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The 'optimal and equitable' climate finance gap*

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Abstract

This study employs a number of Integrated Assessment Models to determine what the optimal financial transfers between high-income and developing economies would be if climate mitigation effort, measured as mitigation costs as a share of GDP, were to be divided equally across regions. We find these to be larger than both current and planned international climate finance flows. Four out of six models imply that a North-South annual financial transfer of around US\$ 400 billion is required by 2050, while the other two models imply larger sums, up to US\$ 2 trillion. The equal effort constraint means that current oil exporting regions - Middle East and Former Soviet Union in particular - would receive relatively large amounts as a share of GDP. However, transfers never exceed 1-2% of GDP for high-income country regions in any model. Some potential sources of funds are reviewed, including carbon markets, public aid, private investment, development banks and special climate-related facilities. At the moment, finance flows through these channels do not appear to be equal to the task. Finally, we draw some policy conclusions, arguing that expanding private investment, if properly managed, could represent the most effective strategy to fill the 'optimal and equitable' climate finance gap.

Keywords: climate finance, equitable development, North-South flows, Integrated Assessment Models, carbon markets

JEL classification: F30, Q54, Q56

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1. Introduction

Climate change is a profoundly asymmetric development issue. First, it is making an impact on an asymmetric world, in which countries strongly differ in their stages of development and levels of income. Second, climate change has asymmetric effects, because damages from climate change are likely to be harsher for many countries with low levels of income (IPCC 2014) and, in the absence of compensating transfers, mitigation and adaptation costs would impose a higher proportional burden on the shoulders of emerging economies (Tavoni et al. 2014).

High-income countries have thus agreed, through the United Nations Framework Convention on Climate Change (UNFCCC), to cover the 'agreed full incremental costs' of implementing mitigation measures and to 'assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation' (UNFCCC 1992). In particular, the 2009 Copenhagen Accord set a goal for high-income countries to mobilise jointly US\$ 100 billion a year by 2020 'to address the needs of developing countries' through the establishment of instruments such as the Green Climate Fund, the Technology Mechanism and Fast-Start Finance (UNFCCC 2009). However, scaling up climate finance to developing countries has been slow, creating a major challenge to the success of international climate-change negotiations (Fenton et al. 2014). Even more importantly, financial targets do not seem to have been chosen on the basis of a well-informed, 'scientific' analysis.

In order to gain more insight into what would be the optimal size and distribution of climate-finance transfers between high-income and emerging economies, this paper employs results from the Integrated Assessment Models (IAMs) participating in the LIMITS project (Kriegler et al. 2014; Tavoni et al. 2015)¹. The aim of the LIMITS project was to study the feasibility of limiting the global temperature increase since pre-industrial times to less than 2°C. It benefited from a number of characteristics that make it a useful source of projections for incremental mitigation costs: all the models used detailed descriptions of the global energy supply system; all used an up-to-date reference scenario including already implemented climate policies; and the mix of types of model provided a form of robustness check on projections.

In this paper, we analyse a scenario in which a global carbon price is used to keep the world below the 2°C ceiling. A global carbon market allows regions to trade emissions permits among themselves, with permits allocated according to an 'equal effort' rule in which abatement efforts (measured in terms of mitigation costs as shares of GDP) are equalised across regions. The projected flows of finance from permit trading are then compared with estimates of current North-South climate financial flows from a variety of sources such as private investment, funds from development banks and Official Development Assistance (ODA). We find the former to be larger than both current and planned international climate

¹ 'LIMITS' stands for 'Low climate IMpact scenarios and the Implications of required Tight emission control Strategies.'

finance flows, and discuss the most effective strategies to fill this ‘optimal and equitable’ gap.

The paper is structured as follows. Section 2 introduces the LIMITS models and scenarios. Section 3 presents the international climate-related financial flows resulting from the implementation of an ‘equal effort’ allocation rule. Section 4 describes the state of current North-South climate finance. Finally, section 5 draws some policy implications and concludes.

2. Equitable climate-finance flows: The modelling framework

This study involves six Integrated Assessment Models from the LIMITS project; GCAM (Kim et al. 2006), IMAGE (Bouwman et al. 2006), MESSAGE (Riahi et al. 2011), REMIND (Leimbach et al. 2010), TIAM-ECN (Keppo and van der Zwaan 2012) and WITCH (Bosetti et al. 2009). The models use a harmonised group of ten geographical regions (Africa, China+, Europe, India+, Latin America, Middle East, North America, Pacific OECD, Reforming Economies and Rest of Asia)². All models cover the time period from 2020 until 2100.

The models are large-scale numerical models that simulate the dynamic interconnections among the economy, climate and the energy system; details of their design can be found in Kriegler et al. (2014). The models represent a diversified range of modelling techniques and assumptions. In some of them, the dynamics are driven by the maximisation of a welfare function related to consumption, while in others the objective is to minimise energy costs. Some assume perfect foresight and apply intertemporal optimisation, while others adopt a recursive dynamic solution instead, where results are calculated for each time step and agents are not required to have perfect foresight. This variety makes the inter-model comparison exercise reflect features of the uncertainty around future physical and economic trajectories.

All the models are used to run the same set of scenarios. The three scenarios most relevant for the purposes of this paper are presented in Table 1: a reference scenario with ‘weak’ climate policies (*RefPol*); a stringent climate policy scenario (*RefPol-450*); and a stringent climate policy scenario with emissions permits and permit trading (*RefPol-450-EE*). None of the model scenarios explicitly take into account any benefits of avoided climate change or any costs of adaptation; hence the LIMITS projections do not reflect a cost-benefit analysis, but rather focus on a cost-effectiveness assessment of policies to keep below the 2°C ceiling.

The *RefPol* scenario assumes that for the rest of the century individual regions implement only the commitments included in the Copenhagen agreement. These commitments are low and fragmented across the regions and lead by 2100 to an increase in global temperatures of 3-4°C (Kriegler et al. 2014).

² For the purposes of this paper, 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. Two models, WITCH and REMIND, also have a Rest of the World region. For more details, see Tavoni et al. (2014).

Table 1 LIMITS scenarios summary

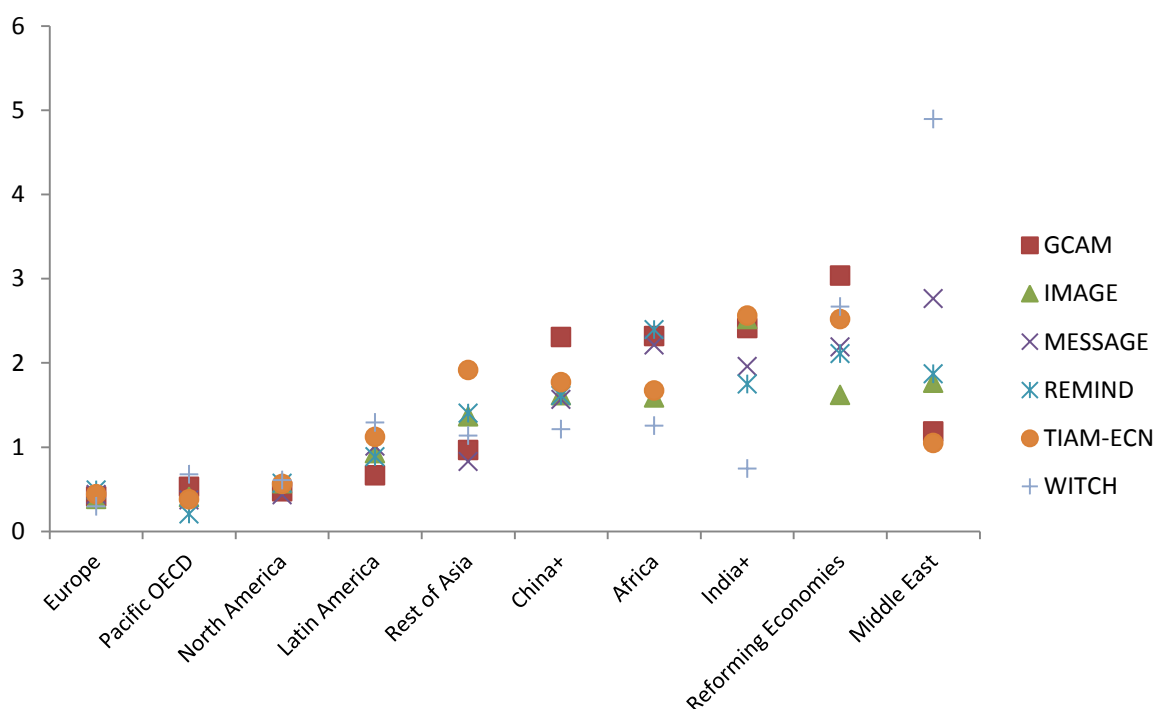
Scenario	CO ₂ e Concentration target (in 2100)	Policy before 2020	Policy after 2020	Burden sharing rule
RefPol	/	Weak policy		/
RefPol-450	450 ppm	Weak policy	Global GHG tax	/
RefPol-450-EE	450 ppm	Weak policy	Global GHG tax	Equal mitigation costs

The *RefPol-450* scenario, by contrast, is LIMITS' main mitigation scenario. It assumes that the Copenhagen Commitments are applied until 2020 but then a globally uniform carbon price is introduced so as to achieve a concentration target of 450 parts per million of CO₂ equivalent (CO₂e) by 2100.³ This can be thought of as a carbon tax applied in all regions and on all GHGs covered by the Kyoto Protocol. This scenario delivers efficient climate-change mitigation, in the sense that suitably discounted consumption is maximised or the discounted costs of decarbonising the energy system are minimised (depending on the model).

In the *RefPol-450-EE* scenario, where EE stands for 'Equal Effort', each region is allocated a certain amount of emissions allowances, which can then be used or sold to other regions in a global carbon market. The allocation of allowances is designed to equalise abatement effort across regions, in the sense that, from 2025/2030 onwards, all regions incur the same mitigation costs as proportion of GDP. An extensive literature exists on climate burden-sharing mechanisms and equity in the distribution of abatement costs (Ringius et al. 2002; Rose et al. 1998). A number of rules governing the allocation of costs have been suggested that could be perceived as fair by both high-income and developing regions, including ones based on the convergence of per capita emissions, carbon intensity, historical responsibility, grandfathering, or a combination thereof. The LIMITS project advances the debate by considering (as one option) a mechanism that aligns current and future mitigation costs, measured as percentage of domestic income, across all regions. The resulting *RefPol-450-EE* scenario provides a useful 'equal effort' benchmark for future negotiations, even though it would not necessarily gain universal acceptance of its fairness, especially by those arguing that historical responsibility for climate change should be taken into account. A more detailed description of the scenario can be found in Tavoni et al. (2014).

³ A concentration of 450ppm CO₂e is consistent with a probability of greater than 67% of remaining below the 2°C ceiling. Temporary overshooting of targets is allowed.

Figure 1 Regional mitigation costs per unit of GDP relative to World in *RefPol-450* (2020-50 cum. values, NPV 5%)



3. Results: ‘Optimal and equitable’ North-South climate finance

3.1. The unequal distribution of costs under efficient mitigation

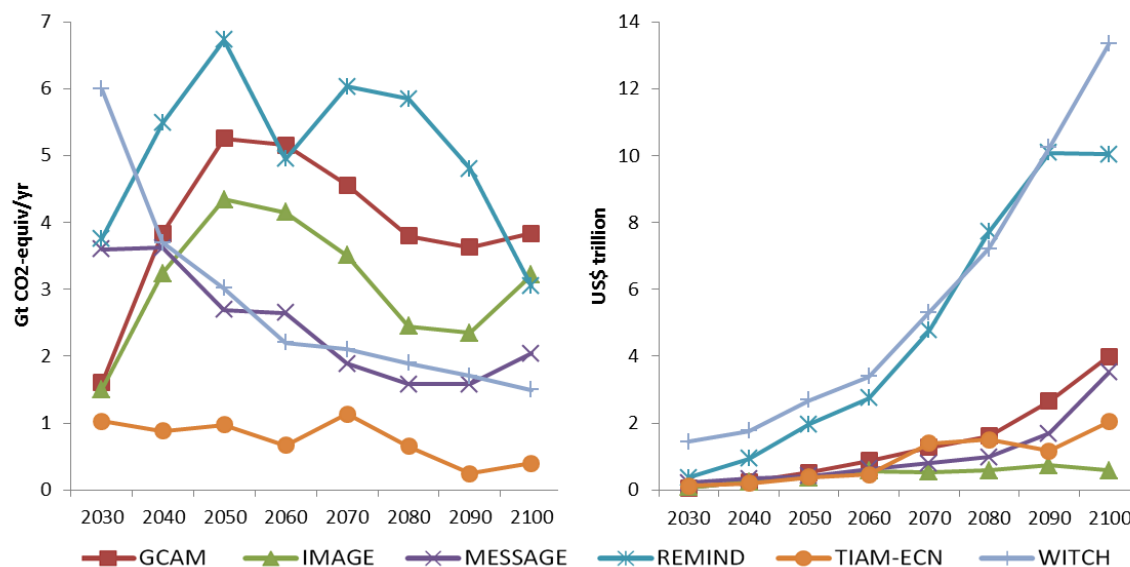
The models project that emissions in *RefPol-450* peak in 2020 and start declining rapidly immediately thereafter, reaching negative values by the end of the century. This causes a loss in income with respect to the baseline *RefPol* scenario, but growth rates remain positive in all regions.

Although total mitigation costs in this scenario are minimised, they are strongly unequally distributed across regions. Figure 1 reports the regional costs⁴ associated with climate-change policies in *RefPol-450* as a proportion of global average mitigation costs⁵. The Figure shows how high-income regions (Europe, Pacific OECD and North America) bear a small proportion of overall mitigation costs, while low-income regions (Africa, India and others) and energy-exporting countries (Reforming Economies and Middle East) suffer mitigation

⁴ As in Tavoni et al. (2014), we compute regional mitigation costs using: consumption losses for models with a macro-economic component (MESSAGE, REMIND and WITCH); abatement costs for IMAGE and GCAM; and energy system costs for TIAM-ECN.

⁵ Comparing regional mitigation costs with global mitigation costs helps to control for the differences in projected global mitigation costs (cumulated over 2020-2050) across models, which are pronounced; projections range from 0.51% of global GDP (IMAGE and GCAM) to 5.84% (WITCH).

Figure 2 Global carbon market for the RefPol-450-EE scenario in volumes (left) and values (right)



costs well above the global average. These results – roughly consistent across models – are due to a variety of reasons, including different abatement potentials, the amount of baseline emissions, energy intensities and the importance of energy exports (Tavoni et al. 2014).

This unbalanced distribution of costs presents a serious obstacle to international climate negotiations. Given the historical responsibility of high-income countries for bringing about climate change so far (MATCH 2008), it is hard to imagine low-income developing regions agreeing to an arrangement in which climate mitigation costs (relative to GDP) are placed mainly on their shoulders.

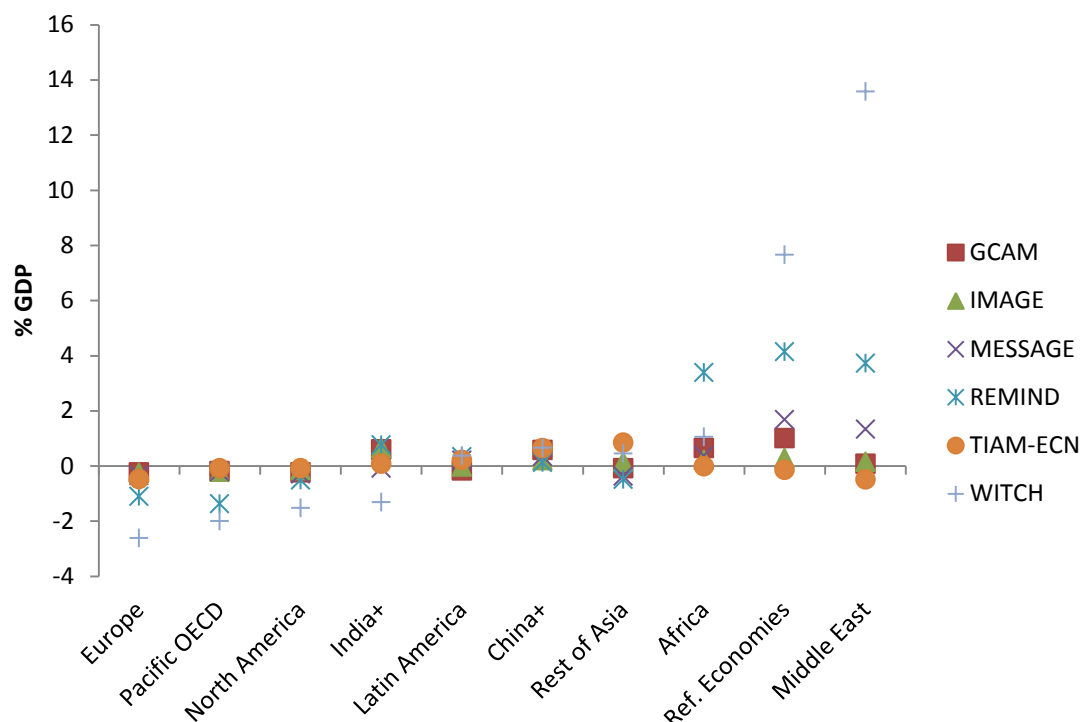
In order to examine the conflict between efficiency and equity along abatement paths, the *RefPol-450-EE* scenario is assessed in the next section.

3.2. Equalisation of Mitigation costs relative to GDP and financial transfers under a global carbon tax

Despite the allocation of emissions allowances according to the ‘equal effort’ rule, in the LIMITS models projected emissions still take place where it is most cost-effective to emit. The regions for which allowances are larger than their projected emissions sell the excess permits to those regions for which projected emissions are higher than the allowances initially allocated.

The left panel of Figure 2 shows the size of the resulting carbon market in terms of the total amount of emissions allowances exchanged each year. In the GCAM and IMAGE models, 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 in 2030 is larger than in GCAM and IMAGE. TIAM-ECN

Figure 3 Climate-related financial transfers in *RefPol-450-EE* (2020-2050 cum. values, NPV 5%)



projects that there will be a very limited market, below 1 GtCO₂e per year, while REMIND projects the largest one, above 5 GtCO₂e for most of the century. This can be contrasted with the volume of trades in 2014 of European Union Allowances (EUA) and Certified Emission Reductions (CERs) in the European Trading System – equal to 9 and 0.3 GtCO₂e, respectively⁶. However, the comparison has only limited validity, as LIMITS values take into account only net inter-regional flows, and not intra-regional ones (such as the ones arising from trade of EUAs).

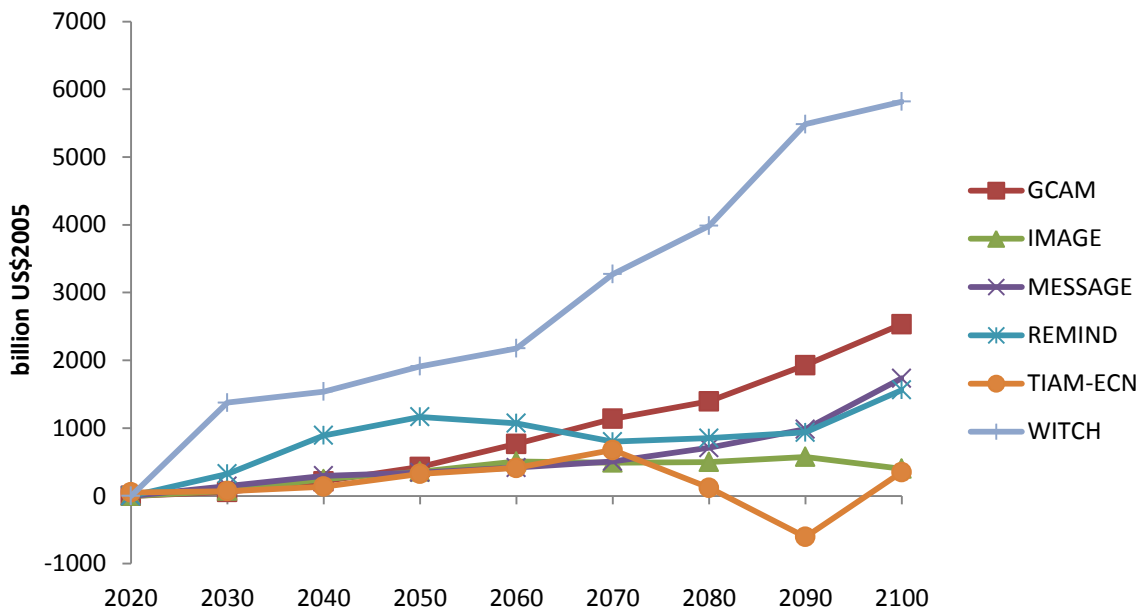
In the right panel of Figure 2, the amount of allowances exchanged is multiplied by each model's carbon price to show the economic value associated with the trade in the global carbon market⁷. WITCH and REMIND stand out as the models in which climate finance flows are the highest, reaching around US\$ 2 trillion by 2050 and more than US\$ 10 trillion by the end of the century. The other models exhibit a less steep increase in trade values, with less than US\$ 400-700 billion in 2050 and around US\$ 4 trillion (GCAM and MESSAGE), US\$ 2 trillion (TIAM-ECN) and US\$ 0.5 trillion (IMAGE) in 2100.

Figure 3 shows the direction of the carbon market financial flows, cumulated over the 2020-2050 period and as a percentage of regional GDP. The total economic value of the carbon market never exceeds 1% of GDP for a region, except in WITCH and REMIND projections, in which it reaches 3-4% in certain regions. High-income regions (Europe, Pacific OECD and North America) are projected to be net buyers of emissions allowances across all models. In

⁶ Data source: Bloomberg.

⁷ These results are highly dependent on the underlying carbon prices, the dynamics of which are very different across models. See Kriegler et al. (2014)

Figure 4 Total annual financial flows to emerging economies in *RefPol-450-EE*



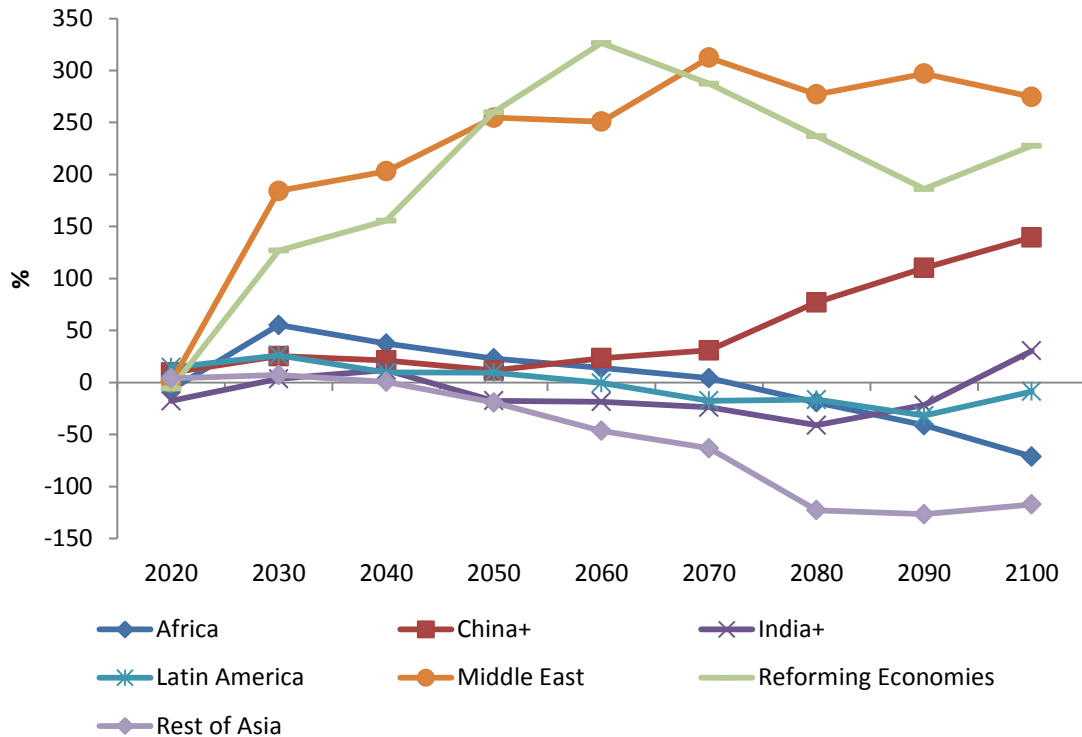
some models, the outflow represents only a small fraction of a percentage point of regional GDP, in others (WITCH and REMIND mainly) the cost of buying additional emissions allowances reaches 1-2% of GDP. The remaining regions show a higher degree of variability across models, but they broadly appear to be net sellers of allowances. These are particularly large in the case of Reforming Economies and the Middle East. This is due to the high mitigation costs that these regions, as energy exporters, suffer in the mitigation scenario without carbon trade: the equalisation of efforts required by the *RefPol-450-EE* scenario creates large financial inflows for them. The African continent also seems to benefit from the ‘equal effort’ allocation, although to a lesser extent.

Figure 4 shows the evolution of financial transfers from high-income to emerging economies over the 2020-2100 period. Despite a few exceptions, the general trend of these flows seems to be upwards throughout the century. By 2050, four out of six models report a North-South financial transfer of around US\$ 400 billion, while in REMIND and WITCH this is higher (US\$ 1 trillion and US\$ 2 trillion respectively). By 2100, North-South climate finance flows have surpassed the US\$ 1 trillion mark in four of the models, and WITCH reports again a higher value (around US\$ 6 trillion). However, these aggregate amounts hide large variation across regions. China, for instance, shows strong financial outflows during the second half of the century according to REMIND; the same happens to Africa and India for WITCH, Latin America for MESSAGE and the Rest of Asia for GCAM and REMIND.

Finally, Figure 5 compares regional financial flows with the optimal investment in energy supply needed to keep temperatures below 2°C. The curves represent the average across models⁸, and give an indication of how adequate potential carbon finance inflows are in

⁸ With the exception of GCAM, the results of which are not comparable with those of the other models.

Figure 5 Carbon financial flows as % of optimal energy supply investment



terms of supporting the required energy transition. A value above 100% means that financial flows resulting from carbon trading will be higher than the optimal energy supply investment, which could therefore be indirectly financed fully by those regions that need to purchase allowances. The results show that inflows for both the Middle East and Reforming Economies will be more than enough to finance the overall amount of their energy investment. The proportion of investment financed by external resources in China will hover around 20-30% until 2070, and will then increase above 100% by the end of the century. Africa will manage to cover a relevant proportion of its energy investment during the next few decades, with a peak around 55% in 2030, but will then become a net purchaser of allowances in the second half of the century. A similar trajectory is followed by Latin America, India, and Rest of Asia.

4. The current state of North-South climate finance

The previous section has presented projections of the financial transfers that would be necessary to equalise mitigation efforts across regions while keeping below the 2°C ceiling. How feasible is the achievement of this 'efficient and equitable' level of North-South climate finance? How large is the financial gap between this level and currently envisaged flows? The rest of the section addresses these questions by reviewing the current state of climate finance and international commitments.

Estimating climate-related financial flows – and in particular the ones flowing from high-income to developing economies – is not an easy task. First, large data gaps exist. These are

especially relevant for the private sector, which is subject to confidentiality concerns as well as to mixed incentives to report, but are present in the public sector as well. Second, there is no harmonised method to track and report climate finance data. No clear definition of 'climate finance' exists, and flows are reported using a number of different metrics, which are sometimes incompatible with each other. As a result, data on North-South climate-finance flows tend to be of low quality, fragmented and unverified (Clapp et al. 2012; CPI 2014; Stadelmann and Michaelowa 2013).

Despite these caveats, some estimates have been provided in the recent literature on climate finance. CPI (2014) calculates the financial resources flowing from OECD to non-OECD countries in 2013 in the range of US\$ 30-55 billion, depending on the method used. Most of this finance originates in development institutions, either bilateral or multilateral. Private investment and bilateral aid also play a role, while climate funds contribute only a very small proportion.

Comparing these estimates with our model-based projections of required North-South climate finance, there is likely to be a large finance gap from 2020 unless actual flows are ramped up rapidly. The next sections consider a number of climate finance sources that might be used to fill this gap.

4.1. Carbon markets and the Clean Development Mechanism

The creation of a global market in emissions allowances, such as the one assumed in the *RefPol-450-EE* scenario, is one option to attract climate-change finance to developing countries. However, the outlook for this channel is not encouraging at the moment.

The only current market-based instrument capable of generating climate-related finance flows from high-income to developing economies is the Clean Development Mechanism (CDM). The CDM was set up by the Kyoto Protocol to provide countries with quantitative mitigation obligations (Annex I countries) with the option to acquire emissions reductions from mitigation projects implemented in non-Annex I countries. Given that developing regions often offer cheaper mitigation options, the CDM allows high-income countries to meet their emissions reduction targets at a lower cost, while promoting sustainable development in emerging economies.

From 2005 to 2014 around 7,500 projects were registered to the CDM, leading to a reduction of 1.5 billion tonnes of CO₂e and an investment of US\$ 410 billion in climate-friendly activities (UNEP DTU 2015). Flows of funds to emerging economies of around US\$ 2.2-2.3 billion were generated from sales of Certified Emission Reductions (CERs) in 2009-10 (Clapp et al. 2012). Unfortunately, due to the European economic crisis and problems with the design of the EU Emissions Trading System, the price of CERs has fallen sharply. As a result, the incentive for potential project developers to invest has been reduced. From 2012 to 2013, investment in CDM-supported activities dropped from its peak of almost US\$ 200 billion to just above US\$ 20 billion (UNEP DTU 2015).

Although the CDM market has substantially weakened, it has helped prepare the ground for other carbon markets to rise. Governments around the world have incorporated lessons

learnt from the CDM in the design of new emissions trading schemes. There are currently 19 regional, national or and subnational ETSs operating. Around 7% of global emissions are now covered by these carbon markets (World Bank 2014).

These markets could be the precursors of a global carbon market yet to come, to be achieved by gradually linking up the sub-global ones (Flachsland et al. 2009; Ranson and Stavins 2014). A link between the California and the Quebec cap-and-trade programmes was set up successfully in January 2014. However, other plans to link carbon markets are currently frozen. Furthermore, discussions regarding linking have until now concerned only high-income countries (USA, Canada, European Union, Australia, Switzerland) so that, even if implemented, they would not contribute to making finance flow towards emerging economies.

4.2. Public sources

Public climate finance can be of two main kinds. First, high-income countries can decide to transfer financial resources directly to an emerging country to help its low-carbon development. In recent years, the climate component of bilateral Official Development Assistance (ODA) has become increasingly relevant, reaching US\$ 21.9 billion in 2013, equal to 17% of total ODA flows (OECD DAC 2014). However, the recent economic crisis reduced the already low aid commitments of high-income countries. In 2013, the long-standing objective of OECD countries to deliver the equivalent of 0.7% of their Gross National Product (GNP) as ODA had been achieved by only five countries out of 28⁹. It is not clear whether high-income countries will agree to increase their contributions to climate finance, and without diverting resources from other development objectives.

Second, high-income countries can support multilateral institutions, which in turn supply finance for climate-friendly activities in developing countries. There are, for example, a growing number of 'climate funds', initiatives designed to help developing countries address the challenges of climate change (CPI 2014). Several of them fall under the aegis of the Global Environment Facility (GEF). In 2013, climate funds spent around US\$ 2.2 billion (CPI 2014), a very low proportion of overall North-South climate finance, and an even smaller proportion of the flows needed in the future. The establishment of the Green Climate Fund (GCF) in 2010 was the centrepiece of the UNFCCC strategy of raising US\$ 100 billion per year for climate-friendly investment in developing countries (UNFCCC 2009). However, commitments of capital reached only just over US\$ 10 billion by the end of 2014 and disbursements were not expected to start until late 2015 (Schalatek et al. 2014).

4.3. Private investment

Private finance is potentially the most important source of funds for climate mitigation investment. Nelson and Pierpont (2013) estimate that as much as US\$ 45 trillion of portfolio investments are currently managed by OECD institutional investors holding long-term assets. Private investment flows can be divided between Foreign Direct Investment (FDI) – which leads to a controlling stake of the activity (>10%) – and portfolio investment (<10%).

⁹ Data source: OECD DAC; available at <http://www.oecd.org/dac/stats/>.

Stadelmann and Michaelowa (2013) estimate North-South climate FDI to have been in the range of US\$ 10-40 billion per year, and portfolio investment around US\$ 4-5 billion, in the period 2008-2011.

However, several obstacles are delaying private finance flows towards low-carbon activities in developing countries. First, at the moment, green investment is not attracting enough finance in general, whether in developing countries or elsewhere. This is due to typical features of many low-carbon assets such as high perceived riskiness, low returns, illiquidity, high upfront capital costs and high financing costs. Second, many developing countries may encounter difficulties in attracting low-carbon FDI because of legal and institutional obstacles (e.g. insufficient incentives and regulation, legal protection and lack of transparency) and socioeconomic challenges (e.g. lack of skills, expertise or training) (UNCTAD 2013). Some of the key factors in attracting FDI, such as market size, potential and availability of natural resources, cannot easily be influenced by public policy interventions (Hornberger et al. 2011).

4.4. Development banking

A fourth type of North-South climate finance source is represented by Development Financial Institutions (DFIs), including national development banks (e.g. Germany's KfW), multilateral development banks (MDBs) (e.g. the World Bank) and bilateral financial institutions (BFIs) (e.g. the Japan International Cooperation Agency - JICA). All these types of development financial institutions have a prominent role in providing climate finance. In 2012, DFIs committed US\$ 121 billion while during 2007-12 at least US\$ 425 billion were provided 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 US\$ 15-22 billion taking the form of international North-South flows. MDBs and BFIs have nonetheless become increasingly important in managing the international financial flows between OECD and non-OECD countries, delivering the majority of total North-South climate finance, according to CPI (2014). In particular MDBs – although limited compared with the national ones by their smaller budgets – have been vigorously involved in financing the green economy.

Multilateral development banks have also been the most active promoters of the diffusion of 'green bonds', which have a substantial 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 labelled green bonds in 2014 was round US\$ 50 billion, with other unlabelled climate-themed bonds amounting to US\$ 450 billion (CBI 2014). These

institutions can also play a role in providing development policy loans and ‘carbon financing’ in the recipient country. MDBs have also played a role as implementing agents of the UNFCCC’s Global Environment Facility (GEF).

5. Conclusions and policy implications

This study has employed a number of Integrated Assessment Models to determine what financial transfers between high-income and developing economies would have to be if climate mitigation effort, measured as mitigation costs as a share of GDP, were to equalised across regions. Four out of six models imply that a North-South annual financial transfer of around US\$ 400 billion is required by 2050, while the other two models imply larger sums. By 2100, the ‘optimal and equitable’ climate finance flows to developing countries are well above US\$ 1 billion according to four of the models. The definition of equal effort means that the reforming economies and current oil exporting regions would receive relatively large amounts as a share of GDP. However, transfers never exceed 1-2% of GDP for high-income country regions in any of the model projections. Hence the cost to high-income countries, while substantial, is not likely to be prohibitive.

The warranted transfers are larger than both current and planned international climate finance flows, and additional resources will have to be employed to meet the models’ projections of finance needs. However, a review of the main possible sources and channels of climate finance suggests that all of them are currently very far from their potential.

The shortcomings of public climate finance appear particularly hard to overcome. The international development finance strategies of most high-income countries have a poor historical record, as shown by the widespread failure to meet the agreed objective of devoting the equivalent of 0.7% of GNP to aid. The climate finance goals to which high-income countries have committed are rather unambitious. For instance, pledges to the Green Climate Fund - supposedly the cornerstone of international action on climate change - represent only a very small proportion of what models show will be needed. In addition, there is no guarantee that pledges will be fulfilled¹⁰. Moreover, the recent emphasis in many high-income economies on reducing budget deficits does not favour helping countries that will soon be direct competitors, and that will be able to finance climate change mitigation on their own (Bowen et al. 2014).

Similarly, carbon markets do not currently appear to be a good instrument with which to fill the North-South climate finance gap, at least in the short run. Existing carbon markets are not flourishing, especially in the case of the now moribund Clean Development Mechanism, the only market that allows for significant international flows. The development of new carbon markets - most notably the prospect of a unified Chinese trading scheme - certainly represents good news, but will only help with meeting domestic mitigation commitments. North-South flows could only take place in the context of a global market, or by linking up

¹⁰ According to Climate Funds Update, out of a total of US\$ 33.5 billion pledged for climate funds, only US\$ 14.9 billion (44.5%) have been deposited so far, and only US\$ 1.7 billion (4.7%) disbursed. See climatefundsupdate.org/data.

existing carbon markets, which however seems an unlikely option in the short to medium term.

Therefore, it is private, profit-driven investment that is most likely to fill the North-South climate finance gap. This can originate from both high-income economies' firms investing directly in developing countries or development banks redirecting the resources raised on private capital markets through the issuance of 'green' financial instruments. These two channels of finance already represent the source of the overwhelming majority of global climate investment (CPI 2014). Relying on investors motivated purely by financial returns may underpin international climate finance more effectively than the fluctuating goodwill of policy-makers.

However, at the moment, climate-friendly investment opportunities are not sufficiently attractive from an economic perspective at either the domestic and international level. Low-carbon investment tends to have long-term time horizons, high initial capital costs, high financing costs and, more importantly, strong perceived risks attached, related to technology evolution, market development and policy support (Frisari et al. 2013). These features often scare investors away.

Various public policies can be designed and implemented to modify the risk/return profile of abatement activities, the most important of which is the introduction of a price on carbon: changing the system of price incentives should make green activities more attractive to firms and households. To complement carbon pricing, or to substitute for it when it would be politically infeasible or economically detrimental to introduce it, there is a wide variety of other policy instruments that can be employed, including de-risking government instruments, 'green' industrial policies and financial regulation (Campiglio 2015; Fay et al. 2013; WEF 2013). Additionally, it is essential for governments of low-income countries to develop robust investment promotion strategies by improving their institutional and regulatory framework, as BRICS countries have been doing in recent years (Bayraktar 2013; UNCTAD 2013). Public finance will still be necessary for sectors in which financial returns are likely to be low even in presence of such policies (e.g. adaptation activities).

Finally, some considerations must be developed regarding the appropriate governance arrangements for future North-South finance flows. In the event that climate finance does expand as rapidly as the projections in this paper suggest is desirable, several developing countries will have to manage financial inflows that are significant relative to GDP. Countries with immature financial intermediation systems and unstable public institutions may incur in a 'climate curse' triggering macroeconomic difficulties through exchange rate appreciation, rent-seeking and the undermining of fiscal discipline (Jakob et al. 2015). Developing countries should therefore continue to improve the efficiency of domestic financial intermediation and ensure monitoring, transparency and debate about the use of the finance flows.

A sounder legal and financial system will also help to raise domestic finance in developing countries. Historical experience suggests 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 employ the revenues raised from

carbon pricing to finance investment in capital embodying low-carbon technologies (Bowen et al. 2014).

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