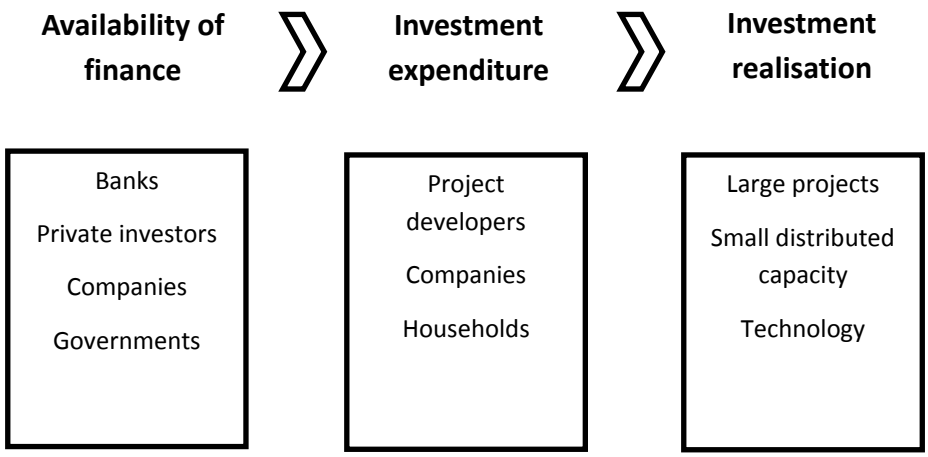


Figure 2 Main sources of climate finance (Source: CPI 2013)

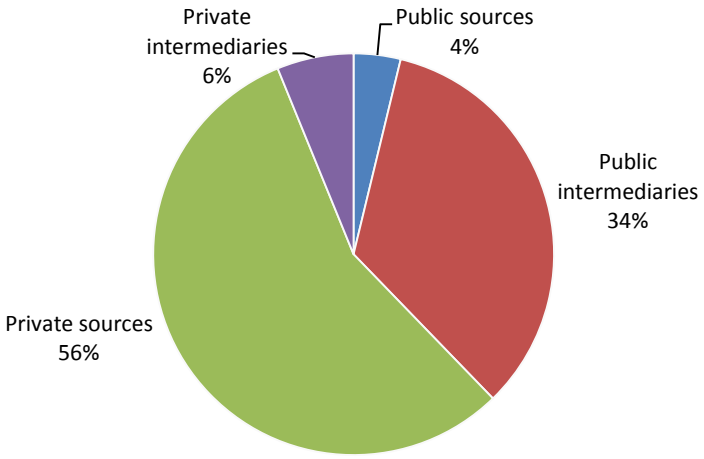


Figure 3 Clean energy investment (Source: FS-UNEP and BNEF 2013)

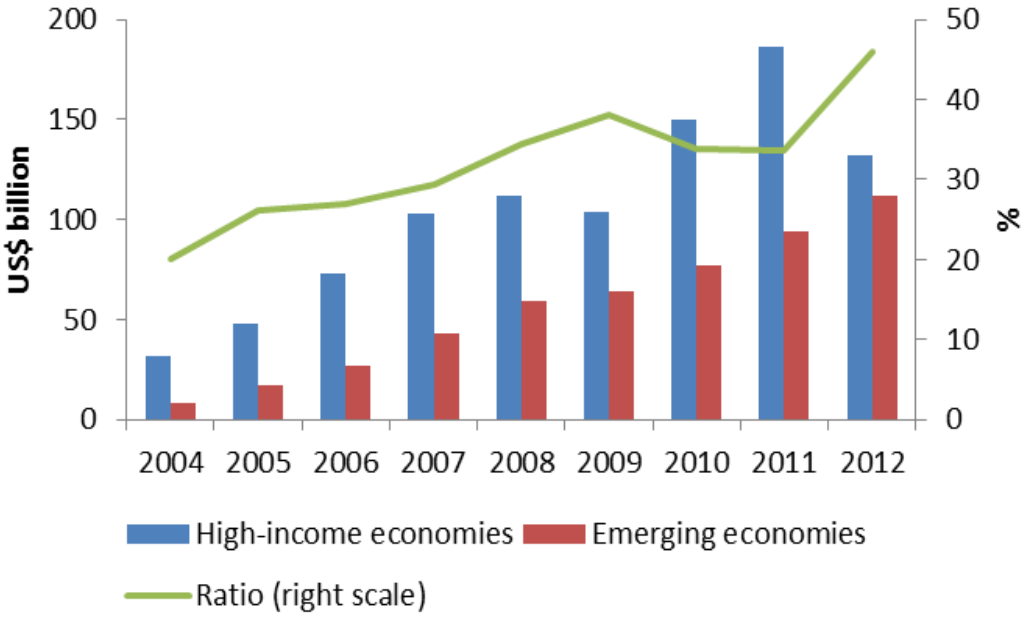


Figure 4 Regional distribution of total climate finance (left chart), origin of climate investments in developing countries (central chart) and sources of North-South climate investments (right chart) (Source: CPI 2013)

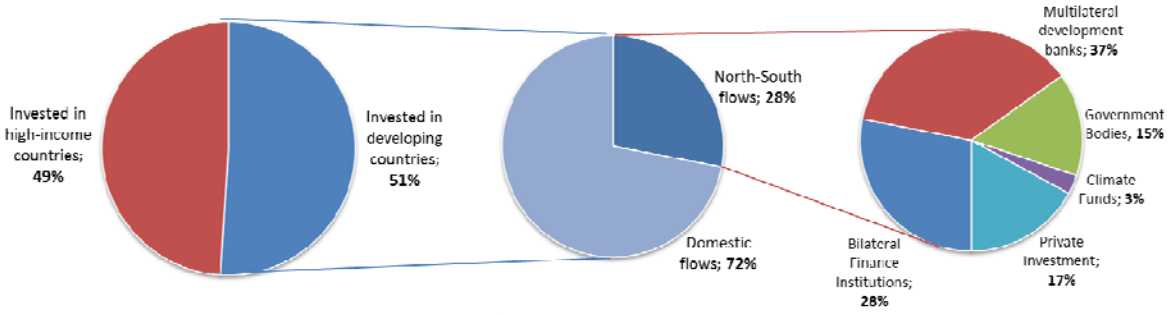


Figure 5: Evolution of climate-related ODA between 2006 and 2011 (Source: OECD DAC 2013)

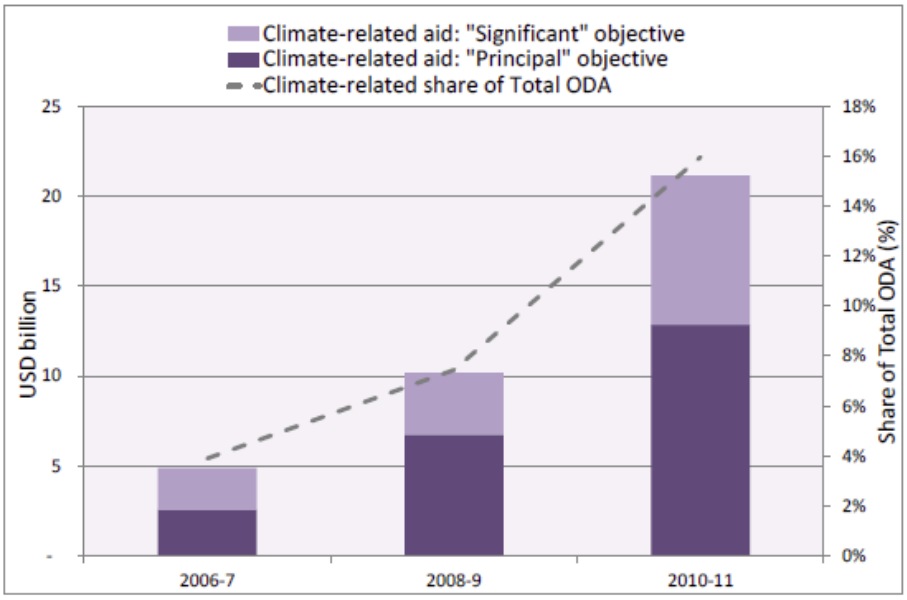


Figure 6: Overview of existing, emerging and potential carbon markets around the world (Source: World Bank 2013)

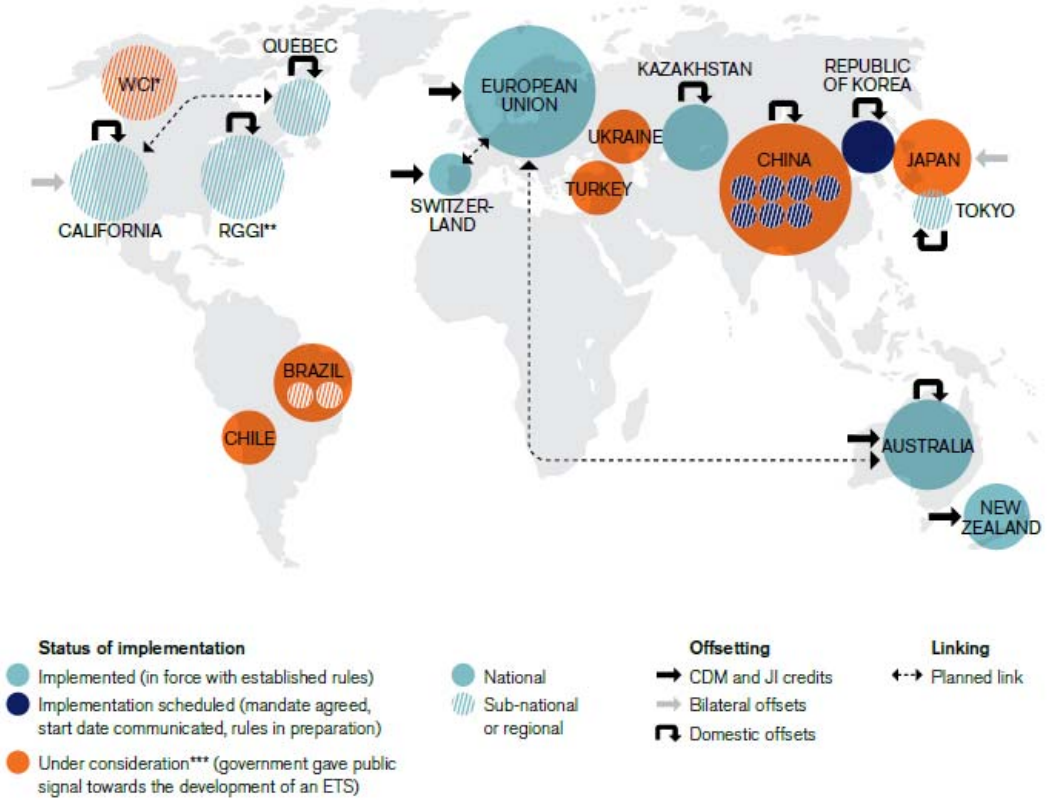


Figure 7 Regional policy costs relative to World in RefPol-450 (2020-50 cumulated values, NPV 5%)

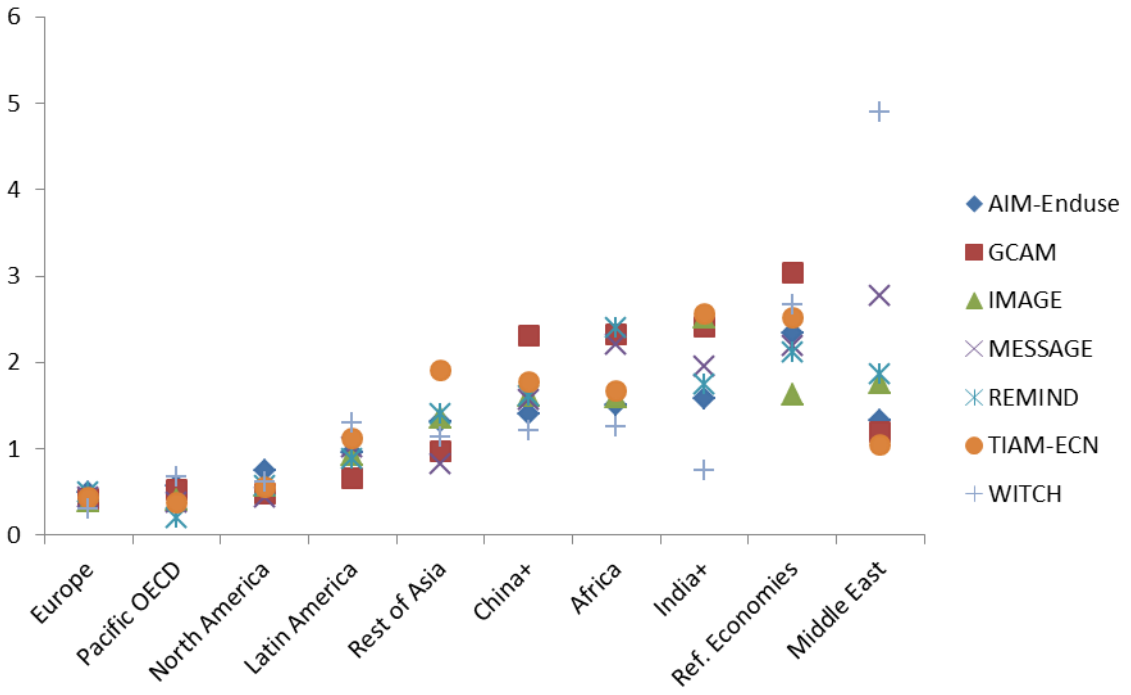


Figure 8 Carbon market sizes (Mt CO2-equiv/yr), RefPol-450-PC (left) and RefPol-450-EE (right)

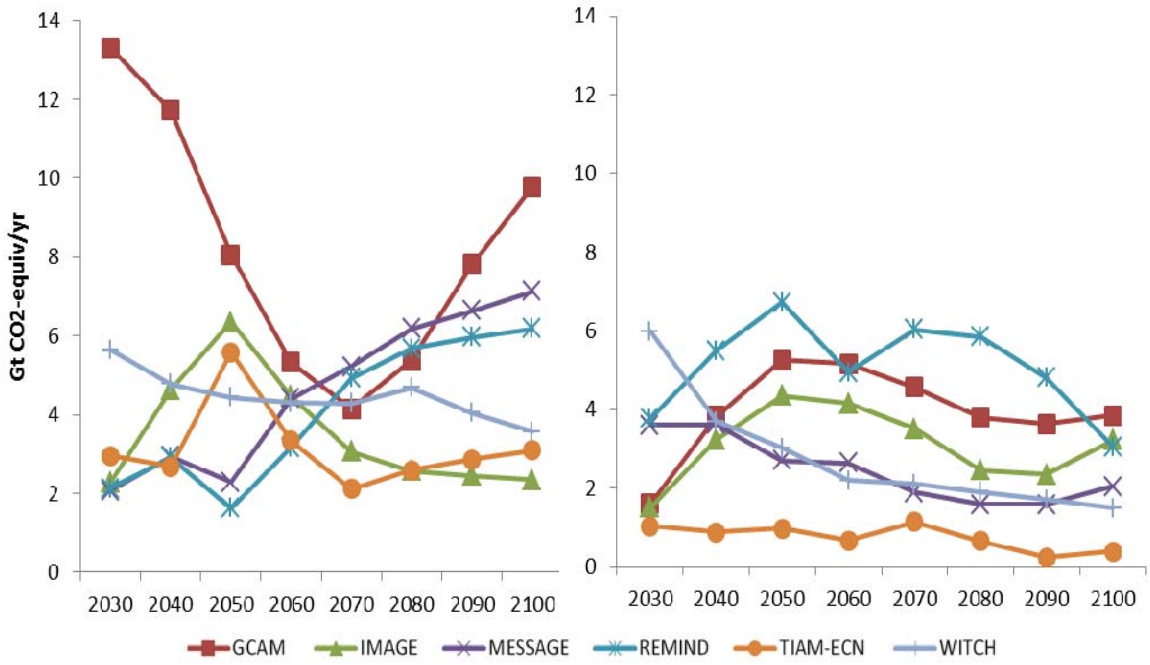


Figure 9 Carbon market sizes (% of global GDP), RefPol-450-PC (left) and RefPol-450-EE (right)

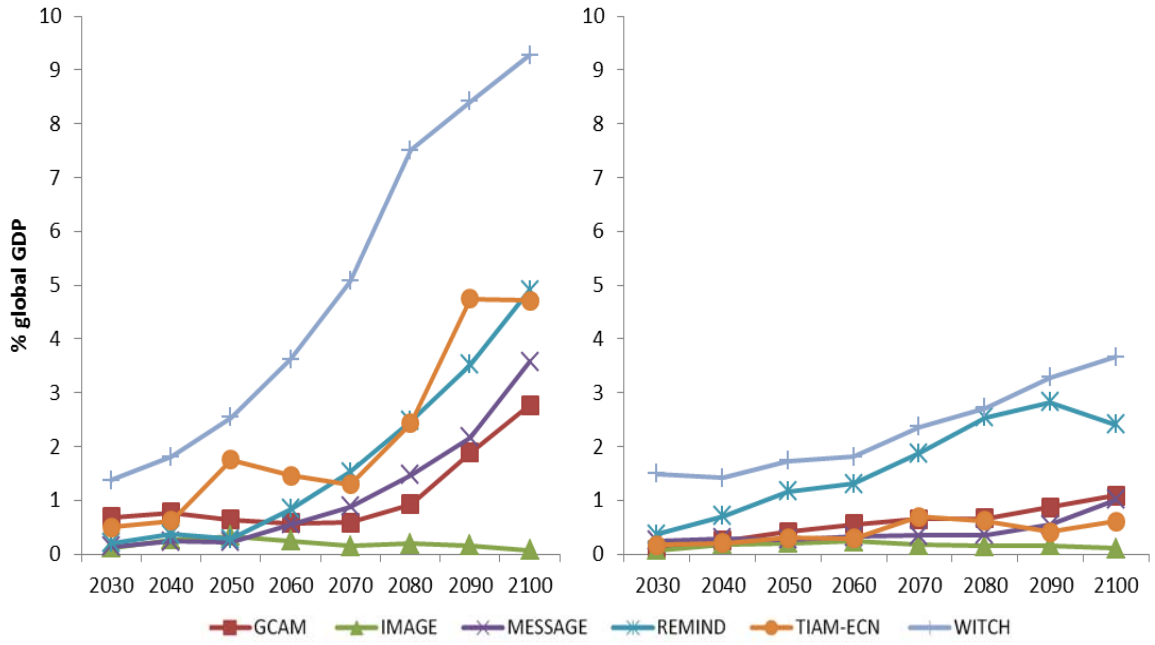
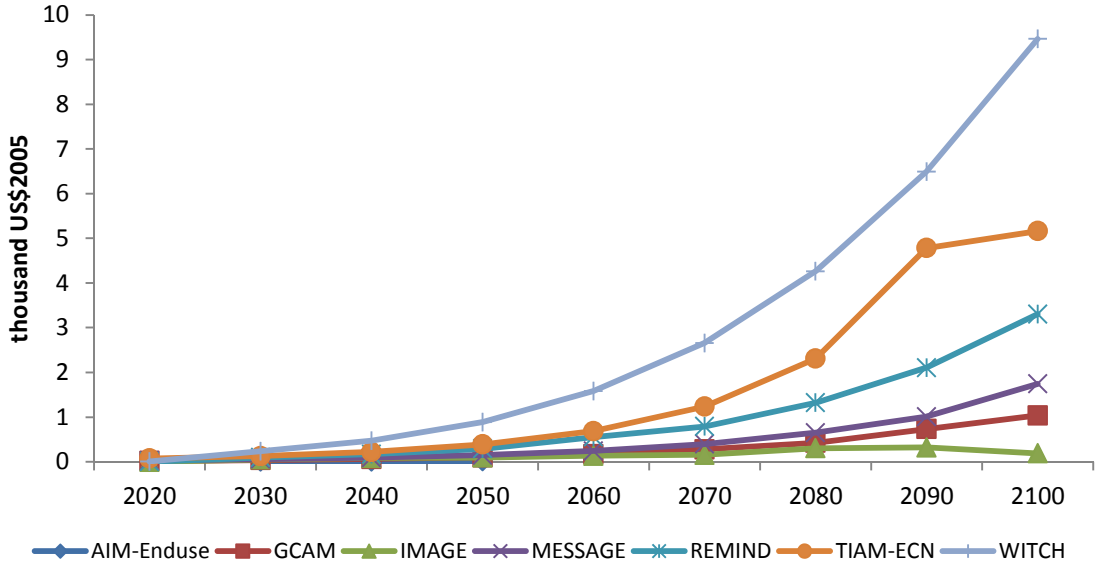


Figure 10 Carbon price dynamics in RefPol-450-PC [31]



[31] Figure 10 shows carbon prices for the RefPol-450-PC scenario. Carbon prices for RefPol-450-EE are almost identical, except for WITCH, in which the carbon price by 2100 is approximately US$ 500 lower than in RefPol-450-PC.

Figure 11 Climate-related financial transfers (RefPol-450-PC, 2020-2050 cum. values, NPV 5%)

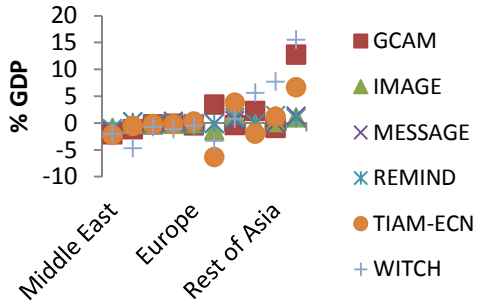


Figure 12 Climate-related financial transfers (RefPol-450-EE, 2020-2050 cum. values, NPV 5%)

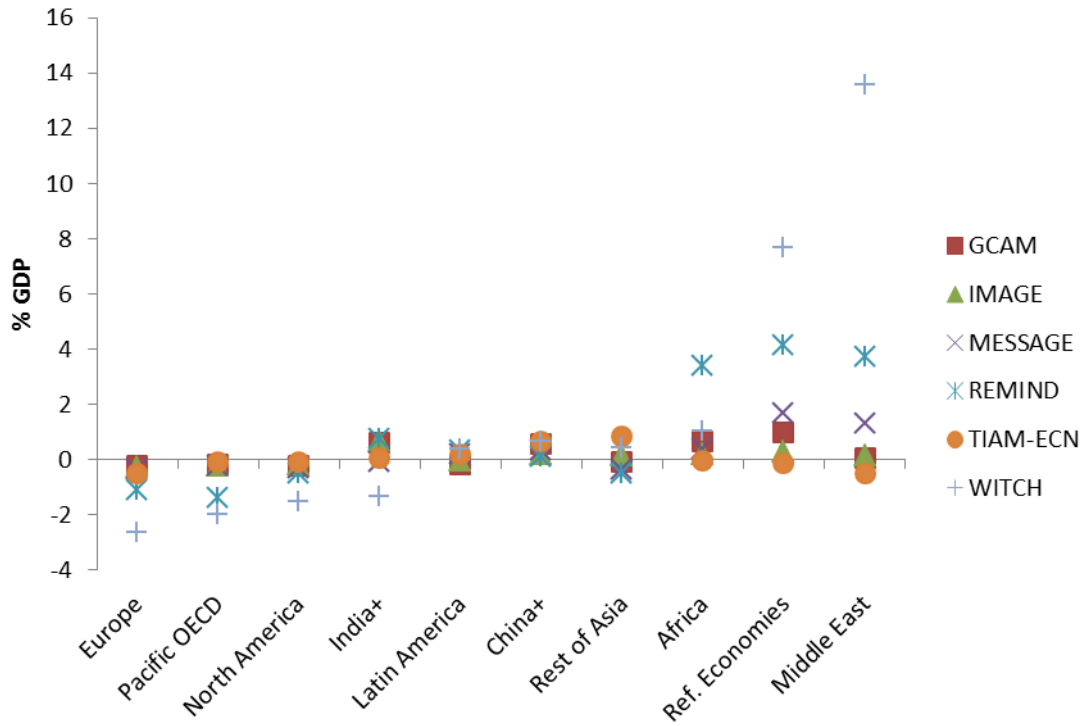


Figure 13 Total annual financial flows to emerging economies in RefPol-450-PC

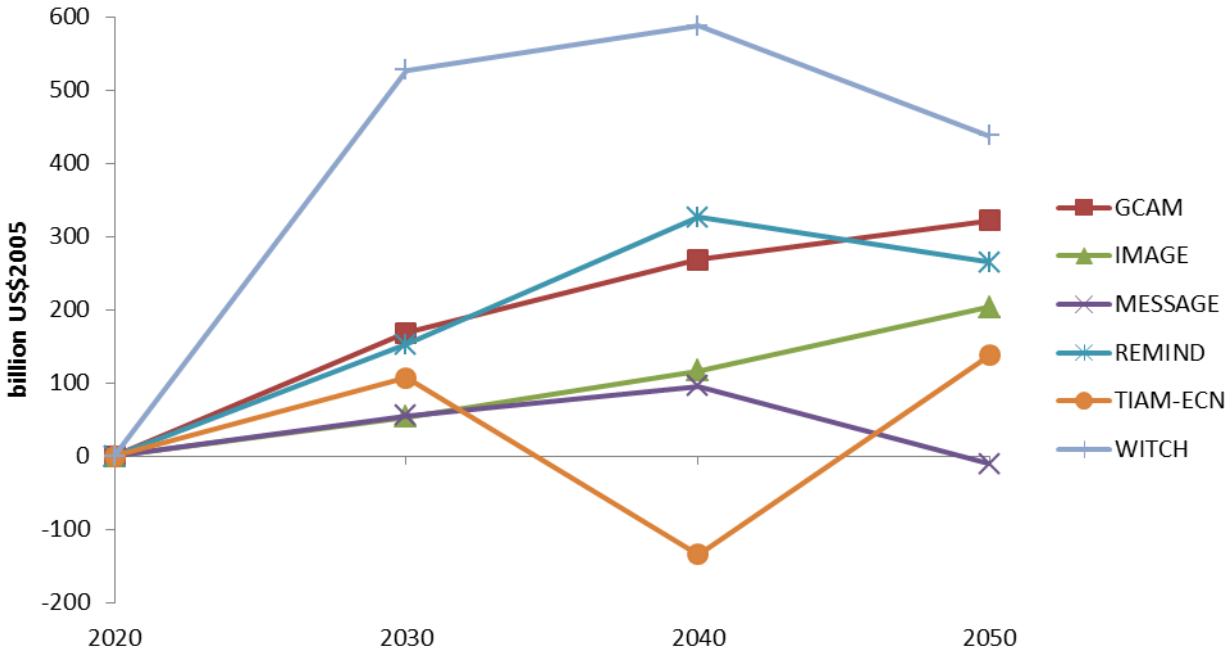


Figure 14 Total annual financial flows to emerging economies in RefPol-450-EE

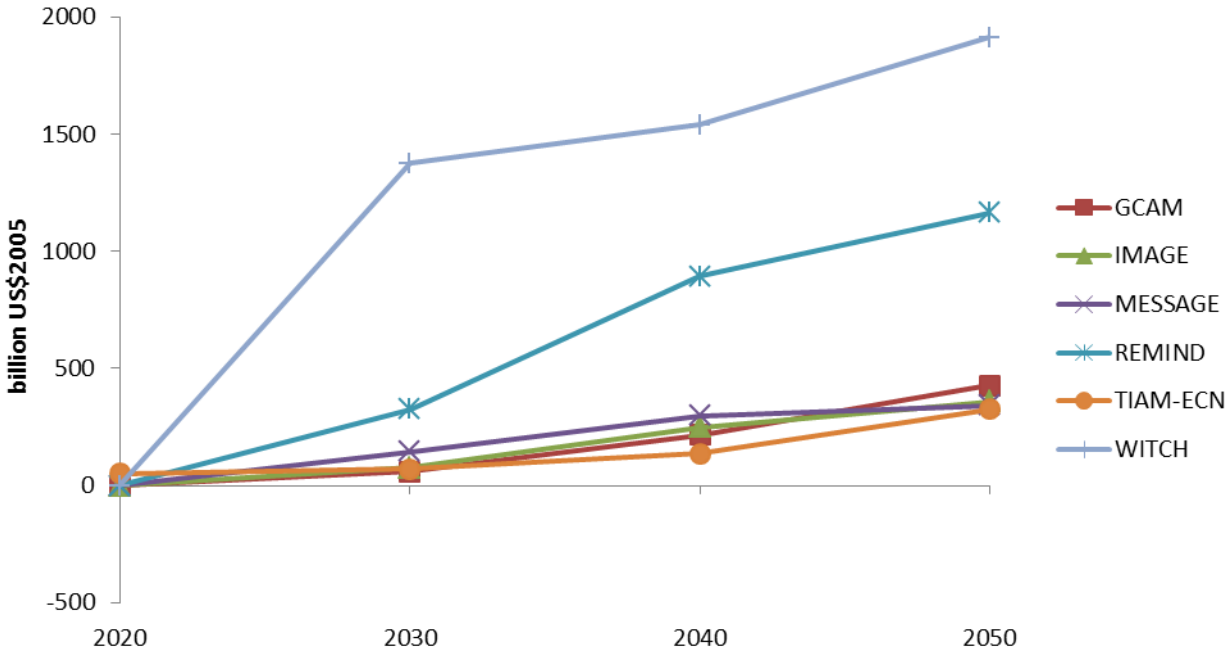


Figure 15 Energy supply domestic investment requirements in RefPol-450 (2020-2050 cumulated values, NPV 5%)

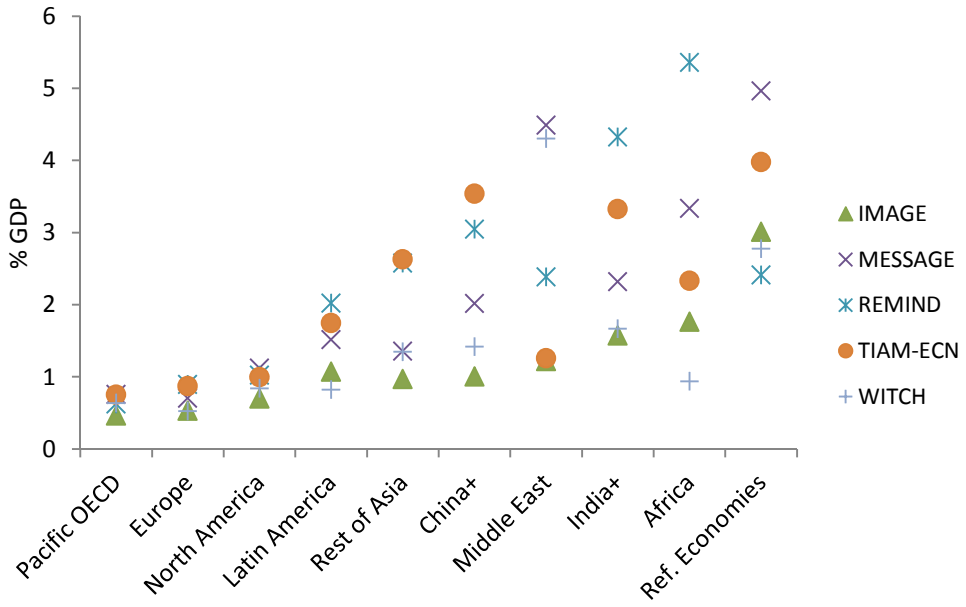


Figure 16 Energy supply domestic investment requirements net of allowances trade in RefPol-450-PC (2020-2050 cumulated values, NPV 5%)

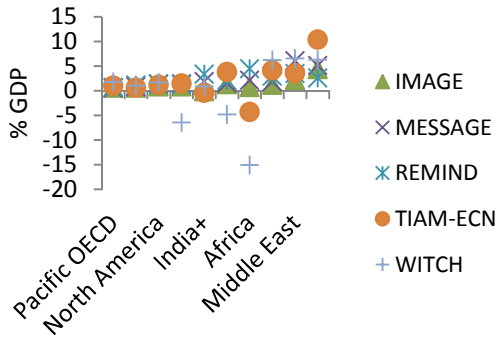


Figure 17 Energy supply domestic investment requirements net of allowances trade in RefPol-450-PC (2020-2050 cumulated values, NPV 5%)