PART VII

Climate Finance

32 The macroeconomics of climate policy: Investments and financial flows

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This chapter illustrates the plausible implications of climate mitigation policy on investments in power generation and on the energy sector in general. The chapter also discusses climate policy related financial flows. The goal is to inform policymakers about a wide range of macroeconomic effects of climate policy and on plausible investment needs in developed and developing countries.

1 Introduction

A large number of studies have examined the technology transformations and the economic cost of many different scenarios of climate mitigation policy (Clarke et al. 2014). Virtually all the scenarios provide estimates of the economic cost of climate mitigation and detailed information on the least-cost technological options to achieve the desired level of greenhouse gas (GHG) concentrations. The technical feasibility and the macroeconomic cost for society of alternative pathways to stabilise the emissions of GHGs are of paramount importance for policymakers and climate negotiators.

The priorities of the research community are thus well justified. However, policymakers and negotiators also need other valuable information, such as on investments and other financial flows induced by climate mitigation policy. For example, the distribution across countries and over time of investment needs is important when negotiating burden-sharing agreements. Economists suggest that carbon taxes or trading of emissions permits are the most efficient policy tools to decarbonise our economies, and that carbon tax revenues can be used to increase the efficiency of the tax system. Policymakers have often expressed interest in using carbon tax revenues to boost mitigation and adaptation efforts. It is thus important to know in advance the expected financial flows from carbon pricing. There are also other politically sensitive questions that cannot be addressed without a broad overview of the macroeconomic consequences of climate policy. For example, all scenarios that stabilise GHG emissions in line with a 2°C target indicate that consumption of fossil fuels must be drastically cut and consumption of bioenergy must increase to many times above the present level. What are the financial implications for fossil fuels producers? What is the long-run effect of climate mitigation policy on the balance of payments of large exporters of fossil energy? How large are the revenues expected to be for the producers of biomass?

Unfortunately, none of these questions has been answered in a satisfactory manner. The most recent Working Group III report to the IPCC, for the first time, has a whole chapter dedicated to cross-cutting investment and financial issues of climate mitigation policy (Gupta et al. 2014). Nevertheless, one of the main messages from this chapter is that the literature still has very large gaps.

There are, however, a growing number of studies that provide insights on a wide range of macroeconomic impacts of climate policy. The goal of this chapter is to survey this literature and to present results and insights that, albeit still partial and uncertain, have implications for climate change negotiations. There are also a growing number of studies that look at the current global climate finance landscape (e.g. Buchner et al. 2014 and the chapter by Buchner and Wilkinson in this book). This chapter will not review those studies and will focus only on the literature that uses Integrated Assessment Models (IAMs) to estimate future investment needs and financial flows.

The rest of the chapter is structured as follows: Section 2 reviews the literature that develops scenarios of future investment needs in climate change mitigation; Section 3 assesses potential revenues from carbon pricing; Section 4 reviews estimates of investment needs in climate change adaptation; and conclusions follow.

2 Investment needs

Without climate policy, the largest fraction of investments in the power sector is expected to go to fossil fuel generation (Gupta et al. 2014). The mean estimate of annual investments in fossil fuel generation among the surveyed studies is equal to US$182 (95 to 234) billion in 2010–2029 and $287 (158 to 364) billion in 2030–2049. This is equivalent to about 50% of total investments in power generation from 2010 to 2049. Of these investments, 80% are expected to go to non-OECD economies.

All the surveyed studies see a strong growth in renewables in the BAU scenario, with annual mean investments ranging from $131 billion to $336 billion from 2030 to 2049. Investments in nuclear power generation are also expected to grow, but there is more uncertainty here in the literature. Between 2030 and 2049 the surveyed studies generate scenarios that range between zero, which implies a phase out of nuclear, to $155 billion per year.

Climate policy that aims to stabilise GHG concentrations at between 430 and 530 ppm CO_2-eq by 2100 (with about 50% probability of achieving the 2°C target) sharply redirects investments from fossil fuel generation to renewables, nuclear power and fossil fuel power plants with carbon capture and storage. Renewable generation technologies and nuclear will require higher up-front capital investments but no, or only little, expenditure on fuels. Fossil fuel power plants with carbon capture and sequestration (CCS) will require both higher up-front capital costs and higher expenditure on fuels, due to the loss of efficiency in order to capture CO_2.

By shifting investments away from fossil fuel power plants, climate policy has the potential to increase investment needs. However, by making power generation more expensive, mitigation policy increases the incentive to reduce the demand for electricity, which decreases the need for investments. Which of the two effects prevails is a matter of empirical investigation.

Overall, the median scenarios suggest that investments in power generation will increase under climate policy, by about $100 billion per year until 2029 and by $400 billion per year between 2030 and 2049. Additional data is reported in Table 1. This investment amount is largely equivalent to the present global flow of investments in power generation (McCollum et al. 2013). To put this into perspective, $400 billion per year is equivalent to 0.5% of gross world product in 2013. However, assuming a 2.5% growth rate from now to 2050, the incremental investments will be equal to just 0.2% of gross world product in 2050. Other studies have found that investments in power generation may instead decline with respect a BAU scenario due to a sharp decline in electricity demand (Carraro et al. 2012, Iyer et al. 2015).

None of the estimates cited above includes investments for the grid or for storage of renewable power generation, because virtually none of the studies surveyed by the IPCC provided this information. One study finds that an additional $17 billion per year is necessary to upgrade transmission and distribution lines and to build storage capacity to manage renewable power generation (Riahi et al. 2012).

Investments in energy efficiency are hard to assess because energy efficiency can be increased in many ways. Energy efficiency improvements are often embodied in new vintages of capital and it is hard to disentangle the cost of each component of complex machineries. Energy efficiency is also increased by investing in new materials and new management practices that cannot be easily quantified. Two studies surveyed by the IPCC suggest that incremental investments in energy efficiency may top $600 billion per year in 2030 and $800 billion per year in 2050 (Gupta et al. 2014 and Table 1).

It is also very rare that models estimate how complex factors such as institutions affect the cost of financing. Iyer et al. (2015) find that investments in climate change mitigation increases after accounting for differences in institutional qualities in different areas of the world.

Very few models track expenditures in research and development (R&D) for climate mitigation. There is wide agreement that climate mitigation policy will trigger innovation and expenditure in R&D will increase, but it is very hard to estimate future investment needs. One message from the literature is that energy-related R&D investments will probably increase manyfold compared to the present level. But in absolute terms the increment is not going to be very large. Investments in energy-related R&D are equal to about 0.02% of GDP at present (Bosetti et al. 2009). Using data from Table 1 and assuming a constant 2.5% growth of the global economy, the additional investments in R&D would be equal to between 0% and 0.08% of global GDP in 2030 and to about 0.07% in 2050.

Table 1 Change of average annual investment in mitigation scenarios

	2010-2029					2030-2049				
	No. of studies	Median	Min	Mean	Max	No. of studies	Median	Min	Mean	Max
World										
Total electricity generation	5	126.3	16.5	104.1	205.2	2	249.9	132.9	249.9	367.0
Renewables	5	85.4	-3.2	86.0	175.6	2	115.6	19.1	115.6	212.1
Nuclear	5	31.6	27.7	43.1	66.8	2	86.8	61.1	86.8	112.6
Power plants with CCS	5	29.8	6.3	40.7	117.2	2	250.1	180.4	250.1	319.9
Total fossil power plants	5	-29.7	-165.8	-65.6	-2.1	2	-202.6	-267.2	-202.6	-138.0
Extraction of fossil fuels	5	-55.9	-368.9	-115.7	8.3	2	-495.7	-724.6	-495.7	-266.8
Energy efficiency across sectors	4	335.7	0.8	328.3	641.0	1	458.0	458.0	458.0	458.0
R&D in energy sector*	3		4.5		78.0			115.0		126.0
Non-OECD										
Total electricity generation	4	48.3	-1.1	51.4	110.1	3	378.9	215.0	347.3	448.1
Renewables	4	44.5	-1.5	48.4	105.9	3	226.8	25.7	173.4	267.6
Nuclear	4	20.0	16.4	19.8	23.1	3	120.4	83.6	117.6	148.8
Power plants with CCS	4	19.7	4.4	32.0	84.4	3	219.6	66.9	247.9	457.2
Total fossil power plants	4	-34.8	-110.8	-48.8	-14.9	3	-159.5	-351.5	-191.5	-63.6
Extraction of fossil fuels	4	-33.9	-278.5	-85.4	4.9	3	-451.3	-1384.5	-722.5	-331.8
Energy efficiency across sectors	3	301.3	0.4	211.5	332.7	2	681.0	571.8	681.0	790.1
OECD										
Total electricity generation	4	40.1	13.3	47.2	95.1	2	81.6	81.1	81.6	82.1
Renewables	4	32.0	-1.7	37.8	88.7	2	31.1	6.6	31.1	55.5

	2010-2029					2030-2049				
	No. of studies	Median	Min	Mean	Max	No. of studies	Median	Min	Mean	Max
Nuclear	4	24.7	11.3	26.1	43.7	2	15.2	7.9	15.2	22.5
Power plants with CCS	4	14.6	1.9	16.0	32.8	2	88.3	39.2	88.3	137.3
Total fossil power plants	4	-28.9	-71.6	-32.6	-1.1	2	-52.9	-84.3	-52.9	-21.5
Extraction of fossil fuels	4	-13.2	-90.4	-28.3	3.4	2	-363.0	-659.9	-363.0	-66.1
Energy efficiency across sectors	3	186.4	0.4	165.0	308.3	1	113.8	113.8	113.8	113.8

Notes: Mitigation scenarios that stabilise concentrations within the range of 430–530 ppm CO2-eq by 2100. Change relative to respective average baseline investments. For a complete list of references, see notes to Figures 16.3 and 16.4 in Gupta et al. (2014).

Source: Data used to draw Figure 16.3 and 16.4 in Gupta et al. (2014). * R&D investments are from UNFCCC (2007), Carraro et al. (2012) and McCollum et al. (2013) for 2010-2029 and from Carraro et al. (2012), Marangoni and Tavoni (2014), McCollum et al. (2013), Bosetti et al. (2009) and IEA (2010).

There are also very few studies that assess the impact of climate policy on investments for the extraction of fossil fuels. This is a sector that will be crucially affected by climate mitigation policy. The implications of climate mitigation policy for fossil fuels extraction are obvious, but estimating investment needs is very hard because reliable data are not available. The scenarios reviewed by the IPCC reveal a few robust messages. First, climate policy will drastically reduce demand for fossil fuels. With policies consistent with a 2°C target, revenues and rents from oil extraction will collapse. Investments in oil extraction drop to just a small fraction of present investments (Carraro et al. 2012, Gupta et al. 2014). Coal and natural gas, even if equipped with carbon capture and storage, will eventually not be profitable because the capture rate is lower than 100%.

This has striking and often overlooked consequences for fossil fuel-exporting countries, especially those with large non-conventional, expensive resources. The reverse of the medal of energy security in developed countries is economic insecurity in fossil fuel-exporting developing and transition economies. There is time for a smooth transition, but actions should be taken now to build skills and capital on a large scale in countries that often lack dynamic economies.

Conversely, some countries may become large exporters of biomass. All the 2°C scenarios assessed by the IPCC rely on massive use of bioenergy at the end of the century (Clarke et al. 2014). The implicit assumption of these models is that international trade of biomass will equate global demand and supply. However, the models do not keep track of the financial implications of a new commodity market that could be as valuable as the oil market today (Favero and Massetti 2014). The 2°C-consistent scenarios suggest that rents from oil resource owners shift to land owners in countries with high biomass productivity, such as Brazil and Russia. In some cases, this will be only a domestic reallocation of rents. In other cases, there will be an international redistribution of wealth.

3 Revenues from carbon pricing

Climate mitigation policy can be implemented in a variety of ways. Command-and-control policies and market tools can be used alternatively or jointly. If emission allowances are auctioned, under general conditions, carbon taxes and cap-and-trade generate the same flow of revenues. In a thought experiment, the carbon tax can be multiplied by the level of GHG emissions to estimate the size of these flows (Carraro et al. 2012). A 2°C-consistent carbon tax would generate up to $3 trillion per year of revenues in OECD economies in 2050; this is equivalent to 3.5% of OECD aggregate GDP. There is large potential for tax reform programmes that shift the tax burden from labour and other productive assets to negative environmental externalities (Goulder 1995, Parry and Bento 2000).

In developing countries, carbon tax revenues would range between 5% and 10% of GDP in 2025 and up to between 20% and 25% of GDP in 2050 (Carraro et al. 2012). These are strikingly high figures, although for some developing countries, collecting these taxes may be a challenge. Carbon tax revenues may be higher than all current tax revenues in many developing countries (Tol 2012). In order to manage such large financial flows, institutions and markets in the Least Developed Countries must be strengthened (Tol 2012).

What will the time profile of these hypothetical carbon price revenues look like? This is an important question for fiscal planning. As a 2°C scenario requires very low or zero GHG emissions at the end of the century, tax revenues must eventually go to zero. The time profile of carbon-pricing revenues between now and the end of the century depends on how fast emissions will decline and on how fast the carbon price will increase. If the carbon price increases faster than emissions decline, revenues will follow a hill-shaped pattern. If emissions decline at a faster pace than the carbon price, carbon-pricing revenues will decline constantly.

It must be noted that a carbon-pricing scheme implies that activities that remove emissions from the atmosphere must be subsidised. The subsidy should be exactly equal to the carbon price. This means that all the scenarios that have total net negative emissions at the end of the century also assume that policymakers are able to subsidise them using revenues from other taxes.

Climate change economists usually run IAMs assuming a globally uniform – thus economically efficient – carbon price. Efficiency allows achieving the global temperature target at the least cost. The underlying hypothesis is that any equity issue can be solved by compensating low-income consumers using the efficiency gains. For example, high-income countries may reduce the cost of mitigation in developing countries by either implementing a global cap-and-trade programme with free allowances for developing countries or by directly investing in decarbonisation measures (see the discussion in the chapter by Stavins in this book). The financial implications of such distribution schemes are huge and often unexplored, with a few notable exceptions (e.g. McKibbin et al. 1998).

For example, an allocation scheme that promotes equity by equalising the abatement effort internationally would generate average annual financial flows to developing countries that range between $67 billion and $800 billion (McCollum et al. 2013). In some regions, financial flows would represent a large fraction of GDP (McCollum et al. 2013). There may be institutional, political, financial and macroeconomic limitations to implement these transfers. These very important considerations are rarely discussed. There may be a costly trade-off between efficiency and equity.

The IPCC review cited above indicates that non-OECD countries may need anywhere from zero to $100 billion of incremental investments in power-generation capacity per year until 2029, with a median estimate of about $50 billion (see Table 1). From 2030 to 2049, investment needs may increase to $270 billion per year in the median scenario. However, as already noted, these estimates are still highly uncertain.

4 Investment needs for adaptation

Assessing investment needs for adaptation to climate change is much harder than for mitigation. It is reasonable to expect that most of the adaptations to climate change will be private and relatively low-scale because adaptation is not plagued by global coordination problems (Mendelsohn 2000). Switching crop types, increasing irrigation, and changing planting and harvesting dates are examples of private adaptation in agriculture, one of the most climate-sensitive sectors. Increasing the use of air conditioning is another example of private adaptation. Unfortunately, there are no estimates of investment needs for these private adaptations.

There are instead some studies that quantify investments needed for large-scale public adaptation projects. However, the evidence from the literature is limited (Chambwera et al. 2014). The often-cited figure of $100 billion per year to finance adaptation in developing countries (UNFCCC 2007) is not supported by a strong peer-reviewed literature.

Negotiators and policymakers should be aware that estimating exact investment needs for adaptation is virtually impossible. First, there are large uncertainties over future local climate patterns. Second, there is high uncertainty over the impacts of future climate change. Third, it is not clear what will be the adaptations chosen by individuals, firms and governments. Finally, investments in adaptation to climate change cannot be easily disentangled from other investments.

The only reliable data exist for investments in protection against sea-level rise (Agrawala and Fankhauser 2008). Investments to protect major coastal cities are expected to be in the order of a few billion dollars per city for the initial construction and 2% per year for maintenance costs (Hallegatte et al. 2013). At the global level, sea level rise protection that satisfies cost-benefit criteria is expected to be equal to 0.02% of global GDP in the worst-case scenario of sea-level rise for this century (Nicholls et al. 2010). Estimates of investments in R&D for adaptation to climate change are highly speculative.

5 Conclusions

What lessons for policymakers and climate change negotiators can be drawn from the literature?

First, there will be winners and losers in climate policy. Climate mitigation policy will sharply increase the demand for wind and solar power generation, and for nuclear and hydro power plants. Efficient cutting-edge technologies and energy management know-how will be in high demand. Producers of these goods will greatly benefit from climate mitigation policy. Also, the forestry sector and producers of biomass that can substitute fossil energy will substantially gain. The biggest losers in climate mitigation policy are fossil fuel producers.

Countries with economies that rely heavily on fossil fuel extraction will suffer very sharp losses if they do not transform their industries. Countries that are not able to become producers of renewable technologies and high-efficiency consumption and capital goods will also likely lose from mitigation policy. This distribution between winners and losers is important because it greatly influences international climate negotiations. There will probably never be a global agreement without some sort of compensation for countries that are expected to lose large rents from fossil fuels.

Second, if governments use carbon pricing as a policy tool – either carbon taxes or auctioned emissions permits – they will be able to collect large carbon revenues. Economic theory does not suggest that these funds should be used to increase government spending; neither does economic theory encourage recycling these funds in mitigation or adaptation projects. Carbon tax revenues should be used where they yield the highest social return. For example, in developed countries they may be used to reduce distortionary taxes, such as taxes on labour. Developing countries may use the carbon funds for poverty alleviation and development. There is no universal answer; the optimal use will vary from country to country.

Third, the largest fraction of the investments in climate mitigation technologies will occur in developing countries. Discussions on how to finance these investments – i.e. burden sharing – must necessarily be at the centre of international negotiations. It will likely be impossible to implement a globally efficient climate policy without large transfers from high- to low-income countries. The consequence of not agreeing on burden sharing is either a low-profile or inefficient climate agreement.

Fourth, most of the investments necessary for both mitigation and adaptation will likely be private. After the right incentives are in place – e.g. a carbon tax – governments will not need to invest in solar power plants. Governments also will not need to invest in private adaptations because individuals and firms already have the incentive to do so. Governments need to invest resources where markets fail – in regulation of the new technologies, R&D in basic research and in public adaptations. In a world with limited government budgets, it is important that governments give high priority to fixing market failures rather than to sponsoring projects that crowd out private investments.

Fifth, if the right incentives are in place and credit markets are functioning well, private investors will be able to finance their investments using global financial markets. Net additional investments to de-carbonise the economy are expected to be large in absolute terms, but modest when compared to GDP. The limited evidence summarised in Table

1 indicates an increment equal to at most 0.4% of GDP in 2050, if one assumes that the world economy will grow at a constant rate of 2%. Financial markets can move resources from sectors where they are not needed (e.g. coal mines) to sectors in expansion (e.g. solar and wind).

Today there is a large gap between observed and desired investments in mitigation (see Buchner et al. 2015). This gap is the result of weak climate policies. The gap in climate mitigation policy generates a gap in investments. Theory and empirical evidence suggest that once the environmental externality has been corrected in a convincing way, investments will flow where needed. Markets are obviously not perfect and governments must intervene to adjust these inefficiencies. But, these seem to be second-order problems. Policymakers and negotiators should focus on the core problem of climate change: emissions of GHGs are an externality that is not paid by polluters. If policymakers close the 'policy gap', the investment gap will also disappear.

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33 Pros and cons of alternative sources of climate change financing and prospects for 'unconventional finance'

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Achieving a transformational change to a low-carbon and climate-resilient global economy requires a massive shift of financing towards climate-friendly activities. In less than a decade, the global financial landscape has undergone significant upheaval and change, and our understanding of opportunities to unlock climate finance has grown. Public and private actors have improved their awareness of the risks and opportunities associated with climate action, and are exploring new ways of investing in climate outcomes, increasing alignment between their policy and business interests and the pressing need to scale up climate finance. This chapter looks at the current global climate finance landscape, discusses the potential sources, actors, and instruments relevant for supporting climate finance for developing countries, and provides more evidence about whether different options contribute to the mobilisation of climate finance.

1 Who pays? Climate finance and the new global deal

As the Paris Summit in December 2015 approaches, countries are preparing emissions reduction targets and plans of action. One of the key questions is how and whether these actions will be financed. In particular, whether the historically rich group of developed countries will make good on their six-year old goal to deliver US$100 billion per year by 2020 to help poorer countries mitigate and adapt to climate impacts.

The absence of an internationally agreed definition of ‘climate finance’ is a major barrier to understanding the magnitude of climate finance and the barriers to climate finance investments. This chapter considers climate finance to include all primary private and public financial investment flows that specifically target low-carbon or climate-resilient development. This definition is consistent with that applied by the Climate Policy Initiative in its *Global Landscape of Climate Finance* reports (Buchner et al. 2011a).

1.1 Since its emergence, the $100 billion goal has been both a touchstone of good faith and a hallmark of mistrust

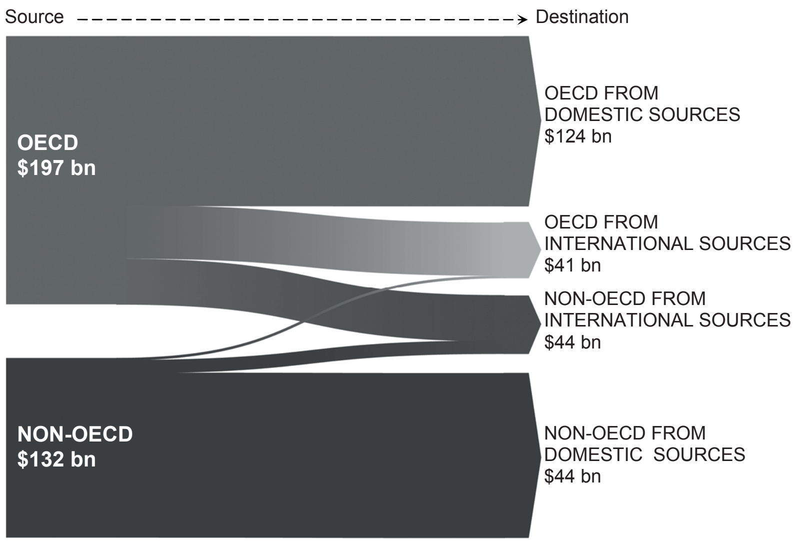
For Paris to succeed, countries must find a way to deal with the $100 billion question meaningfully and transparently. Crucially, they must also move beyond it. Dealing with it is no easy thing. To begin with, the language of the original agreement was vague, making it difficult to implement or to track progress. For example, what is climate finance? What alternative sources are ‘legitimate’? Second, despite known tracking difficulties, demonstrating progress transparently has now itself become a raison d’être, which if unmet, threatens to stall progress and undermine trust. The biggest challenge by far, however, may be moving beyond the dollars and cents, expectations, and political division that serve only to distract from achieving real impact on the ground.

While the challenges are big, the opportunities associated with getting financing right are even bigger. Much progress has been made in recent years to improve tracking systems and build knowledge about how *climate finance – as opposed to pure climate policy* – works. With this knowledge, there is a real opportunity for governments in Paris to deliver the seeds of a systemic shift that can take the $100 billion, a sizeable amount of which will be public finance from developed countries, and ensure it *supplements* and *complements* public resources from developing countries, and that together these public resources unlock trillions of dollars in private capital sitting in the margins to support the world’s transition to a low-carbon, climate-resilient future.

1.2 The world is making progress on the $100 billion goal

The $100 billion goal emerged at the height of the 2008-2009 financial crisis. Global economic recovery has been dynamic, bumpy, and complex – a situation that has presented challenges for economic, financial, and climate policymakers. After 2009, most economies shifted to a lower growth path (UN WESP 2015), which has been felt in weaker public finances. Even within this context, global climate finance flows reached $331 billion in 2013 (Buchner et al. 2014).[1] While investment in developing and developed countries was almost equally split, $34 billion, or roughly 10% of all investment, was transferred from developed to developing countries.

Figure 1 Cross-border climate finance flows



Source: Climate Policy Initiative 2014 (http://climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2014/)

In terms of transfers to developing countries, $22 billion was transferred as bilateral overseas development assistance, of which $11 billion was grants and $10 billion was loans. In addition, $3-4 billion was provided as non-concessional finance by bilateral development finance institutions (Buchner et al. 2014). Multilateral development banks

1 The authors of the *Global Landscape of Climate Finance* reports have repeatedly stressed that the overall estimates and the $100 billion UNFCCC climate finance goal are not comparable. For more information, see the 'methodology' in Buchner et al. (2014).

(MDBs) provided the remainder of public flows, while private finance accounted for around $2 billion.[2]

1.3 While the progress is significant, it falls far short of estimated global need.

The IEA estimated that from 2011 to 2050, an additional $1.1 trillion is needed each year in the energy sector alone to keep global temperature rise below 2°C (IEA 2014). The biggest challenge to shift resources from traditional, fossil-based activities to low-carbon ones is that aided and abetted by government subsidies across countries (IEA 2014),[3] investment in fossil fuel-intensive industries continues to outpace investment in clean energy and climate resilience and has a lifecycle that goes many years into the future.[4]

The good news is that the capital is available and important global trends present opportunities across countries to unlock billions more in low-carbon and climate-resilient investments around the world. The New Climate Economy (NCE) estimated that $89 trillion would be invested globally in infrastructure by 2030 – before accounting for climate action (NCE 2014).[5] At the same time, the cost of some renewable energies has fallen significantly, making these technologies price-competitive with polluting alternatives (see the chapter by Bosetti in this book, and also Buchner et al. 2014).[6] Project developers and households are installing more, for less. Oil prices also have dropped dramatically in the past year, presenting governments with a once-in-a-generation opportunity to level the carbon playing field by eliminating subsidies and pricing carbon without large cost impacts to consumers.

2 The Bloomberg New Energy Finance (BNEF) database categorises flows as coming from a developed country if they originate with a company or entity headquartered in an OECD country. This estimate is a very conservative lower bound estimate and excludes foreign direct investment to avoid double counting.

3 See the chapter by Massetti in this book for illustrations of plausible implications of climate mitigation policy on investments in power generation and on the energy sector in general.

4 For example, $950 million was invested in coal, oil and gas extraction, transportation and refining and fossil fuel power plants. In 2013, governments paid $550 billion in global consumer subsidies to support fossil fuels, compared with just $121 billion to support renewable energy (IEA 2014).

5 Reviewing a number of studies in his chapter in this book, Massetti suggests that without climate policy, the largest fraction of investments in the power sector is expected to go to fossil fuel generation – the mean estimate of annual investments in fossil fuel generation among the surveyed studies is equal to $182 billion in 2010–2029 and $287 billion in 2030–2049. This is equivalent to about 50% of total investments in power generation from 2010 to 2049.

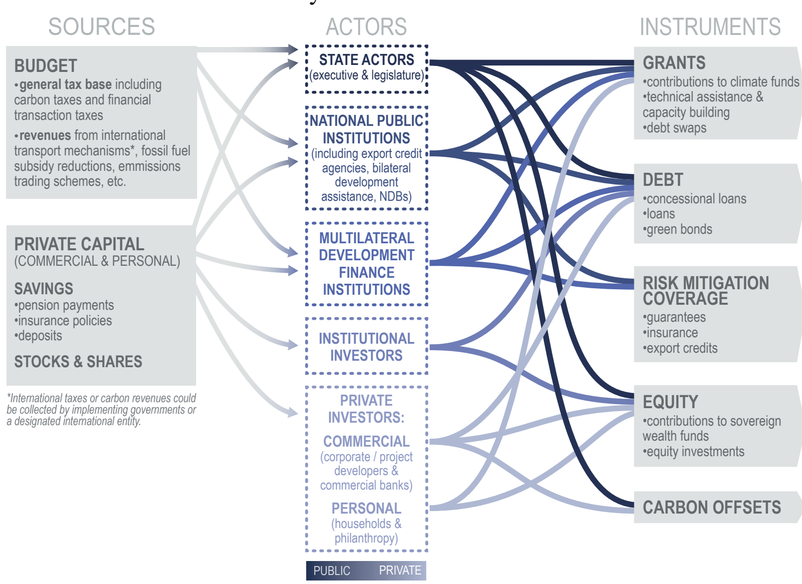
6 See the chapter by Bosetti in this book for a better understanding of how the costs of different renewable energy technologies are likely to evolve.

2 Concrete options to achieve financial transformation

Significant analysis has improved our understanding about the sources, actors, and instruments of climate finance (CPI and Cicero 2015). We know now that the global climate finance system is a complex continuum of relationships and transactions (see Figure 2), driven by public finance, policies and incentives on the one side, and the need to balance risks and returns on the other.

The international community has helped to develop a more comprehensive picture of climate finance than existed in 2009 when the $100 billion goal emerged. This in turn is helping to improve understanding about where the world stands in relation to global finance and temperature goals, but more importantly, to identify which kinds of support correspond best to different needs, and whether resources are being optimised (CPI and Cicero 2015). For example, in general, the public sector should fund the cost of public goods and services, and risks that the private sector isn't willing or able to bear. Continuing to develop understanding of climate finance flows should ultimately help actors learn how to spend money wisely and effectively redirect financial resources from high- to low-carbon uses.

Figure 2 The climate finance system



Source: CPI and Cicero (2015).

2.1 Get domestic enabling environments right

In 2013, 74% of climate finance originated and was spent in the same country or region. This percentage rose to 90% for private investments, highlighting that investors everywhere prefer familiar policy environments that provide incentives and confidence around returns.

Domestic public finance, supplemented by international resources where necessary, can fund the establishment of institutions and capacity, technical assistance, incremental costs, project-specific grants, and loans. Direct equity investments of public finance, alongside commercial tranches, can help build confidence, speed up financial closure, or take more risky positions in mezzanine structures. Governments can also take positions as shareholders, particularly in companies that deliver strategic goods and services such as electricity and water, and which are or were state monopolies (Buchner et al. 2013). Active and passive shareholding is practiced by governments in developed and developing countries. In China in 2012, 84% of climate investments had some degree of public shareholding, and rates of public shareholding are also high in the US (68%) and Germany (54%) (Buchner et al. 2013, 2014).

Examples of policies that help level the carbon playing field across actors include:

- Regulatory standards such as emissions and performance standards, technology and production standards, which increase the cost of emitting carbon by penalising actors who fail to meet established standards, and create incentives to seek out low-carbon options;
- Feed-in-tariff or support policies and renewable-portfolio standards, which have helped to drive diffusion and pay for incremental costs (IPCC 2014a,b);
- Policies to support research and development in technology, which can complement adaptation and mitigation policies, and if properly implemented, can reduce costs; and
- Technology-push policies such as publicly funded research, development and deployment, combined with financing support for technology adoption, which can help to overcome the ‘valley of death’ between small-scale prototype phases and successful commercialisation (IEA 2014, IPCC 2014a,b, FS-UNEP-BNEF 2015).

2.2 Support public finance institutions as agents of change

Development finance institutions (such as multilateral and national development banks), bilateral development agencies, and even possibly new institutions such as the Green Climate Fund, pool experience and toolsets that can pay for goods and services that private actors cannot or will not pay for, and which can help investors manage risks.

Bilateral agencies have a substantial role in supporting adaptation activities (almost 50% of their total contributions in 2013 were grants targeting adaptation; Buchner et al. 2014). Bilateral DFIs and MDBs can raise funds on capital markets in addition to government contributions, and also play a pivotal role in mobilising private finance by providing risk coverage, concessional and non-concessional lending and technical assistance, and by managing and implementing projects for climate funds. The emergent Green Climate Fund could play a catalytic role in ensuring that vulnerable countries' needs are met, particularly where national development bank-type institutions do not exist, by helping to realign incentives and find new ways to mainstream climate risk mitigation.

National development banks (NDBs) are also increasingly key players in low-carbon economic development as executors of public development mandates. They have the capacity to mainstream climate considerations across broader national policy portfolios (such as infrastructure, rural development and urban planning), and can reduce perceived trade-offs, build complementarity and increase co-benefits, making it easier to dedicate public financial resources (OECD 2009, IPCC 2014a,b). Especially in less mature markets where costs and risks can make financing unaffordable, by using lower cost public capital, NDBs can significantly lower financing costs that would otherwise make investments prohibitive (NCE 2014). NDBs committed $70 billion in 2012, and many also function as channels of multilateral and bilateral development finance (Buchner et al. 2013).

2.3 Alternative sources may be difficult to implement

An important lesson to emerge since 2009 is that 'alternative sources' identified previously (see, for example, AGF 2010) have had mixed results, particularly in relation to the $100 billion goal:

- Developed and developing countries and regions around the world have introduced *carbon pricing through carbon markets and taxes* (CPI and Cicero 2015, and Wang and Musiric 2015). The value of global ETSs as of 1 April 2015 is about $34 billion, while the existing carbon taxes around the world are estimated to be valued at $14 billion (see the chapter by Wang and Musiric in this book). The value of the global carbon market is expected to reach €70 billion in 2015 (*Business Green* 2015).[7] However, in relation to the $100 billion, carbon markets have failed on two counts. First, the markets have not yet resulted in a global carbon price that is adequate to deliver significant finance to developing countries. Second, even where carbon markets generate funds, they have delivered little by way of new finance transferred to developing countries. Earmarking revenues from auction schemes, or grandfathering allowances, has happened in some domestic contexts within the EU ETS, but it is still uncommon practice globally.
- *International transport* has been seen as an attractive source of potential climate finance as it is not currently subject to emissions reduction measures, and lies outside the national boundaries of emissions accounting systems. With revenues benchmarked to carbon prices in the range of \$20-25/tCO_2, the AGF estimated these could generate around $10 billion in climate finance per year by 2020 (AGF 2010). Securing international agreement is the main barrier to implementation.
- Appetite for levying an *international financial transactions tax* may have stirred following the public bailout of many private banking institutions following the 2008 financial crisis. However, concerns about market distortions and deeply entrenched national positions mean such an instrument is unlikely to be implanted on a global scale.

7 As secondary transactions, the value of carbon markets is not captured by climate finance tracking exercises such as CPI's *Global Landscape of Climate Financ*e.

- The *green bond market* has grown since its initiation in 2008 to $64 billion[8] in total by May 2015. Half of this amount was issued in 2014 alone, demonstrating the significant momentum the market has achieved in a relatively short time. The bonds themselves are simply 'hypothecated' bonds – that is, the use of proceeds for the bond is linked to green activities and the value of the bond equals the value of these green assets. However, this does not translate into the bonds being secured by these green assets. Rather, they are backed by the balance sheet of the issuer, thereby enjoying the same risk profile. This allows investors who are interested in green activities to purchase the bonds, but to not suffer any extra credit risks. A total of 98% of green bonds come from institutions in the developed world, specifically the UK, US and Europe. Investors consist of *institutional investors* such as pension funds and insurance companies that are familiar with setting aside allocations for investment-grade bonds from these issuers. Further issuance of green bonds, especially by sovereigns in developing countries, including major emerging economies, could unlock cross-border climate finance.

A review of 'alternative' sources of finance demonstrates that often these require government actions in addition to carbon pricing – for example, to 'earmark' or 'hypothecate' public revenues – to fund climate finance, and often require multilateral agreement to implement. Further, many of these sources can blur the boundary between public and private action, both because the source is unclear, and also because public investors may sometimes take quasi-commercial positions, as shareholders, insurers, and institutional investors. Finally, it is clear that 'alternative' sources are less likely to succeed in the immediate term wherever they require international agreement, while those that require secondary actions by governments to dedicate proceeds or revenues can face strong domestic political opposition.

8 Source: CPI analysis; Bloomberg data (accessed 29 April 2015).

3 Conclusion

Significant coordination and strong government leadership will be needed to align policies, pricing signals, and financial instruments across the world to steer finance towards a low-carbon and climate-resilient future. However, the costs of transformation may be lower than once thought, with economies of scale, better knowledge, and linked global markets all playing a role in making investment go further. If countries get it right, the New Climate Economy estimates that making envisaged infrastructure climate-compatible would only cost an additional $4.1 trillion, or 5% of projected investments, which might also be offset by lower operating costs (NCE 2014).

The climate negotiations in Paris could play an important role in paving the way for such a low-carbon, climate-resilient future. Most importantly, COP21 could nudge the UNFCCC climate finance stream towards an outcome that acknowledges progress, and anchors future progress in the real economy. Across the world, and especially in developing countries with their growing energy demands and huge infrastructure needs, nationally sponsored development plans that insist on climate as an integral component of development will unlock innovation and pipelines of projects. Coordinated action by public actors in developed and developing countries could help to systematise options to reduce risks and close financial and technical gaps, resulting in more effective mobilisation of climate finance. Specifically, a number of elements could signal progress in changing in the narrative:

- *A common language*. COP21 could help create a common ground for definitions related to climate finance, crucially moving beyond the decoupling of climate from development, to mainstream climate action and globalise the development issue.
- *The landscape of climate finance*. By acknowledging the variety of actors, sources, instruments and complex interactions (see Figure 1) – including, for example South-South finance flows and the role of domestic private finance in developing countries – COP21 could broaden the view on possible options to scale up climate finance, acknowledging also that there are multiple pathways to get to the $100 billion target (and beyond). In this context, lessons on practical and operational solutions could be highlighted to fast-track climate investments that meet countries' needs and use financial resources most effectively.

- *Transparency of climate finance*. One of the conditions for improving trust between Parties and for reaching an ambitious agreement at COP21 is enhanced transparency on the implementation of the commitment by developed countries to mobilise $100 billion a year by 2020, from a variety of sources, to support climate adaptation and mitigation actions in developing countries. To this end, COP21 could highlight progress made by various actors towards better understanding the current climate finance picture and pathways to the $100 billion and agree on a work programme, outside of the UNFCCC, to further add clarity after Paris.
- *An aspirational climate finance goal*. COP21 could explicitly recognise that the $100 billion target is not an end point but a starting point that should aim to unlock domestic investments in developing countries, recognising that solutions come mainly domestically, possibly triggered by international support. By considering an aspirational climate finance goal, and avoiding further numerical targets, COP21 could enable a focus on impact and results on the ground, setting the basis for moving the world most effectively onto a low-carbon, climate-resilient pathway.

By moving the discussions within the UNFCCC climate finance negotiations away from pure politics toward the real economy, the Paris Agreements could turn the $100 billion into trillions in the near future, closing the gap between finance delivered and finance needed. A core condition for this to happen is that COP21 builds the trust amongst Parties about the overarching goal, and establishes a clear pathway forward, with milestones for the road from Paris to 2020, and beyond.

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34 Harnessing the animal spirits of finance for a low-carbon transition

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This chapter starts from an apparent contradiction between the quest for upgrading the funding for a low-carbon transition and the constraints impinging upon the world economy in the aftermath of the 2008 financial crisis. It argues that new financial tools are needed to remove this contradiction and trigger a massive wave of low-carbon investments, and explains why carbon prices alone cannot do the job. It points out that, in the absence of a benevolent lender, high upfront costs of low-carbon projects under uncertainty about the cost of equipment and the duration of the maturation phase of the projects mean that investments which could be profitable are frozen. The creation of Climate Remediation Assets (CRAs) based on a governments' public guarantee, along with carbon pricing, would remove this barrier to investing in low-carbon activities. Based on this guarantee, project developers can obtain carbon certificates from their banks and reimburse them in certified emission reductions and not in cash. This is possible because the central bank provides the banking system with liquidity corresponding to the carbon certificates which, once recuperated by the central bank, appear as CRAs on its balance sheet. The chapter then discusses how, by creating a new vehicle suitable for bridging long-term assets and short-term cash balances, CRA-based devices could both trigger a low-carbon transition and help drive the world economy out of the current state of doldrums and instability.

1 Introduction

Time is running out to act on climate change; it is also running out to act on poverty eradication and sustainable development. These challenges cannot be met independently from each other, because there will be no involvement of developing countries if climate policies slow down their exit from poverty, and because climate change might create tensions that make development unsustainable. This is why we have to resist the temptation to postpone significant climate action until the end of the current adverse economic context. Finance, the key constraint in the aftermath of the 2008 crisis, cannot but be part of the solution. This chapter explores how.

Paradoxically, given its influence on our economies, finance has until recently been a minor topic in climate negotiations. One exception was the Brazilian proposal in 1997 for a compliance fund to implement the common but differentiated responsibility (CBDR) principle (UNFCCC 1997). This was symptomatic of doubts of non–Annex 1 countries about the willingness of Annex 1 countries to make the transfers[1] needed to compensate for the impacts of significant carbon prices on their economies.[2] COP16 in Copenhagen (in 2009) marked a turning point by establishing a Green Climate Fund (GCF), but it did so in a context where pressures on public budgets and a fragile economic recovery in OECD countries had exacerbated 'donor fatigue'. Discussions on the GCF are at risk of remaining an adversarial exercise between the 'North' and the 'South' and of missing the key challenge, which is the redirection of investments all over the world towards a low-carbon transition of an order of magnitude beyond what can be expected from public finance.[3]

Section 1 shows why, to overcome these drawbacks, the 'mental map' of policy analysts must account for the time profile of investments needed to achieve a low-carbon transition and also incorporate finance in the toolkit of incentives to be mobilised. Section 2 suggests reforms of the prevailing financial intermediation

1 Limits to these transfers were an implicit motivation of the Byrd-Hagel resolution of the US Senate (1997) (see http://www.nationalcenter.org/KyotoSenate.html) and of the EU request of 'concrete ceilings' to imports of emissions allowances through cap-and-trade systems (see Hourcade and Ghersi 2002).

2 These impacts are high in countries that are still in a development phase and require energy-intensive materials to build basic infrastructures (Luderer et al. 2012).

3 The global estimated need in infrastructure investments between now and 2030 is US$89 trillion, rising to $93 trillion if climate is to be properly addressed (New Climate Economy 2014). The major challenge is obviously the redirection of a large fraction of the $89 trillion.

through the creation of carbon assets valued at an agreed notional price of mitigation activities. Section 3 shows how these reforms can help drive the world economy out of the current economic doldrums and gain support for climate policies from climate-agnostic policymakers in charge of economic policies who are focused on the short-term challenges of employment and debt reduction.

2 Finance and carbon pricing

The Kyoto Protocol was the outcome of a succession of diplomatic *faits accomplis* (Bodansky 2001) with many possible interpretations. The dominant interpretation was governed by a mental map in which a world carbon market would connect *abatement cost curves* all over the world and *select-cost-efficient techniques* given the uniform carbon price imposed on all the carbon emitters.

The difficulties in establishing a world cap-and-trade system generated an extensive literature on the wedges between technical costs, GDP variations, and welfare variations.[4] Less attention has been dedicated to the fact that, in the models establishing the superiority of this policy tool, technologies are assumed to be selected according to their present expected value for a given discount rate. This ranking is made regardless of the time profile of the operating costs of projects. This amounts to an assumption of unlimited access to financing, which seems quite unrealistic.

Figure 1 depicts the time profile of the expected operating accounts of two example projects. Project A, with a capital-intensive technology, has a higher expected present value (i.e. the discounted sum of lower purchase of fossil fuels minus the capital expenditures and operational costs) than project B, but it might not be selected because of its higher upfront costs. During the incubation phase of the project, a bad surprise regarding these costs (indicated by the dashed lines) might indeed generate a deficit of operating accounts beyond a 'danger line', D, i.e. the level of deficit the decision-maker does not want to cross. These bad surprises can come from a mismanagement of

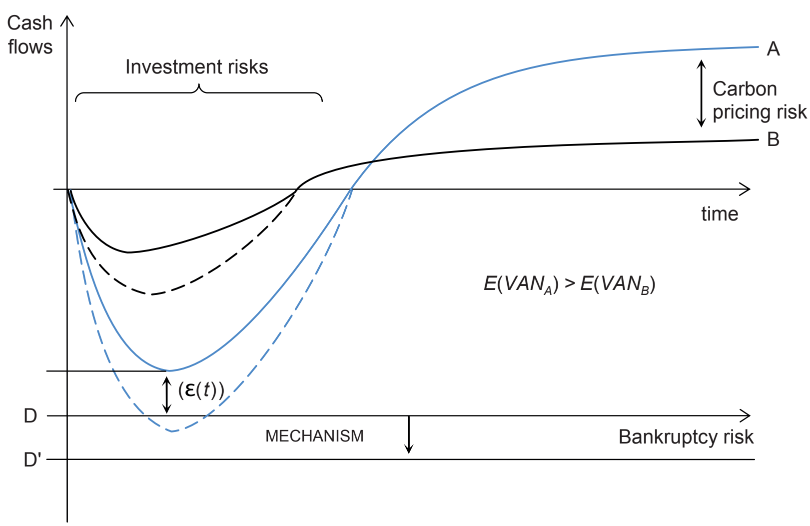
4 These wedges come from the propagation of higher energy prices throughout the economies, uncertainty about the efficiency of the compensatory transfers, incomplete and fragmented markets (energy, labour, real estate) and pre-existing fiscal systems.

projects, a cost increase for certain equipment, or a discovery of technical difficulties in non-mature technologies.

This situation is typical of households that require very short payback periods for their investments in energy efficiency. This is also the case of firms with limited access to finance (be it via debt, equity or self-finance). In the absence of a benevolent lender with unlimited lending capacities, onerous debt-servicing lowers their operating surpluses and poses a threat to dividend payments to their shareholders if their bank loses confidence. Ultimately, the value of the firm might be affected, with a risk of bankruptcy or hostile takeover.

Carbon pricing improves the relative efficiency of low-carbon projects, but it does so during the operation phase only for projects not stifled by the existence of the 'danger line'. One can argue that sufficiently high carbon prices could encourage decision-makers to take the risk. But they would have to be very high because the cost of approaching and crossing the danger line is highly non-linear and because they would have to cover the 'noise' of other unfavourable signals (such as real estate prices, oil prices and exchange rates) indicated by $\varepsilon(t)$ in Figure 1. Financial devices are thus needed to move the 'danger line' (from D to D′), to decrease the risks arising from overruns of upfront investment costs, and to increase the effect of carbon pricing.

Figure 1 Investment risks, finance and carbon pricing



The existence of this danger line does not only constrain low-carbon projects, it characterises a business environment in which managers have to pay close attention to the short-term value of the firm. In this 'shareholder business regime' (Roe 1994),[5] managers do not have full latitude to use the net profits of their firm to maximise its long-term growth. Put simply, investors face a 'Buridan's ass' dilemma.[6] They pay no attention to which direction long-term investments should go, and are not helped by the difficulty of the present system of financial intermediation to fund productive investments. Ultimately, private savers are reluctant to maintain investment rates in the industry, preferring instead speculative or liquid assets. This interplay between financial factors and heightened uncertainty (Lewis 2014) is now recognised as having a prominent role in the gap between real growth and potential growth, and in a chronic excess of savings over investments (Blanchard 2015). The question, then, is whether there exist financial devices designed to support low-carbon investments that can reduce this gap.

3 Towards the creation of Climate Remediation Assets (CRAs)[7]

To understand the type of mechanism suitable to operate this redirection of investments, it is useful to remember historical examples of links between finance and deep technological revolutions. In the nineteenth century, the impressive deployment of railways was unleashed thanks to various (country-specific) forms of public guarantees on investments and the creation of assets on the lands adjoining the lines. This combination reassured investors that they could recuperate valuable assets in the case of insufficient revenues from the traffic between two connected cities (Fogel 1964, Landes 1969). An equivalent to this device for triggering the low-carbon transition would be for governments to provide a *public statutory guarantee on a new asset, which allows the central bank to provide new credit lines refundable with certified reductions of*

5 For the implications of a 'shareholder value regime' and a 'managerial business regime' on growth, see Hallegatte et al. (2008).

6 The legend satirises Buridan, a theologian at the Sorbonne, who recommended postponing action until having received full information about the context. In this legend, the donkey dies of hunger and thirst because it hesitated too long in making a decision between eating hay or drinking water.

7 The rationale for this device is described in Hourcade et al. (2012), and a version centred on the European context is developed in Aglietta et al. (2015).

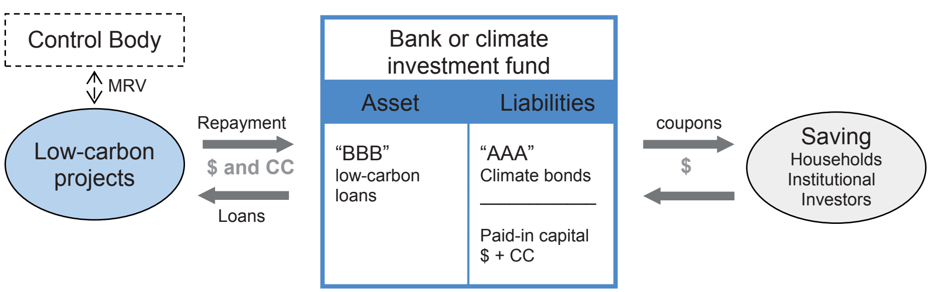
CO_2 emissions. The targeted credit facility would make possible bigger loans to low-carbon investments by lowering the financial risk. The facility could be operationalised through four steps.

1. *The international community recognises that climate remediation activities generate 'something of value'*. This value of Climate Remediation Activities (VCRAs) could be expressed through a notional price per tonne of avoided CO_2 emissions to be incorporated in new investments. It would comprise both the costs of meeting the 2°C target and the various co-benefits of mitigation activities (air pollution, benefits from recycling the revenues of carbon pricing, energy security). Controversies around the social cost of carbon (SSC) have cast doubts over the possibility of agreeing on such a value. But there are three differences between the concepts of the SSC and the VCRA. First, the VCRA would not be used to weigh climate change damages over the long run against the costs of mitigation; it would be estimated for a given target, and disputes about the discount rate would matter less. Second, countries might agree to the same VCRA for different reasons based on their own perceptions of the domestic co-benefits of climate mitigation within, for example, the estimated space of carbon prices given by the IPCC (US$55 to $140 per tonne of CO_2 in 2030 for a 450 ppm scenario) (Clarke et al. 2015). Third, contrary to a real carbon price, a VCRA would not directly hurt existing capital stock, would have less direct distributive impacts, and would therefore be at less risk of being blocked by a coalition of vested interests.
2. *Governments commit, on a voluntary basis, to backing (up to a predetermined quantity) carbon certificates (CCs)* to be allocated to low-carbon projects and priced at the VCRA. This allocation of CCs would lower the danger line stifling the capital-intensive low-carbon projects since, for example, a $100 loan would be reimbursed $50 in cash and $50 in carbon certificates. This would require an effective system of MRV along the lines described by Wiener in his chapter in this book, and monitoring by an independent body under the UNFCCC that would set the rules for the attribution of CCs per type of project in each country.
3. *Building on the governments guarantee, CCs are accepted* by financial intermediaries as *repayment for part of low-carbon loans,* because CCs can be either converted into climate remediation assets eligible for quantitative easing programmes launched by

central banks, or can be used as a guarantee for refinancing by the central banks of low-carbon loans up to their carbon value. Ultimately, after effective carbon emission reductions have been verified, the carbon certificates would be converted into Climate Remediation Assets that enter on the central bank's balance sheets (see Box 1).

4. *Banks or specialised climate funds* use the carbon-based monetary facility *to back highly rated climate-friendly financial products*, such as 'AAA' climate bonds, to attract long-term saving. This could be done by turning BBB portfolios of projects into AAA climate bonds via the public guarantee to CCs and the various pooling methods. Provided they have confidence in the declared value of CRAs, institutional investors might be interested in safe and sustainable bonds instead of speculative financial products for both ethical and regulatory purposes. This mechanism (illustrated in Figure 2) is critical for the redirection of private savings, without which the low-carbon transition will not trigger the virtuous economic circle developed in the next section. An important point for the political economy of the climate negotiations is that part of the CCs could be used to scale up the Green Climate Fund in order to secure multilateral cooperation and to avoid the Nationally Appropriate Mitigation Actions (NAMAs) being funded only by bilateral overseas assistance and the possible 'greenwashing' of this assistance.

Figure 2 Carbon certificates and the redirection of long-term saving towards low-carbon investments



This mechanism ultimately comes down to the issuing of money backed by a public guarantee and, akin to the case of US railways, backed by the real wealth of low-carbon infrastructures as collateral. It would rely on two major pillars in addition to the MRV process.

The first pillar is the value of CRAs, so far neglected in a literature that has focused on the financial channels and the evolution of prudential rules to improve the financial intermediation system. VCRAs play a critical role for four reasons. First, as it has the same efficiency effect as a carbon price, a VCRA hedges against the cost of fragmentation and political arbitrariness of low-carbon initiatives and carbon finance innovation. In this respect, it can constitute a lever for the deployment of climate finance devices, as described by Buchner and Wilkinson in their chapter in this book. Second, it helps countries make their INDCs economically consistent, since the loans will incorporate the same implicit carbon value. Third, because it is the discounted value of the flow of social values – which increases over time – it offsets the penalty imposed by discount rates on long-lived investments. Fourth, it hedges against the risk of lax monetary creation and of 'carbon bubbles', because the CCs have a nominal face value from which speculators on secondary bond markets cannot depart too much.

The second pillar is the quantitative commitments made by governments. Political realism suggests that this kind of system can be launched only by a 'club of the willing'. Contrary to what Nordhaus (2015) envisages for carbon pricing clubs, the incentive to join the club and to observe its rules would not be provided by penalties but by automatically depriving defaulting countries of access to the credit facilities opened by the system. Such a system needs agreed-upon rules on governments' commitments to back a given amount of carbon savings investments backed by governments, which go beyond the scope of this chapter. One key principle, developed in Hourcade and Shukla (2015), would be to organise rules such that they act as pull-back forces inciting countries to narrow the distance between their emissions and a normative trajectory. What matters is that these rules would not play the same role as in the case of the Kyoto Protocol;[8] there would be no immediate consequence for domestic energy prices and the amount of international transfers would be controlled ex ante (only a share of the credit lines opened thanks to governmental backing).

8 Unlike the very successful Montreal Protocol on reducing ozone-depleting substances that included trade restrictions between parties and non-parties, Article 18 of the Kyoto Protocol prohibited the use of a compliance mechanism that would entail "binding consequences" unless adopted by amendment of the Treaty. As under the GATT, under the Kyoto Protocol a sanction against a party had to be approved by the party it was aimed at! (Mathys and Melo 2011). The reasons for this outcome are explained in Hourcade and Ghersi (2002).

Box 1 The creation of CRAs and the circuit of balance sheets

Table 1 shows how a central bank's balance sheet is transformed by the creation of a CRA starting from a \$1,000 loan to a low-carbon entrepreneur expected to realise 10 units of CO_2 emissions reduction and a VCRA set at 10/tCO_2. The loan is divided into two credit lines (Table 1): \$900 lent at rate r_l and financed by deposits remunerated at rate r_d, and \$100 equivalent lent by the central bank to a commercial bank that can be paid back with certified carbon certificates (CCs). Prudential rules about minimum capital requirement only apply to the first credit line (900 r_l) as a zero coefficient risk is applied to the second credit line backed by a government guarantee. The net worth increase of the commercial or development bank is only $0.08*900r_l$ instead of $0.08*1000r_l$ in the BAU case (i.e. conventional funding of the project).

The CB now owns a new \$100 claim on the commercial bank. Thanks to the \$1,000 loan, the entrepreneur launches the low-carbon project (LCP) with an expected return of R^{LC}, giving total expected revenues of \$1,000 R^{LC}. Under the assumption that the project realises the 5 units of expected emission reductions, two lines appear on the liability side of the entrepreneur's balance sheet: \$900 paid back with the monetary revenues of the project at the interest rate r_l, and \$100 paid back with carbon certificates.

Table 1 Balance sheets at time of opening the low-carbon loan

Central bank		Commercial bank		Entrepreneur	
Asset	Liability	Asset	Liability	Asset	Liability
				100 R^{LC}	
Loan CO_2		$+900r^l$	$+900r^d$		$+900r^l$
+100	+100	+100	+100		+100
			$+0.08(900r^l)$		
10 CO_2	100				
Reduction of CO_2	Drawing rights				

As the project realises emission reductions, the entrepreneur receives CCs. At the loan maturity (Table 2), the entrepreneur has reimbursed the entire $900 debt with the project revenues and has received 10 CCs for the project's emissions reductions. The first credit line of the balance sheet of the commercial bank becomes null and only the second credit line remains.

Table 2 Balance sheets at the end of the payback period of the low-carbon loan before the asset swap

Central bank		Commercial banks		Entrepreneur	
Asset	Liability	Asset	Liability	Asset	Liability
				1000 R^{LC}	
Loan CO_2		+0	+0	-900r^l	+0
+100	+100	+100	+100	+10 CC	+100
			+0		
10 CO_2	100				
Reduction of CO_2	Drawing rights				

Then the central bank performs an asset swap, as it accepts the 10 CC as repayment of its $100 financial claims and the second credit line corresponding to the 'carbon debt' of the low-carbon project can be cancelled out (Table 3). The total amount of carbon-based liquidities that the central bank can still issue is reduced by 100.

Table 3 Balance sheets after the carbon asset swap

Central bank		Commercial banks		Entrepreneur	
Asset	Liability	Asset	Liability	Asset	Liability
10 CC				1000 R^{LC}	
~~Loan CO_2~~		+0	+0	-900r^l	+0
~~+100~~	+100	~~+100~~	~~+100~~	~~+10 CC~~	~~+100~~
			+0		
~~10 CO_2~~	~~100~~				
Reduction of CO_2	Drawing rights				

Other circuits are possible. Commercial banks with a high share of low-carbon projects in their loan book would have a less risky balance sheet, as it would benefit from a public guarantee. They could keep part of the carbon assets. Banks would then be rewarded with a reduction of the cost of their prudential capital constraint by applying a zero risk coefficient – in the same fashion as with sovereign bonds – to the fraction of the loan that comes from central bank liquidities backed by the value of emission reductions. Firms could also keep the CRAs in their balance sheet to improve their value in terms of the Capital Asset Pricing Model.

4 Crowding out, or dragging the world out of the economic doldrums?

The primary aim of a CRA device is to trigger a wave of low-carbon investments that are currently blocked by their upfront cost in today's uncertain economic context, and many such investments exist.[9] Further, this device would facilitate the deployment of price-based mechanisms – the amount of financially viable low-carbon investments for a given carbon price would be higher and the existence of a VCRA and of a strong MRV process would make it easier to turn the product of mitigation activities into financial carbon assets. Governments will have a real incentive to implement carbon-pricing policies to generate more carbon assets, which will balance the public budget.

The fact that these devices are good for climate mitigation does not imply that they are good for the economy in general. The strong arguments in favour of the 'green growth hypothesis' (OECD 2009, World Bank 2012) are often countered by the 'crowding out' argument (Popp 2012), i.e. that to bias investments in favour of low-carbon projects would crowd out other investments that could be socially and economically beneficial and would thus generate no positive impact on economic growth.

This argument has to be revisited in the current adverse world economic context of a gap between potential growth and real growth. One of the sources of this gap is the

9 One good analysis of the orders of magnitude of this leverage can be found in De Gouvello and Zelenco (2010) in their hypothesis of a low-carbon development facility.

saving glut, diagnosed by Ben Bernanke in 2005, due to a high propensity to save and a low propensity to invest. This leads to difficulties in maintaining sufficient demand to sustain normal levels of output, and explains the warnings about the 'depression economics' (Krugman 2009) and secular stagnation (Summers 2014). The CRAs could help prevent this via the creation of intermediaries that are able to bridge long-term assets and short-term cash balances so that savings are invested productively without incurring the risks of excessive leverage, maturity mismatch (illiquid long-term assets financed by short-term assets) and interconnectedness (unsecured liabilities of money market funds), which fostered the systemic crisis.[10]

Illustrative simulations suggest that, over the short run, the CRAs would boost investments and final demand by backing credit facilities with equipment and infrastructures as collateral. Their macroeconomic impact could be important because they imply incremental investment efforts (around 0.5% of GDP over the forthcoming decades) with a high ripple effect because the level of redirected investments is around 8-9% of the gross capital formation.[11] This redirection would entail inevitable tradeoffs and choices, but would not mean sacrificing social priorities. It would bring the economy closer to its potential growth by reducing the saving glut and satisfices the social aims through low-carbon techniques. Over the long run, it would translate into reality Schumpeter's message that long-lasting innovation waves can take off only when their promise is supported by the 'animal spirits of finance'. Instead of generating long-term investment shortfalls and repeated speculative bubbles, these animal spirits would trigger a wave of 'green' innovation (Stern 2010, Stern and Rydge 2012) that is necessary to sustain a long growth cycle, much as oil, automobiles and mass production did in the previous century.

A low-carbon transition supported by the CRA device could thus have a macroeconomic value that should be of interest to climate-agnostic policymakers. In addition to reducing the gap between the propensity to save and the propensity to invest, it would also help

10 Multilateral finance institutions (the ADB, the World Bank, the EBRD, and the EIB) invest in principle on long-run horizons. But the scope of their interventions remains limited and they are not suitable for driving savings towards the multiplicity of scales of investments that are needed, including small-scale ones. Insurance companies work on reducing risks of long-term investments, but do not invest in these themselves. On the limits of the current financial institutions, see UNEP- (2015), Canfin-Grandjean Commission (2015) and OECD (2015).

11 Simulations carried out on the basis of the of the International Energy Agency's *World Energy Outlook* (IEA 2014) and published in Hourcade et al. (2014).

to address one of the major 'fault lines' of the world economy as pointed out by Rajan R.G. (2010), that is, the development strategy of developing countries. This strategy is currently based on export-led growth, which is implies excessive dependence on the ability of foreign consumers to pay. It constrains domestic demand and to leads to under-valuations of currencies.

Governments are hesitant to alter this strategy because of the uncertainty over recovering jobs lost in the export-led sectors through the domestic-oriented production sectors, and the risk of excess protection in domestic-oriented production sectors resulting in inefficient projects. A CRA device would facilitate this strategic change. In addition to generating important North-South flows in support of INDCs directed towards domestic markets and activities, it would address the IMF's warning about the lack of infrastructure investments (IMF 2014) and, given the sectors concerned (energy access, buildings, transportation), would contribute to inclusive development (World Bank 2012). It would also decrease the need for a 'war chest' of official reserves in foreign currencies, since the CRAs would become a de facto common numeraire for interbank settlement payments.

5 Conclusions

I have argued that harnessing the animal spirits of finance to enable a low-carbon transition is necessary for launching ambitious climate policies and would help bring the world economy out of the current context of economic uncertainty. The proposed Climate Remediation Assets (CRAs) are a way to achieve the required ambitious climate policies. CRAs would be instrumental in implementing the "*paradigm shift*" adopted in Cancun *"towards building a low-carbon society that offers substantial opportunities and ensures continued high growth and sustainable development"* and *"equitable access to sustainable development" (UNFCCC 2011).* The underlying intuition is that the required climate policies question the implicit social contract at the national and international levels that relies on cheap energy and cheap fossil fuels, which has led both households and enterprises to adopt behaviours based on capital stock (mobility, housing modes, location of human settlements) that cannot be altered overnight.

Finance is, with fiscal systems, a key component of any new social contract. Monetary-based finance would in effect be saying: *"My government really thinks that avoiding carbon emissions is something of value. By adopting CRAs it is giving clear and immediately tangible support to investment initiatives in low-carbon projects and technologies, and in doing so it is proving its commitment to combatting global warming and to a more sustainable development, and helps me to take part"*.

This is a form of forward contract that has to be passed within each country, but will realise its potential only if it quickly involves most of the international community. This is possible because a fully-fledged CRA system would not require adversarial negotiations over the division of the remaining global CO_2 emissions budget (Averchenkova et al. (2014). It needs an agreement on the economic and social value of mitigation activities and on rules to coordinate the amount of CRAs that governments commit to backing. These rules will be a way of translating the CBDR principle between countries – with different historical responsibilities for both climate change and the current drawbacks of the financial system – in the context of a cooperative process.

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35 Measuring vulnerability to climate change for allocating funds to adaptation

Patrick Guillaumont
Ferdi

The debates on financing adaptation to climate change have so far not really addressed its allocation across developing countries. This chapter examines how the concessional funds for adaptation should be allocated. The principle proposed is a 'vulnerability-based allocation' (VBA) whereby funds are allocated to developing countries primarily according to their vulnerability to climate change, for which they are not responsible. To this end, a physical vulnerability to climate change index (PVCCI) is proposed, as tentatively established by Ferdi, which aggregates the physical impacts of climate change according to their main identifiable channels. The index is likely to be updated regularly. Its average level is given for some groups of countries, such as LDCs and SIDS. To determine the allocation of adaptation funds, the index should be used in a simple formula that also includes income per head, since the poorer countries are, the less resilient they are to climate change. The choice of the parameters of the formula will express, in a transparent way, the consensus of the international community on the principles of the allocation of 'adaptation credits' by country. A tentative simulation shows the relative share that each group of countries would receive (with more than half going to LDCs), as well as the ratios of the level of allocation per head to the average for developing countries (which are high for SIDS and for LDCs). Adaptation credits could be used by countries via accredited financial institutions to which they would submit their adaptation programs or projects.

1 Introduction: The geographical allocation of adaptation funds within 'climate finance'

The discussions on financing the responses to climate change in developing countries too often mingle separate issues. Indeed, adaptation to climate change cannot be dissociated from economic development, or be designed regardless of mitigation of climate change, which is itself essential in development strategy. But these interactions are at the operational level. They do not negate the need to distinguish between the respective sources of funding available for development, adaptation and mitigation, in particular between the respective concessional sources, and their justification.

Two problems arise in financing each of these three purposes: first, the mobilisation of resources; and second, their allocation among recipient countries. The mobilisation of resources has so far held much more of the attention of negotiators and experts than their allocation (Brender and Jacquet 2015, Canfin and Granjean 2015; Westphal et al. 2015). The final declaration of the July 2015 UN Conference on Financing for Development (held in Addis Ababa) is revealing in this regard. Concerning climate finance, it recalls the commitment of developed countries to mobilise US$100 billion per year from 2020 "from a wide variety of sources to address the needs of developing countries", as well as the need for transparent methods of reporting climate finance (United Nations 2015, para. 60). It welcomes the implementation of the Green Climate Fund (GCF) and the decision of its Board "to aim for a 50:50 balance between mitigation and adaptation over time on a grant equivalent basis and to aim for a floor of 50 per cent of the adaptation allocation for particularly vulnerable countries, including least developed countries, small island developing States and African countries "(United Nations 2015, para. 61). The rule to be used for sharing of the GCF between adaptation and mitigation has not yet been decided for the remaining and major part of the $100 billion; the same holds for the aim of a minimum of half to go to vulnerable countries.

It is assumed here that the total amount of climate resources mobilised for developing countries is a given (see the chapters by Buchner and Wilkinson and Massetti in this book), as well as the sharing of these resources between mitigation and adaptation. It is also assumed that it has been decided that the share will be provided in a concessional manner, and that concessional resources will be additional to those already mobilised for development.

Using these assumptions, we examine how concessional resources for adaptation should be allocated among developing countries. This chapter first presents the principles the allocation should meet, and stresses the need to take into account the vulnerability to climate change of each country (Section 2). Section 3 discusses the nature of the vulnerability to be considered and proposes a new index that is independent of countries' political choices. Finally, Section 4 discusses how the principles can be implemented and the index used in a global allocation system for adaptation funds (Section 4).

2 Principles of allocation of climate change adaptation funds among developing countries: Specificity of adaptation

For climate change adaptation funds, as with development assistance, three principles of allocation must be combined: effectiveness of the use of the funds with regard to the objective, equity in their distribution between countries, and transparency. To allocate the funds in a multilateral framework, transparency can be sought through an allocation formula that expresses the consensus of stakeholders. This has been done by the multilateral development banks (MDB) with a 'performance-based allocation' (PBA) formula that leads to an allocation of the available resources on the basis of a predominant performance indicator[1] as well as income per head (with a lower level of this expressing greater needs for a country). The application of this formula has seen many changes, complications and exceptions, which have been criticised and greatly reduce the transparency of allocation (see, in particular, Kanbur 2005, Guillaumont and Wagner 2015, Guillaumont et al. 2015a). For the allocation of adaptation funds among developing countries, it is possible to use a different formula that ensures transparency while avoiding the criticism aimed at PBA.

1 Derived mainly from the Country Policy and Institutional Assessment (CIPA), a composite index used by the MDBs.

2.1 Allocation for mitigation and allocation for adaptation: Two rationales

It is not possible to simultaneously determine the desirable geographical allocation of funds for adaptation and funds for mitigation, because their objectives are different.

Mitigation of climate change largely corresponds to the production of a global public good. It must be implemented in individual countries, but in the interest of the whole planet. Effectiveness is mainly assessed here in terms of avoided CO_2, rather than in terms of the development of the countries where mitigation is implemented. With regard to effectiveness, the corresponding funds should be used where mitigation opportunities are greatest (for a discussion, see the chapter by Massetti in this book). However, granted on a concessional basis to poor countries, these credits can also help the countries to implement a strategy of clean development, an example being funds for the maintenance of tropical forests (see also the chapter by Angelsen in this book). This criterion of needs can be satisfied by a simple condition of eligibility or by a modulation of concessionality according to income per head.

In contrast, adaptation concerns each country individually, and the funds a country receives for adaptation are supposed to be used for its own development. They can be channelled in different ways and according to specific criteria, but their use cannot be dissociated from that of development assistance. There is therefore a risk of fungibility undermining the additionality of resources. It is the specificity of the criteria applied to the allocation of adaptation funds that allows them to be differentiated from the other flows for development.

2.2 Adaptation: The ethical basis of a criterion of vulnerability to climate change

The specificity of vulnerability to climate change is obviously that most poor countries facing it are not responsible for it.[2] This vulnerability constitutes an allocation criterion for meeting the principle of equity (or need), which is without equivalent. There may be

2 As noted by, among others, Kaudia in her chapter in this book that highlights the importance of adaptation for poor countries.

a precedent in the allocation of official development assistance (ODA), where structural economic vulnerability is sometimes considered as one of the possible allocation criteria. But for vulnerability to climate change the justification is stronger, for two reasons. First, and most importantly, there is a moral debt of the developed countries responsible for climate change owed to those who suffer from it. Birdsall and de Nevers (2012) speak of a 'causal responsibility', which creates an 'entitlement' for countries affected by climate change. Second, as will be seen below, it is possible to design a vulnerability index that is more clearly independent of countries' own choices than the index commonly used to measure structural economic vulnerability, namely, the UN's Economic Vulnerability Index (EVI).

Even if the idea of using an index of vulnerability to climate change as a criterion for the allocation of funds for adaptation was first presented in conjunction with the use of structural economic vulnerability as a criterion for the allocation of ODA (Guillaumont 2008, 2009 , 2015), it is independent of ODA because of its ethical basis. The idea was first proposed by Ferdi (Guillaumont and Simonet 2011, 2014) and by the Center for Global Development (CGD) (Wheeler 2011, Birdsall and De Nevers, 2012), as well as in works prepared for the World Bank's *World Development Report 2010* (Barr et al. 2010; Füssel, 2010, World Bank 2010), although these various works do not converge on the way to assess the vulnerability to be taken into account for allocation.[3]

3 The few works since devoted to this topic seem to have been about the allocation of resources from the Green Climate Fund, dealing simultaneously with mitigation and adaptation (Polycarp et al. 2013), or dealing separately with adaptation (Noble 2013), but without using a quantitative criterion of vulnerability to climate change.

3 An index of vulnerability to climate change as a criterion for the allocation of the adaptation funds

3.1 What kind of indicator for measuring vulnerability?

There are many indices of vulnerability to climate (change?).[4] However, not being designed for this specific purpose, they generally do not meet the requirements for serving as a criterion for the allocation of adaptation resources.

First, the index must be independent of countries' policies. If a country's policy leads to a reduction of vulnerability by increasing the capacity for adaptation, i.e. resilience, this should not be a reason to reduce the allocation. Indeed, vulnerability includes two components which logically impact on the allocation but in opposite directions. Truly exogenous vulnerability, which results from a shock suffered by the country for which it is not responsible, unquestionably deserves external support. This is not the case for vulnerability that could be reduced by a country improving its ability to adapt. Good political resilience,[5] which lowers vulnerability, could be a possible performance criterion (if it is considered useful to have such a criterion). This distinction applies in particular to resilience that results both from structural factors – such as income per head or human capital, which are generally taken into account separately in the allocation process, with a low level resulting in more support – and resilience policy, weakness in which may lead to less support. Most of the available indices mix the two types of vulnerability, which of course enables them to offer a broad view of countries' vulnerabilities, but makes them inappropriate for allocation.[6]

Second, and for similar reasons, for international comparison and allocation it does not seem appropriate to use vulnerability indices corresponding to an assessment of the economic damage expected from climate change.[7] Considerable progress has been

4 Survey in Fussel (2010), Guillaumont et al. (2015a) and Miola et al. (2015).

5 That can be translated into special measures such as external reserves, insurance mechanisms, and so on.

6 A significant example is given by the index ND-GAIN (University of Notre Dame Global Adaptation Index) (Chen et al. 2015).

7 Wheeler (2011) refers to the agricultural productivity losses estimated by Cline (2007) for the CGD.

made in the assessment of this damage, as evidenced in the review of the 'new climate economy' literature by Dell et al. (2014). The chapter by Hallegate et al. in this book provides examples. However, these estimates are inevitably open to debate and partial, as stressed by the authors. For example, agricultural production losses resulting from increased aridity in the distant future depend not only on the evolution of rainfall precipitation and temperatures, but also on the evolution of techniques, research, and agricultural policies. In addition, some economic damage from climate change is even more difficult to predict and measure (e.g. in the area of peace and security). Generally, damage estimates involve assumptions about adaptation policies that are specific to each country, and each country should make its own decision if the principles of ownership and alignment are to be met. Estimates of the costs of potential damage or adaptation carried out on a global scale are extremely useful for the global mobilisation of resources, but they cannot serve as the basis for the allocation of adaptation credits between countries.[8]

Third, the relevant vulnerability for the allocation of adaptation funds, because of the above-mentioned ethical argument, is vulnerability to climate *change*, not climate vulnerability in itself, which has always existed in various forms in different regions of the world. The latter 'climate' vulnerability does not entail the responsibility of developed countries in the same way.

In short, we propose the use of a *physical* index of vulnerability to climate change that is *exogenous*, implies no socioeconomic estimates, and captures in an adaptive way the impact of climate *change*, rather than just the climate itself. Since the index will reflect a change that is likely to continue, and the only non-debatable change is one that is observed (the prospects for which vary with the arrival of new observations), the index must be constantly updated.

8 The World Bank highlights the fragility of the 'across country' conclusions on the costs of adaptation (World Bank 2010a, p. 89).

3.2 A Physical Vulnerability to Climate Change Index (PVCCI)

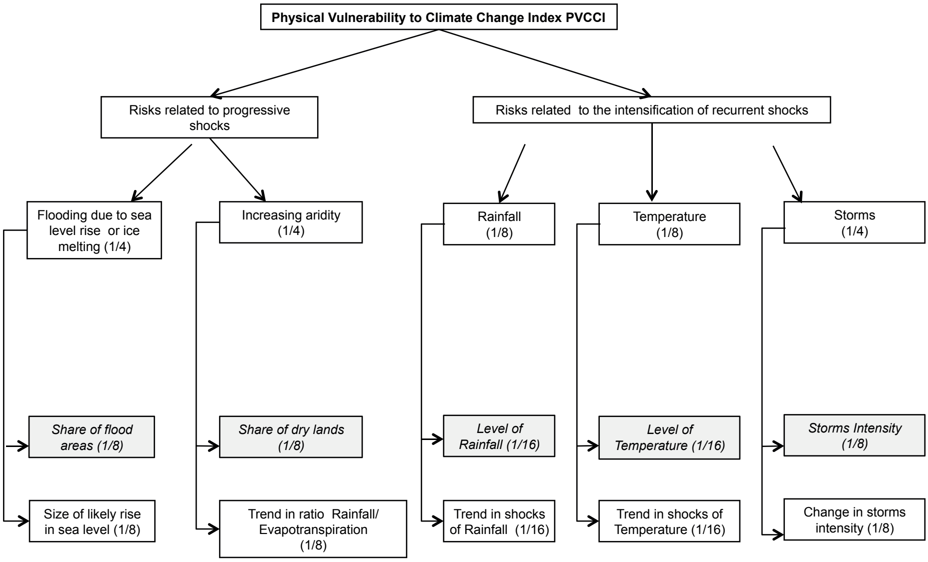
An indicator of vulnerability to climate change which meets the above-mentioned criteria (exogeneity of components, absence of socioeconomic variables, and a focus on the impact of the change) was set up by Ferdi in 2011 (Guillaumont and Simonet 2011) and subsequently revised on several occasions to use new data or to incorporate methodological improvements (Guillaumont and Simonet 2014; Guillaumont et al. 2015b). It is a dynamic, forward-looking indicator – although based on past data – that relies on a distinction between two kinds of risks that arise from climate change:

1. risks related to *progressive shocks*, such as the rise in sea level (risk of flooding), a rising trend for temperatures, or a decreasing trend in rainfall precipitation (risk of desertification); and
2. (2) risks associated with *the intensification of recurrent shocks*, whether rainfall shocks, temperature shocks, or cyclones.

For each of these two types of shock, the index – like the EVI – relies on a distinction between the size of shocks and the exposure to shocks. Since the sources of vulnerability are heterogeneous and the vulnerability of each country is specific, the indices corresponding to the various types of shocks are aggregated through a quadratic average, which gives more weight to those components that reflect vulnerability more.

In its current structure, the PVCCI does not include resilience (i.e. the capacity to adapt to shocks), since, as outlined above, resilience is determined by two categories of factors that influence the allocation in opposite directions: structural factors (income per head and human capital), and resilience policy.

Figure 1 Components of the Physical Vulnerability to Climate Change Index



Note: The boxes correspond to the last rows of the graph respectively refer to exposure components (in italics) and to the size of the shocks component.

3.2 Groups of countries most vulnerable to climate change

The Addis Ababa declaration welcomes the objective of the Green Climate Fund to allocate half of its resources to 'vulnerable countries', identifying the LDCs, SIDS and African countries. For the consensus to operate, it should rely on a quantitative assessment. Estimates of the index may indeed differ according to the method of calculation. The latest Ferdi estimates[9] do not provide evidence of an average level of physical vulnerability to climate change for LDCs that is significantly different from that of other developing countries, but structural economic vulnerability among LDCs (using the EVI index) is significantly higher, which is to be expected as EVI is a criterion for the identification of least-developed countries. However, the PVCCI does not include structural resilience, which is much lower in LDCs (and Africa) due to lower levels of human capital and income per head. LDCs are therefore especially

9 Calculations by Sosso Feindouno at Ferdi.

vulnerable to climate change if we consider 'structural vulnerability', including the physical vulnerability and the structural factors of low resilience.

For the SIDS, the average level of the PVCCI is slightly higher than that of other developing countries (and close to that of LDCs, which is not the case for EVI).

Table 1 Physical Vulnerability to Climate Change Index by country group

Group of countries	Average	Median	St. dev.	Min.	Max.
Developing countries (108)	45.6	44.7	7.3	31.4	63.2
LDC (47)	46.0	42.2	7.2	33.2	59.0
Non LDC (61)	45.2	45.8	7.5	31.4	63.2
SIDS (24)	47.8	48.2	9.1	31.4	63.2
SIDS-LDC (10)	47.5	48.1	9.1	33.2	59.0
SIDS Non-LDC (14)	48.0	48.2	9.4	31.4	63.2

There is in fact a large spread in the index scores within each country category, which is a major reason for determining the allocation country-by-country on the basis of criteria such as the PVCCI rather than by membership of a category. We can then examine the results for each category.

4 Implementation: Design and use of 'adaptation credits'

Now, assume that there is a consensus on an index of physical vulnerability to climate change, which is available to most developing countries. How can it be used for the allocation of adaptation funds? A consensus on an allocation formula is still needed which, from this index and other possible criteria, may determine an allocation of the total adaptation fund between countries. An 'adaptation credit' would correspond to the 'normal allocation' estimated for each country. On this basis, a country could apply to various financial institutions through which the adaptation funds would be channelled.

4.1 Measurement of the 'adaptation credits' from an allocation formula

The formula should express the simple idea that the adaptation funds must meet the needs of countries affected by climate change, for which they are not responsible and which they are less able to cope with the poorer they are. The formula should be based on two essential criteria: physical vulnerability to climate change, and income per head (and/or the level of human capital). The variables corresponding to the two criteria would be introduced preferably in a multiplicative function, in order to show the elasticity of the allocation to each criterion.

The model may seem akin to the PBA that all the multilateral development banks use to allocate their concessional credits (Guillaumont and Wagner 2015). However, it is different for two reasons. First, it includes an indicator of vulnerability, while the MDBs so far have not integrated economic vulnerability in their model.[10] Second, and most importantly, in the PBA the criterion of 'performance' (essentially governance) plays a major role. Priority is given to effectiveness over equity. For the allocation of adaptation funds, the priority is instead on equity, because of the ethical basis for the financing of adaptation. It is essential that the adopted measure of vulnerability to climate change reflects a vulnerability *for which they are not responsible*, in order to justify the support of the international community. Income per head is utilised to reflect the need for concessional adaptation resources, with a low level indicating low structural resilience.

This approach is similar to the point of view expressed by Birdsall and de Nevers (2012), but it differs from the way in which some authors – influenced by the PBA and thus giving a major weight to the 'performance' measure – consider the allocation of funds for adaptation (Barr et al. 2010, World Bank 2010b). The model proposed here is a *vulnerability*-based allocation (VBA) rather than a PBA.

Using the same calibration of the variables as in the PBA model used by the MDBs and the same functional form, a model has been built from only three variables: level of income per head (AY), a measure of PVCCI (V), and the size of the population (P).[11] The results of a simulation carried out for illustrative purposes[12] on a sample of 106

10 An exception is the Caribbean Development Bank. The European Commission has recently used EVI for the allocation of assistance (European Commission 2015).

11 According to the following formula, allocation to country $i = P^a i.\ AY^b i.\ V^c i$.

12 Simulations run by Laurent Wagner at Ferdi (here with the following parameters: a = 1; b = 2; c = 4). Simulations with a parameter a<1 are legitimate due to the structural resilience of small countries.

countries, using the latest version of Ferdi's PVCCI and figures for income per head and population from 2014, are given in Table 2. The table shows the following:

1. Column (1): The relative share of the allocation for LDCs, SIDS, low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs), and sub-Saharan African countries (SSA).
2. Column (2): The relative share of the population in each group.
3. Columns (3) and (4): An index of the relative allocation per capita, respectively a weighted average, given by the ratio of (1) to (2), and a simple average (index > 1 if the allocation per capita is higher than the global average), with some indicators of the spread within each group (in columns (5) to (7)).

According to this simulation, LDCs would receive over half of the adaptation credits. The SIDS group would receive a level of credits per head that is close to the average, due to the fact that many SIDS have a fairly high level of income per head. When an exponent lower than one is applied to the population size, in order to reflect a lower resilience due to small size, the allocation per head of the SIDS becomes higher than average. Of course, there is a wide range of scores for the index across countries.

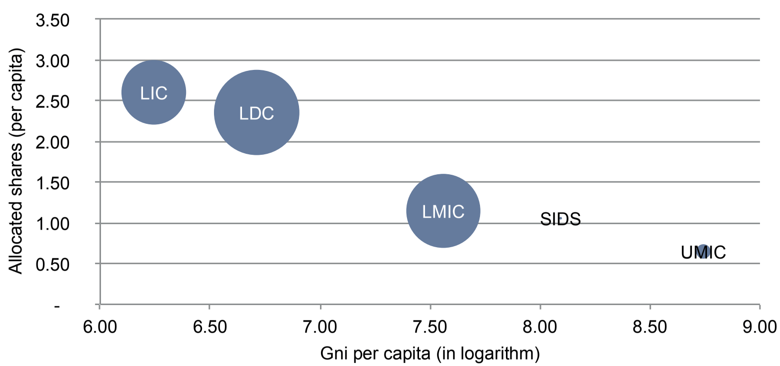
Figure 2 summarises these observations by representing for each group of countries both the relative level of the allocation per head as a function of GNI per head, and the relative share of the total allocation (shown by the size of the bubbles).

It should be underlined that the 'normal allocations' are designated from continuous criteria and not from category membership. If LDCs receive half of the adaptation credits, this is due not to a quota but to their characteristics. Some LDCs may only be a slightly vulnerable to climate change and receive few credits for adaptation, while at the same time they may have a high economic vulnerability that is likely to lead to a relatively high level of ODA per head. Middle-income non-LDCs may be highly vulnerable to climate change, so justifying a fairly high level of allocation for adaptation, without being eligible for a high level of ODA. In this regard, the allocation of adaptation credits based on an indicator of vulnerability to climate change should help to achieve the 'smooth transition' wanted by the United Nations for the countries graduating from the LDC category, many of which are vulnerable to climate change.

Table 2 Vulnerability-based allocation of adaptation resources for 106 developing countries

	Share of allocated resources (%) (1)	Share of total population (%) (2)	Relative allocation per capita (weighted average) (3)=(1)/(2)	Relative allocation per capita (simple average) (4)	Relative allocation per capita (std. deviation) (5)	Relative allocation per capita (max.) (6)	Relative allocation per capita (min.) (7)
LIC	42.22%	20.03%	2.11	2.60	3.12	10.14	0.15
LMIC	48.37%	49.38%	0.98	1.15	1.40	4.99	0.01
UMIC	9.41%	30.59%	0.31	0.65	0.73	2.63	0.00
LDC	55.75%	30.28%	1.84	2.36	2.74	10.14	0.02
SIDS	1.71%	1.77%	0.97	1.06	1.07	3.75	0.01

Figure 2 Relative allocation per capita for adaptation and GNI per capita (a=1)



Under the influence of donors, governance factors might be introduced in the model of allocation of funds for adaptation, with a positive sign as a criterion of effectiveness or performance. A logical criterion would then be an indicator of resilience policy. But, as seen above, resilience related to a country's own willingness is difficult to measure. What could an alternative measure be? Could it be general economic performance through a measure similar to that used for the PBA? Or the quality of a country's policy to combat global warming, which is a more relevant criterion of allocation for mitigation than adaptation? Or an evaluation of the portfolio of projects implemented in the country using foreign aid?

None of these options seems legitimate with regard to the ethical argument specific to adaptation stated above. Should adaptation credits be reduced for a fragile state due to bad governance related to its fragility? When using credits, the quality of adaptation projects can be controlled.

4.2 Use of adaptation credits by countries: Competition between the accredited bodies

How could a country use its 'adaptation credit' ?

It seems to be agreed that a number of institutions will be accredited to receive additional climate resources from the international community (not only the Green Climate Fund, but also the MDBs, UNDP, and various bilateral development agencies). In the proposed system, a developing country to which an adaptation credit is allocated will be allowed to draw any part of this credit from the accredited institution of its choice. An international body (which may be the Green Climate Fund) will be responsible for keeping an account of the allocations received by the accredited institutions and the drawings made from them. The total amount of adaptation credits would not exceed that of the allocations. The allocations and the credits could be measured in terms of their grant element, so that projects can be implemented under the financial conditions that are most appropriate in each case.

Each country holding an adaptation credit may thus present to the institution of its choice projects or adaptation programmes. The accredited institution will ensure that it is a real adaptation project or programme, and will then analyse its modalities with the country, as it does for its other operations. Each country can thus use its adaptation credit through the institution that offers the best financial conditions and technical services.

In the above, we have assumed that from the total resources mobilised for adaptation, what each accredited institution manages is determined on a discretionary basis by the adaptation fund donors. One might also imagine that the Green Climate Fund, instead of becoming an additional institution for direct funding of adaptation projects or programmes, could intervene simply as a refinancing body for the accredited institutions or as a subsidising instrument for eligible projects or programmes. Accredited institutions would then receive their resources partly and on a discretionary basis from bilateral sources, and partly (or only, if so decided by the international community) through the Green Climate Fund, depending on the quality of the programmes and projects that are submitted. Consistency with development programmes and projects would be achieved at the operational level by the accredited institutions, which are skilled in the art. Compliance with the objective of adaptation would be achieved through the mode of financing, in particular the Green Climate Fund, whose function for adaptation would then be redefined.

The use of funds described above for the adaptation process is legitimate only if donors are willing to ensure that mobilised funds are used to adapt, regardless of the risks of fungibility. The contribution of developed countries should be based on each country's responsibility for global warming. The proposal only aims at allocating the amount of additional resources that will be mobilised for adaptation by the international community. Donors can, of course, provide more adaptation resources than they will be committed to providing. They will be all the more inclined to do so since their development assistance, without being reduced, will be adapted to climate change.

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