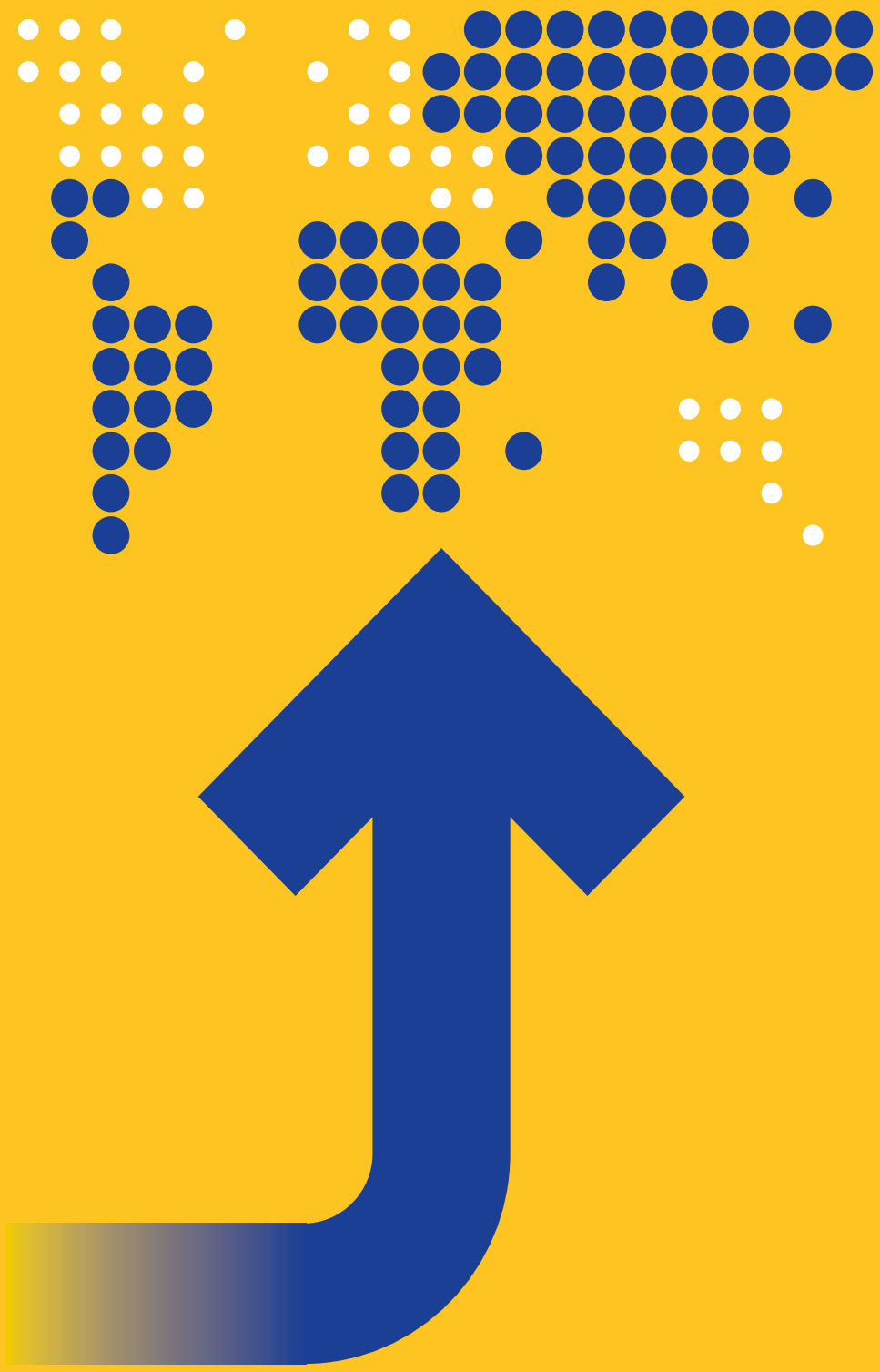

NOVEMBER 3-5, 2015 TOKYO, JAPAN

EMERGING MARKETS FORUM

2015 GLOBAL MEETING

Emerging Markets and Climate Change

Alexander Pfeiffer & Cameron Hepburn

Background Paper

Emerging Markets Forum
A nonprofit initiative of the Centennial Group

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Emerging Markets & Climate Change

Alexander Pfeiffer & Cameron Hepburn

Introduction

After the failure of international negotiations in Copenhagen in 2009 to meet expectations, there was a relative lull in public and political interest in tackling climate change. Predictably, this state of affairs changed markedly in 2014. Climate change returned to the political agenda with the United States-China deal in late 2014 and the anticipation of the December 2015 United Nations conference in Paris. The increased focus on climate change is significant for emerging market economies,1 where there is a great deal at stake—substantial opportunities and significant risks. The renewed focus was driven by several factors of which five events were among the most important.

First, the bilateral climate deal between the United States and China in November 2014 surprised many commentators and included commitments by both parties to reduce emissions that could create new opportunities for emerging market economies.

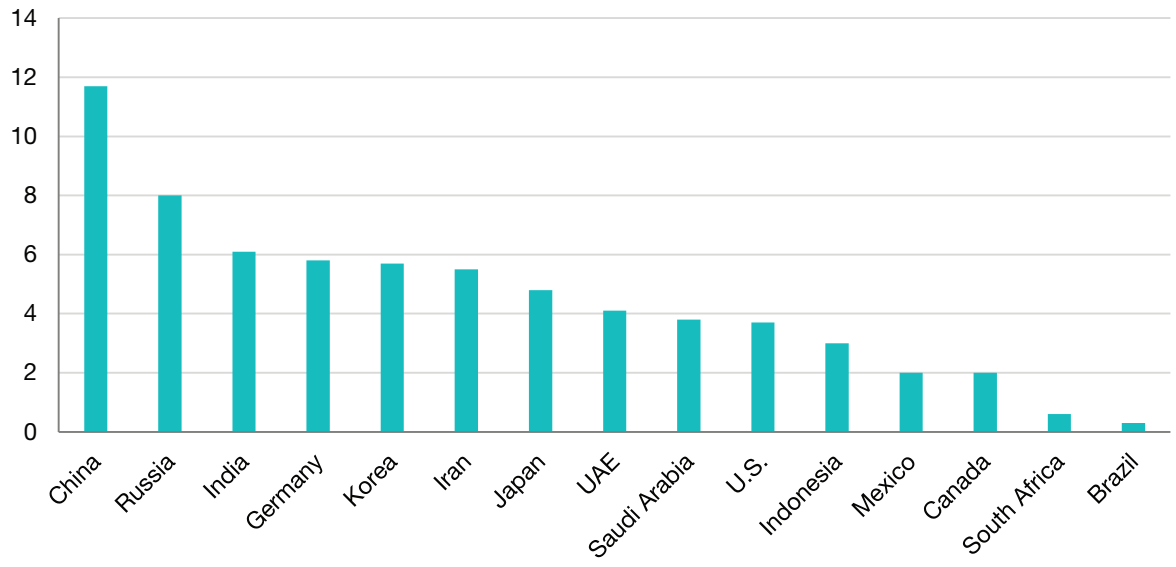
Second, the release of the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) concluded that it is now even more likely—95-100 percent likely—that humans are the predominant cause of climate change and that extremely severe outcomes cannot be ruled out, including in Central Asia and Latin America (Intergovernmental Panel on Climate Change 2014). Critically, a core finding was that emissions need to be reduced to net zero for stabilization of temperatures at any level.

Third, research and announcements from the IMF, the World Bank, and the Bank of England about the economic benefits of action on climate change and the risks to fossil fuel industries put the issue on the agenda of mainstream financial communities. Perhaps the three most striking findings are that fossil fuel subsidies now total over $5 trillion, when calculated on a post-tax basis,2 that local air

1. Different definitions for 'emerging market economies' exist, most of them have in common that an emerging market is a country that has some characteristics of a developed market, but does not meet the standards of a fully developed market (e.g. GDP per capita and various others).

2. This calculation includes as a 'subsidy' all of the unpriced

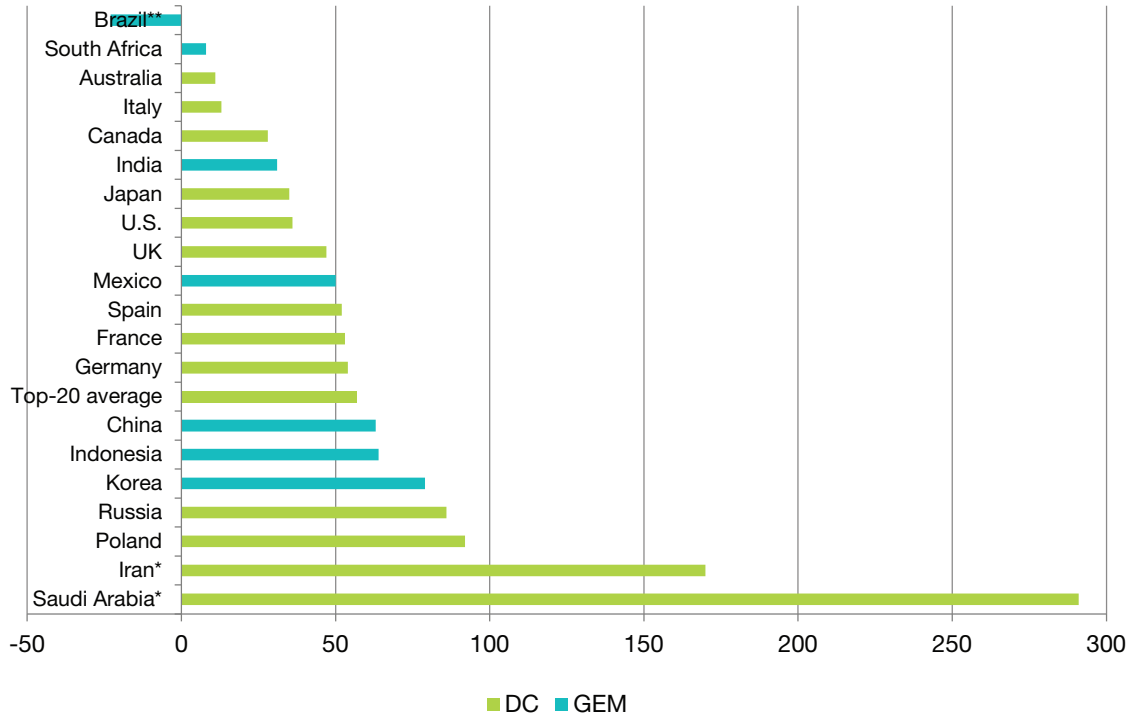
Figure 1: Cost of outdoor air polution as a percentage of GDP (2010)



Note: From PM 2.5 exposure, cost as % of GDP 2010 (median estimates), top 15 carbon dioxide emitters
Source: Hamilton et al (2014)

The New Climate Economy report, chaired by the former center-right President Calderon of Mexico, concluded that action for a better climate was in any case required for better economic growth.

Figure 2: Self-interested domestic carbon prices: Nationally efficient carbon dioxide prices for top 20 emitters, 2010 (in USD/tons of carbon dioxide)



Note: *For Saudi Arabia and Iran there is a large gap between current taxes (which are negative for these countries) and corrective taxes, implying large co- benefits per ton of CO2 reduced, **Brazil with negative efficient price because fuel taxes currently overcharge for domestic externalities
Source: Parry et al. (2014)

pollution is reducing economic output in China by around 10 percent (Figure 1), and that self-interested carbon prices for many key emerging market countries are already $30 or more (Figure 2).

Fourth, the United Nations "Climate Summit" in New York in September 2014 saw around 700,000 people demonstrating around the world to demand that world leaders take action, coupled with a range of corporate and sub-national commitments (Foderaro 2014).

Fifth, two reports on the business and economics of climate change sought to reclaim issue for the centre-right of politics in 2014. The Risky Business report in the United States, backed by a cross-party group including Henry Paulson, former U.S. Secretary of the Treasury under President George W. Bush, identified climate risks to the United States in very granular fashion, identifying likely impacts (floods, storm surges, crop risks, etc.) in each local community (Risky Business 2015). The New Climate Economy report, chaired by the former center-right President Calderon of Mexico, concluded that action for a better climate was in any case required for better economic growth (The New Climate Economy 2015).

externalities from fossil fuels, such as the damage to health and to the climate. The 'post-tax' basis is so named because the subsidies are calculated compared to a world in which the optimal internalising taxes have been applied (Coady et al. 2015).

Real progress is occurring in scientific labs, start-up companies and small and large businesses around the world. With these innovations emerging, the global energy landscape is starting to change.

Figure 3: Share price of Peabody Energy Corp. (BTU) on NYSE (2011-2014)

Source: Google Finance

However, there are still roadblocks and backward steps. The repeal of the carbon price in Australia3 and the continuing extraction of bitumen from oil sands in Canada4 are just two examples. The likely outcome from Paris is that a broad 'coalition of the willing' will sign up to individual actions, referred to as 'intended national determined contributions', or INDCs. But such contributions are unlikely to have any credible enforcement mechanism and even if implemented, will not constrain temperature increases to below 2°C. If this were all that will be done to tackle climate change, the future would look problematic for sustained growth and prosperity in emerging markets.

But the United Nations process represents only a small part of the action. Real progress is occurring in scientific labs, start-up companies and small and large businesses around the world. With these innovations emerging, the global energy landscape is starting to change. There are remarkable new renewable energy technologies emerging at various stages, plummeting in cost, and the development of cheap gas has reduced demand for coal in the USA. Meanwhile, the collapse of oil prices in 2014 raises the bar for new renewable technologies, but also means that much of the current and planned capital expenditure on fossil fuel exploration and production now looks uneconomic. Indeed, there is growing realization that investing in fossil fuel assets that are supposed to generate returns over the next 30-40 years entails considerable risks in a rapidly changing context. The risk of 'stranded assets' — large capital investments that end up devalued or worthless because of changes in the environmental or regulatory landscape — is now being actively discussed at the Board of the oil majors grappling with the challenges to their business models. Large coal-focused companies, such as Peabody Limited, have seen their market capitalization severely hit by the emergence of gas and renewables, with a decline of almost 90 per cent between April 1, 2011 (72.71 USD) and December 15, 2014 (7.55 USD), as shown in figure 3.

In Europe too, utilities are struggling to come to terms with a shifting energy landscape – the Chief Executive Office of the largest utility, RWE, admitted in a press conference in March 2014 that "(…) we were late entering into the renewables market — possibly too late".5 RWE suffered a collapse in market capitalization of more than 50 per cent between January 21, 2011 (55.46 USD) and

3. http://www.reuters.com/article/2014/07/18/us-australia-carbon-vote-idUSKBN0FM04J20140718 (retrieved Dec. 14, 2014).
4. http://www.economist.com/news/science-and-technology/21615488-new-technologies-are-being-used-extract-bitumen-oil-sands-steam (retrieved Dec. 14, 2014)

5. http://www.bloomberg.com/news/2014-04-14/coal-rises-vampire-like-as-german-utilities-seek-survival.html (retrieved Dec. 16, 2014)

Economic prosperity in a world with a changing climate and government policy will be generated by innovations in energy and agriculture and the intelligent deployment of infrastructure that preserves options in uncertain times.

December 12, 2014 (27.12 USD) as it failed to anticipate the German 'Energiewende' – the transition to renewable energy, energy efficiency and sustainable development. A second large German utility, E.ON, announced in November 2014 that it was hiving off its fossil fuels interests so that it could focus on renewable energy, distribution networks and energy efficiency.6 This announcement comes only weeks after Swedish state-owned energy company Vattenfall announced plans to sell off its German lignite coal operations because of an incompatibility with the company's climate change goals.7 Business as usual increasingly looks extremely risky – in energy markets, survival requires change.

Economic prosperity in a world with a changing climate and government policy will be generated by innovations in energy and agriculture and the intelligent deployment of infrastructure that preserves options in uncertain times. For instance, some $90 trillion will be invested globally in infrastructure over the next 15 years, around $60 trillion thereof in emerging markets, much of it catering to rapidly growing and urbanizing populations (The Global Commission on the Economy and Climate 2014; Stern 2014). This investment could promote compact, clean, resource-efficient cities, with lower health care costs and a variety of wealth-generating interactions between inhabitants. In contrast, replicating tired old models of isolation in urban sprawl would be a lost opportunity for Central Asian economies that would damage prosperity, increase pollution and greenhouse gas emissions and hence exacerbate climate risks.

Intelligent infrastructure and innovative, cheap clean technologies could create economic growth and new jobs. These opportunities clearly provide medium-term benefits and may also deliver short-term net gains, although the latter is more contentious in times when and places where clean technologies are not yet cheaper than dirty. Nevertheless, the local benefits from reduced emissions and pollution are now unequivocal, creating substantial value for many emerging economies and they do not depend on bilateral or international agreements. As noted above, IMF research in 2014 concluded that the implementation of relatively high carbon prices is in the self-interest of many countries because of the direct local economic benefits to the implementing country (Coady et al. 2015).

In general, a key idea of the last two years is that the enlightened self-interest by countries can take us quite some distance towards a stable climate and a prosperous future (Hepburn & Ward 2011). There are many actions that may be taken by emerging market economies, individually and as a group, to promote higher economic growth and productivity while reducing climate risk. At present, instead, some countries are harming their own citizens by not addressing climate change seriously (Box 1).

In addition to the advantages from sitting in the driving seat during this economic transition, and avoiding waking up 'too late' like RWE, there are longer-run benefits of risk reduction. The early impacts of global warming are already being observed, and scientists expect changes in the climate to continue given the ever-increasing stock of greenhouse gases. It is now understood that once certain tipping points are reached, there is a real risk of environmental change becoming much more difficult to limit to manageable levels. As Ward et al. (2012) identified, emerging markets have a critical role to play in reducing the risks of higher temperatures and extreme events.8 It is a fair approximation to say that without both action in emerging markets and rich economies, the risks of these catastrophic outcomes cannot be reduced to reasonable levels. While almost all emerging markets including most countries in Africa, Latin America, and Asia would benefit from the actions against climate change (in the

6. http://uk.reuters.com/article/2014/11/30/uk-e-on-divesture-idUKKCN0JE0TZ20141130 (retrieved Dec. 16, 2014).
7. http://www.theguardian.com/environment/2014/oct/30/swedish-energy-company-vattenfall-plans-to-sell-its-german-coal-operations (retrieved Dec. 16, 2014).
8. Ward, John, et al. "Self-interested low-carbon growth in Brazil, China, and India." Global Journal of Emerging Market Economies 4.3 (2012): 291-318.

Even with ambitious action by the G20 Developed Economies (GDEs) , GEMs will still experience most of the damaging conse¬quences of climate change.

Box 1: Should Emerging Market Economies Act on Climate Change, or Wait

Continued fossil fuel-driven growth could leave Earth around 4.9°C warmer in 2100 than in 1990 and sea levels 0.5 meters higher. This would have extremely damaging implications for G20 Emerging Markets (GEMs), with economic damages possibly causing annual GDP to be 6.0 percent lower than it otherwise would be by 2100. The last time global temperatures were this high — the Eocene period, 35-55 million years ago — swampy forests cov¬ered much of the world and there were alligators near the North Pole.

Even with ambitious action by the G20 Developed Economies (GDEs) , GEMs will still experience most of the damaging conse¬quences of climate change. If GDEs reduce their emissions by 80 from 1990 levels by 2050, tem¬perature increases over 1990 levels might still be 4.4°C in 2100, because over the next decades the GEMs will contribute the lion's share of global emissions growth.

For GEMs to avoid the damaging consequences of climate change, they must take ambitious action alongside GDEs. GEMs are now responsible for roughly the same amount of emissions as the GDEs. China has replaced the United States as the world's largest emitter. Rapid economic growth to 2050 coupled with population growth implies GEMs will con¬tribute most to future emissions. While GDEs have contributed the most to historic emissions, it is the GEMs that are expected to be responsible for much of the future warming of the planet. If GEMs restrain their emissions to 2005 levels by 2050, and reduce emissions from deforestation by 50 percent, temperature increases from 1990 levels may be limited to 2.7°C. This would avoid some of the worst impacts. Through action, GEMs can control their own destiny—and that of the planet.

A significant proportion of the benefits generated by GEM action are the result of China, India and Brazil controlling their emissions. If these three GEMs alone were to take action then temperature increases may be restricted to around 3.5°C above 1990 levels. This would reduce the damages experienced by these countries. China's losses are estimated at 2.2 percent of 2100 GDP, compared with 3.2 percent if no GEMs act, and India's losses at 4.2 percent of GDP, compared to 5.9 percent without any GEM action.

Regardless of whether some or all GEMs act, these temperature increases would still be likely to have serious consequences. Many scientists regard a 2°C increase as a maximum before the risks of dangerous climate change become unacceptable. This position is recognized in the Copenhagen Accord. Limiting tem¬perature increases to 2°C on pre-industrial levels would require more ambitious action by GEMs, GDEs, and also the rest of the world.

Given this, it is unsurprising that GEMs have already begun to take action. There has already been a rapid and pronounced acceleration in low-carbon innovation activity within the GEMs. China, for instance, is now one of the leading countries in the world in solar, wind and nuclear power, electric cars, and high-speed rail technologies. Brazil has launched a sophisticated real-time deforestation tracking mechanism and committed to reducing deforestation. India's eleventh five year plan (2008-2012) includes measures aiming to increase energy efficiency by 20 percentage points by 2016-17. South Korea and Mexico have put in place absolute emission targets, and it is likely that several GEMs will beat the US to the introduction of carbon pricing.

Current policies are not enough, however. Accelerated action could trigger a low-carbon race that the GEMs are well positioned to win. As well as reduc¬ing the climate damages GEMs may face, coordinated GEM action could prompt GDEs to ramp up their emission reductions, providing larger markets for GEM low-carbon products. For instance, a HSBC report predicted that if governments went beyond the commitments they made during the run up to COP 15 then, even by 2020, the low-carbon market would be worth $2.7 trillion; 30 percent larger than if governments simply kept to their Copenhagen 2015 commitments and 100 percent larger than in their worst-case scenario.

There are costs to the transition, but the costs only increase with delay. Fossil fuel intensive growth implies the construction of new, dirty capital stock which is likely to have to be scrapped early once the full cost of dirty production is accounted for. Early action will also speed up the rate of technical progress in low-carbon technologies. Both these factors mean that starting early can allow for a more gradual and planned, and hence less costly, transition. For instance if GEMs started taking action in 2012 to bring emissions back to 2005 levels by 2050, then they would only have to achieve annual reductions in emissions of 0.4

Overall, then, there are very significant economic implications of climate change for the emerging market economies, including those of South America, Asia and Central Asia.

Box 1: Should Emerging Market Economies Act on Climate Change, or Wait

percent per annum. If they wait until 2030 before starting to take action (a typical 'delayed action' starting point), with the intention of reaching the same target by 2070, then average reductions of 1.5 percent per annum might be required. While historical experience shows that reductions of 0.5 percent per annum are achievable without significant economic consequences, reductions of more than 1.0 percent per annum have typically only been associated with prolonged economic recessions. All in all, research suggests that costs to emerging economies could be between 25 percent and 33 percent lower with early action.

Post transition, GEMs will have more secure energy supplies. Currently, six of the nine GEMs are reliant on imports for more than 20 percent of their total energy require¬ments. Fossil fuels provide a small number of countries with disproportionate economic and geopolitical power. In contrast, many low-carbon energy resources (solar, wind, hydro, nuclear, biomass, geothermal) are more readily available in GEM countries.

GEMs will also be healthier and more efficient. Of the ten cities with the worst air pollution in the world, nine are in GEM countries. Fossil fuel combustion is largely to blame for the adverse health consequences for the 50 million people who live in these cities; each year in China alone air pollution is thought to cause 270,0000 cases of chronic bronchitis and 400,000 hospital admissions for respiratory or cardiovascular disease. Air pollution problems are also due to cause an additional $6 to $10 bil¬lion per annum in crop yield losses in India and China by 2030. These problems are sufficiently great, and alleviating them so important, that one study has suggested that reducing emissions by 15 percent through a carbon price in China would be desirable on these grounds alone. Moreover, there is the possibility for GEMs to implement measures that both reduce emissions and generate effi¬ciency savings of at least $100 billion per annum.

GEMs could seize the climate policy agenda, and open up these broader opportunities, with a coordinated, self-interested announcement to exploit the fear of "losing the low-carbon race" in the West. Such a strategy would likely thwart resistance within GDEs to action on climate change, which would be to the benefit of GEMs. Irrespective of GDE action, however, without early action by the GEMs, they themselves risk bearing the impacts of dangerous climate change.

medium- and long-term) and have a significant impact on the success of international climate efforts, the influence of the actions in the GEM countries9 is likely to be the largest within this group. Figure 4 shows that provided the rich countries act, whether there is much residual risk of 5-6°C warming depends almost entirely on the G20 emerging market (GEM) economies. An optimal outcome requires more than mere enlightened self-interest, but it does not require global agreement of over 190 nations. Rather, a coalition, club or grouping of major countries – key emerging markets with the US and Europe – clearly appraised of their joint interest, could deliver a good outcome.10

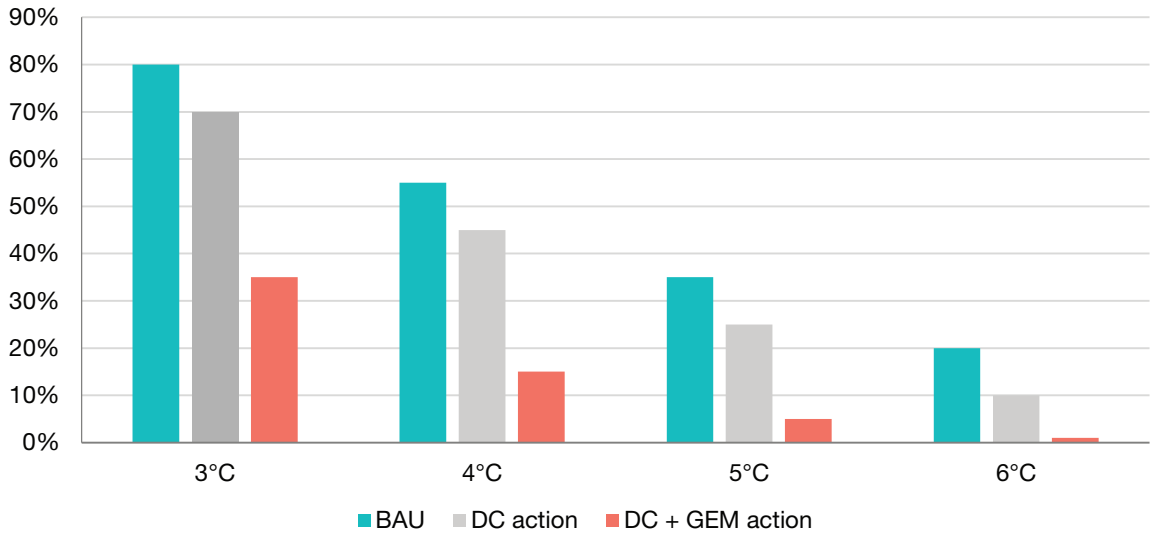
Overall, then, there are very significant economic implications of climate change for the emerging market economies, including those of South America, Asia and Central Asia. This chapter explores those implications in more detail in the following three sections. Section II provides an update on the science, including new knowledge about the risks to emerging markets created by changes to the climate itself, such as effects of water stress (section II.2.a), extreme climate events (section II.2.b), and

9. This chapter also makes use of the grouping of G-20 Emerging Markets, or GEMs, which includes (Argentina, Brazil, China, India, Indonesia, South Korea, Mexico, South Africa, and Turkey).

10. Nordhaus, W. (2015) 'Climate clubs: overcoming free-riding in international climate policy' American Economic Review, 105(4), 1339-1370.

While the short-term implications are not on the scale, say, as the negative implications of the global financial crises or the positive effects of new global trade deal, they are nevertheless substantial. And, in the longer term, the changes in climate could require us to "redraw the map," literally.

Figure 4: Risk reduction from emerging market action



Source: Ward et al. (2012)

heat stress (section II.2.c). Section III considers the economic threats and opportunities created by the transition to a low-carbon economy, with a focus on three particular examples – economic efficiency, productivity, and energy security (section III.1), opportunities in new markets (section III.2), and the risk of capital investment into high-carbon assets that will subsequently be "stranded" (section III.3.). As the U.S.-China deal shows, once the economic benefits of the transition are broadly recognized the policy response in major trading partners of emerging markets can be very rapid indeed. Section IV puts these findings in the current political context examining potential future directions.

The chapter concludes with some estimates of the scale of these effects (section V). While the short-term implications are not on the scale, say, as the negative implications of the global financial crises or the positive effects of new global trade deal, they are nevertheless substantial. And, in the longer term, the changes in climate could require us to "redraw the map", literally. Changes in physical geography would doubtless lead to changes in political geography, as humans move in large numbers from environmentally stressed to more habitable environment. While many of these risks remain remote in time, such are the lags in our infrastructure and climate systems.

The scientific context

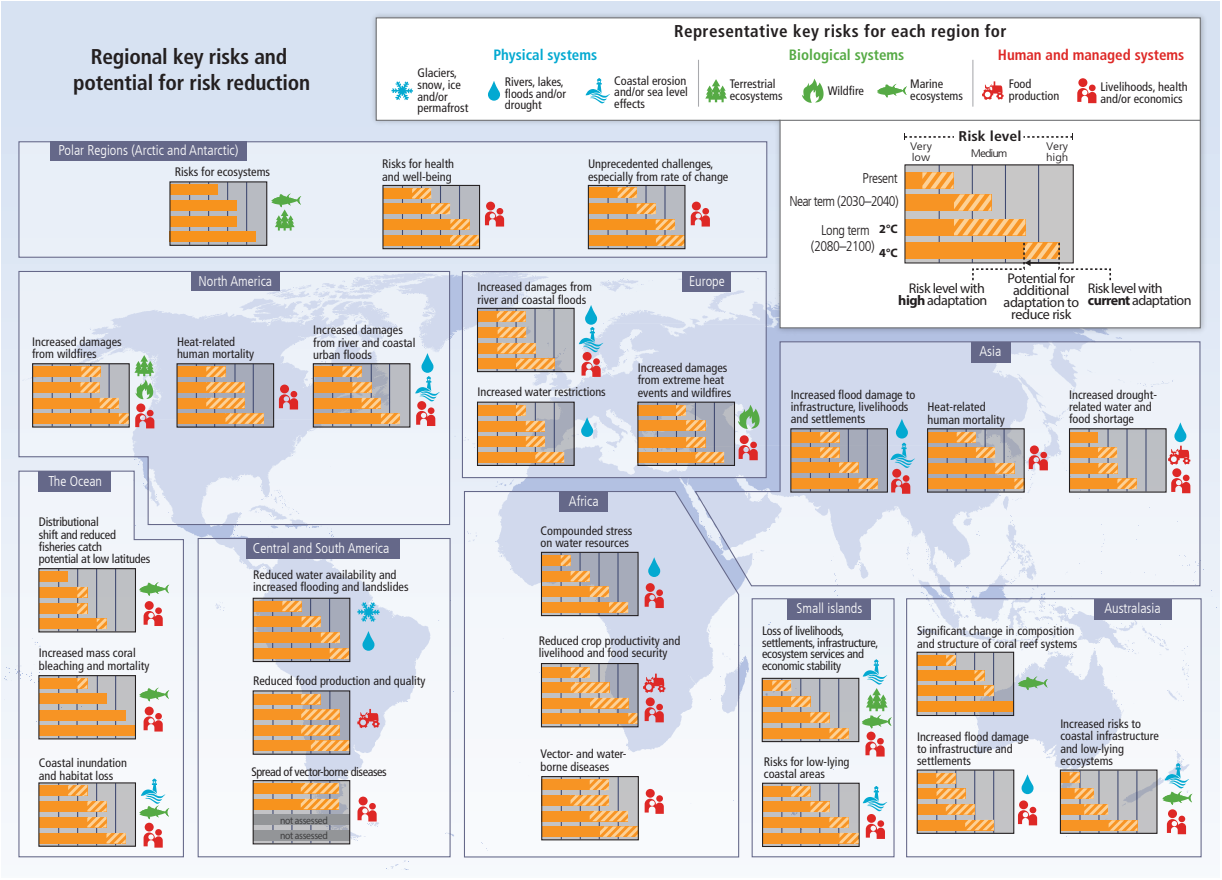
The IPCC's fifth assessment report (AR5)

The three core findings of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), published in September 2014, are: (1) climate change exists and is man-made; (2) the impacts of climate change are already observable in weather patterns and on human societies, and (3) unless we reduce net emissions of greenhouse gases (GHGs) to zero, further global warming and continued change of our weather patterns will occur, severely affecting human and nature systems. Each of these are considered in turn.

The first major finding rests upon the following simple analysis. First, every year, human production and

Natural processes are thus not to blame for the increased GHGs in the atmosphere—humans are the cause.

Figure 5: Climate change has a variety of risks that are specific to various part of the world



Source: IPCC (2014)

consumption leads to emissions of around 40 billion tons of GHG equivalent, such as carbon dioxide, methane, and nitrous oxide. Second, the atmospheric concentration of GHGs has been rising along with these emissions, and is now higher than at any other point in time over the last 800,000 years. Third, the increase in GHGs in the atmosphere is from human processes, because fossil carbon has a different proportion of carbon 14 isotope to natural carbon—and the human marker is observed in the atmosphere. Natural processes are thus not to blame for the increased GHGs in the atmosphere—humans are the cause. Fourth, precisely how much heat is trapped by GHGs is known—this can be measured in a laboratory and is beyond debate. An increase in GHGs is therefore expected to lead to warming. Fifth, warming since pre-industrial levels is indeed unequivocally observed and the changes in the atmosphere and oceans over the mid-20th century are unprecedented. For these reasons, it is now beyond doubt that changes in climate are occurring and humans are contributing to it. What is new in 2014 is the conclusion from the IPCC that it is extremely likely (specifically 95-100 percent likely) that humans are the

The second major finding from the IPCC is that this change in climate is already having worrying effects on the weather, with impacts on human and natural systems across the globe.

predominant cause of the warming between 1951 and 2010. In comparison to the last report (AR4) in 2007, there is now unfortunately even greater evidence that human activities are the cause of global warming.

The second major finding from the IPCC is that this change in climate is already having worrying effects on the weather, with impacts on human and natural systems across the globe. These impacts vary strongly between regions. After the mid-20th century, many observed extreme weather events can now be linked to human influence on the climate. Examples include the increase in observed heat waves, and the observed reduction in cold temperature extremes, an increase in sea levels, and an increase in the number of heavy precipitation events. These events have already had significant influences on human and natural systems via the increasing number of strong storms, droughts, floods, and other events, e.g., landslides after heavy rain. The magnitude of the impact of such events depends heavily on the exposure of these systems in the affected regions (people, assets, and infrastructure at risk) and also the vulnerability (resilience to external shocks) of these human and natural systems, but it is now statistically clear that climate change has increased the frequency of intense climate disasters (Thomas, Albert & Hepburn 2014).

Figure 5 provides an overview of current and expected risks from climate change, with heat-related mortality, water and food shortages, and flood damage highlighted for Asia as a whole. It also considers the risk of death from heat waves in Asia (see "human related heat mortality" panel). There is currently a medium risk (top bar, grey component) of death by heat waves, reduced to a low risk (top bar, blue component) by adaptation measures such as air conditioning. In the near term (2030-2040), this risk will rise to a medium-high level, reduced to a medium level by adaptation. If the human race is able to contain temperature rises to 2°C, which will already be very difficult, then the risk is "only" high, reduced to medium-high with adaptation. On business-as-usual trajectories, which involve 4°C temperature increases, the risk of death from heat waves in Asia is very high, and the best outcome with adaptation is still high to very high.

The third key finding from the IPCC is that it is the cumulative emissions of GHGs over time that will determine the global mean warming by the late 21st century and beyond. Thus, unless net emissions are reduced to zero, the temperature will continue to rise. The current projections of emissions are not consistent with limiting global warming to below 1.5-2.0°C by 2050. While the pledges under the Cancun agreement are consistent with scenarios that give a "likely" chance (66-100 percent probability) of limiting global warming to below 3°C (in 2100), current projections of global carbon emissions pathway rather suggest an increase of 3.7-4.8°C (in 2100) if no new policies to mitigate climate change are implemented. This would increase the likelihood of "severe, pervasive, and irreversible impacts for people and ecosystems" as a result of the increased incidence of heat waves, more frequent and intense water stress (storms, floods, droughts, etc.), acidification of oceans, and increased sea levels (IPCC 2014). Because impacts depend upon cumulative emissions, i.e. the stock of GHGs in the atmosphere, the world is already most likely in the position where it will need technologies to suck GHGs out of the atmosphere to constrain temperature increases. Completely decarbonizing global economic systems and halting all GHG emissions is unlikely to be enough given projected emissions—negative emissions technologies will be required.

The IPCC therefore concludes that humans need to start preparing to adapt to climate changes, in addition to working as hard as possible to prevent the worst scenarios from emerging. With luck, the climate will not be as sensitive to increases in GHGs as it currently appears, and the warming that results from GHG emissions will be at the lower end of the range of estimates. But rather than relying on luck, a prudent strategy involves innovating to reduce the cost of clean technologies, and sensibly applying (at the least) self-interested carbon prices to accelerate the

Climate changes and impacts are already underway, and scientists project the impacts to increase in severity and frequency in the coming years and decades.

inevitable transition to full decarbonisation. It is plausible that enlightened self-interest and a strong focus on innovation could contain warming to 3°C or lower.

Climate change in Emerging Markets

This section explores the impacts from physical changes to the climate (rather than policy and market transitions) on emerging market economies. Climate changes and impacts are already underway, and scientists project the impacts to increase in severity and frequency in the coming years and decades. Understanding the risks is relevant to the actions that might be pursued now, so that emerging market economies are as prepared as possible for the impacts to come. Understanding the risks also helps clarify the nature of the collective interest shared by emerging market economies in taking action to reduce greenhouse gas emissions, and in ensuring that rich countries to do similarly.

The physical impacts from climate change span all sectors and regions, and four notable IPPC AR5 conclusions (with high confidence) are that there will be:

1. Risk of severe ill-health and disrupted livelihoods resulting from storm surges, sea-level rise, and coastal flooding; inland flooding in some urban regions; and periods of extreme heat;
2. Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services;
3. Risk of food and water insecurity and loss of rural livelihoods and income, particularly for poorer populations; and
4. Risk of loss of ecosystems; biodiversity; and ecosystem goods, functions, and services.

The core implication is that emerging markets have an interest in strong action on emissions globally. Even if rich countries take seriously ambitious action, this is not enough – action in emerging markets is also required to avoid the worst risks.11 If action is not taken, and temperatures continue to rise, emerging markets will likely lose valuable human and physical assets. At the same time, as we shall see, emerging markets have a substantial opportunity to lead on significantly reducing global carbon emissions.

To assess the impacts from changes to climate this section reports on the three different scenarios developed by Ward et al. (2012), which are related to the IPCC's four Representative Concentration Pathways (RPC) scenarios from its recent AR 5:

In a high-carbon scenario, often described as business as usual (BAU), recent trends in emissions are projected forward on the basis of GDP forecasts and on forecasts from the climate change modelling literature. In the modelling conducted by Ward et al. (2012),12 this scenario involves global mean temperatures by 2100 that are 3.9°C above 1990 levels and projects a global mean sea-level rise of approx. 0.5m for the same period.

In a developed country action scenario (DC action), only developed countries commit to reduce emissions by 80 per cent on 1990 levels by 2050. In this scenario Ward et al. (2012) project an increase of 3.3°C by 2100 above 1990 levels with a 10 per cent probability that temperature increase could exceed 6°C and a 45 per cent probability that temperature increase will exceed 4°C – often used as threshold for impacts of catastrophic climate change. Mean sea-level rise in the DC action scenario is projected to be approx. 0.4m by 2100 above 1990 levels with a 33 per cent probability of a rise above 0.5 m.

The climate outcomes in both the BAU as well as the DC action scenario, indicate that the world will be substantially hotter and the outcomes are comparable to the outcome of the IPCC's RPC8.5 scenario which projects a temperature increase of 3.7°C (likely range of 2.6-4.8°C

11. Ward, John, et al. "Self-interested low-carbon growth in Brazil, China, and India." Global Journal of Emerging Market Economies 4.3 (2012): 291-318.
12. Ward et al. (2012) use the MAGICC model, a model also used by the IPCC in its Assessment Reports, to assess the impacts of the different scenarios.

The key conclusion is therefore that action by the G20 emerging markets (GEMs), led by Brazil, India, and China, is critical to reducing the risk of catastrophic climate change.

increase) and a global mean sea-level rise of 0.63m (likely range of 0.45-0.82 m) by 2100 above 1990 levels.

The third scenario analysed by Ward et al. (2012) assumes developed country plus GEM action (DC + GEM action) where, in addition to developed country action, GEMs also commit to ensuring that emissions (except from land use change) are at 2005 levels by 2050 and emissions from land use change fall by 50 per cent on 2005 levels. The models show that the expected 2100 temperature increase in this scenario would be significantly reduced to 2.4°C (almost a full degree Celsius lower than if only developed countries take action) and the risk of temperature increase of more than 6°C is almost zero. In other words, if and only if GEMs take action along with the developed countries, a temperature increase of more than 6°C can almost certainly be avoided. The expected global mean sea-level rise in this scenario is approx. 0.3-0.35m and its results largely accord with the IPCC's RCP6.0 scenario, which projects a 2100 temperature increase of 2.2°C (above 1990 levels) (likely range of 1.4-3.1°C) and a global mean sea-level rise of 0.48m (likely range of 0.33-0.63 m).

It should be mentioned that the IPCC includes 2 additional scenarios in its latest AR5 – the RCP2.6 and the RCP4.5 – which are defined by lower expected temperature increase and sea-level rise (see figure 6 below). These scenarios would require significantly higher reductions of carbon emissions from developed and GEM countries (and other countries) than described above. They represent aggressive action on climate change that, even if collectively rational, extends well beyond the narrow self-interest of individual countries.

The models suggest that there is a significant risk of severe losses of GDP in the GEM in the BAU and the DC action scenarios. Ward et al. (2012) suggest for example, that by 2100 for the three largest GEMs – China, India, and Brazil – the loss of GDP from quantifiable impacts could be up to 8-10 per cent of GDP (with a probability of 10 per cent) if the GEMs don't take action against climate change.[13] China would experience damages of as much as 8–10 per cent of GDP by 2100 (with 10 per cent probability), an estimate which declines to only 2-4 per cent of GDP in the DC + GEM action scenario. In India, the equivalent figures are 3-10 per cent of GDP which falls to only 1-5 per cent in the DC + GEM action scenario and in Brazil the range of maximum damages is 2–9 per cent of GDP in the BAU and DC action scenarios and only 1–4 per cent of GDP with GEM action as well.

The key conclusion is therefore that action by the G20 emerging markets (GEMs), led by Brazil, India, and China, is critical to reducing the risk of catastrophic climate change. The maximum damages suffered in these three countries – Brazil, India, and China – in 2100 halves in a scenario in which GEMs join developed countries in taking climate action compared to a situation where they take no action. GEM action would, for instance, reduce the risk of devastating floods in Shanghai, the risk of Amazonian dieback, and the risk of significant interruptions to the hydrological cycle in India that could reduce water supplies that are vital to the prosperity of 250 million people (Ward et al., 2012). We now turn to consider some of the key climate impacts in more detail.

a. Adverse effects from water stress (e.g. droughts)

In a substantially hotter world, the models project significant changes to the global water cycle. While changes will not be uniform around the world, billions of people will experience either very much reduced or very much increased water supply compared to current conditions (Ward et al. 2006). For example, the flow of rivers from the Himalayas, which serve countries accounting for around half the world's current population, would likely be disrupted (Stern 2007). The IPCC forecasts that high latitudes and the equatorial Pacific as well as many mid-latitude

13. Despite significant differences in the modeling assumptions and framework across the three models used (RICE, FUND, and PAGE), and consequently on the absolute magnitude of damages anticipated

Furthermore, increased temperature; sediment, nutrient, and pollutant loadings from heavy rainfall; increased concentrations of pollutants during droughts; and the disruption of treatment facilities during floods will likely reduce raw water quality and pose risks to drinking water quality.

Figure 6: Overview of 4 IPCC representative concentration pathways (RCPs)

		2046-2065		2081-2100	
	Scenario	Mean	Likely range	Mean	Likely range
Global mean surface temperature change (°C)	RCP2.6	1	0.4 – 1.6	1	0.3 – 1.7
	RCP4.5	1.4	0.9 – 2.0	1.8	1.1 – 2.6
	RCP6.0	1.3	0.8 – 1.8	2.2	1.4 – 3.1
	RCP8.5	2	1.4 – 2.6	3.7	2.6 – 4.8
	Scenario	Mean	Likely range	Mean	Likely range
Global mean sea-level rise (m)	RCP2.6	0.24	0.17 – 0.32	0.4	0.26 – 0.55
	RCP4.5	0.26	0.19 – 0.33	0.47	0.32 – 0.63
	RCP6.0	0.25	0.18 – 0.32	0.48	0.33 – 0.63
	RCP8.5	0.3	0.22 – 0.38	0.63	0.45 – 0.82

Source: IPCC (2014): AR5

wet regions are likely to experience an increase in annual mean precipitation under the RCP8.5 scenario, while many mid-latitude and subtropical dry regions will see a decrease of mean precipitation.

Furthermore, increased temperature; sediment, nutrient, and pollutant loadings from heavy rainfall; increased concentrations of pollutants during droughts; and the disruption of treatment facilities during floods will likely reduce raw water quality and pose risks to drinking water quality. Or—put differently—already wet regions with a lot of precipitation would likely see more rainfall but a deterioration of water quality, while many subtropical regions, which are already comparatively dry today, would see less rainfall and more drought. Extreme precipitation events over most mid-latitude landmasses and over wet tropical regions would become more intense and more frequent in the RCP8.5 scenario (i.e. the BAU and the DC action scenarios) leading, for example, to an increase of the area affected by the monsoon. At the same time the monsoon precipitation and the El Niño-Southern Oscillation (ENSO) related precipitation variability on regional scales are also likely to intensify. The IPCC concludes, that "…the fractions of the global population that will experience water scarcity and be affected by major river floods are projected to increase with the level of warming in the 21st century [because] climate change over the 21st century is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions […], intensifying competition for water among sectors […]" (IPCC 2014).

In Brazil, for example, the changing rainfall probability, intensity, and location in the BAU and DC action scenarios could result in a dieback of the Amazonian rainforest14 with profound consequences for Brazil and the entire world. The Amazonian rainforest produces approx. 20 per cent of the world's oxygen,15 harbours approx. 20 per cent animal and plant species in the world, and accounts for approx. 20 per cent of freshwater input into the world's oceans.16 Loss of rainforest could have a massive desta-

14. e.g. Lenton, Timothy M., et al. "Tipping elements in the Earth's climate system." Proceedings of the National Academy of Sciences 105.6 (2008): 1786-1793; Ward, John, et al. "Self-interested low-carbon growth in Brazil, China, and India." Global Journal of Emerging Market Economies 4.3 (2012): 291-318.

15. Maxwell, Simon. "World development report 2010: Development and climate change." (2010): 299-301.

16. Parry, Martin L., ed. Climate Change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on

However, the climate change induced sea-level rise will threaten even more assets in the GEMs and a large number of GEM cities.

bilizing impact on global emissions because the total carbon stored in the Amazon rainforest is estimated to be 150-200 GtC.17 By comparison, total global emissions in 2012 were around 10.6 GtC.18

India and the surrounding region provides another case where the adverse effects of increased water stress are expected to reduce the flow of the Brahmaputra and Indus rivers lowering the feeding capacity of each river basin by around 25–30 million people by as early as 2065.19 In this region of the world, political tensions associated with water shortages, as well as concerns over migration, are already high. Models predict these impacts have an associated probability of over 75 per cent in the BAU and DC action scenarios but less than 50 per cent chance in the DC + GEM action scenario.20

b. Extreme events, disease, and conflict

Extreme events and sea level rise: The IPCC finds that "climate-change-related risks from extreme events, such as heat waves, heavy precipitation and coastal flooding, are already moderate […]" and that "… with 1°C additional warming, risks are high…" because "risks associated with some types of extreme events, e.g., extreme heat, increase progressively with further warming […]" (IPCC 2014).

Global mean sea levels will continue to rise over the course of this century. While the rise will not be uniform across all regions, it is very likely that we will see at least some rise in 95 per cent of the ocean area and about 70 per cent of the coastlines worldwide will likely experience sea-level change within ±20 per cent of the global mean. In the BAU and the DC action scenarios, the global mean sea level is expected to rise by 0.4-0.5m by 2100 and in the DC + GEM action scenario still 0.3-0.4m rise are expected. The IPCC expects at least 0.4m rise in its RCP2.6 scenario (0.26-0.55m likely range) and up to 6.3m (likely range 4.5-8.2m) in its RCP8.5 scenario.

In the US, the Risky Business Report finds that between USD 66-106 billion worth of existing coastal property could be below sea level by 2050 and USD 238-507 billion by 2100 with a 5 per cent chance of damage beyond USD 701 billion by 2100 and USD 730 billion of additional property at risk during high tide.21

However, the climate change induced sea-level rise will threaten even more assets in the GEMs and a large number of GEM cities. For instance Nicholls et al. (2008)22, who list the cities most vulnerable to an extreme surge-induced flood in a world with 0.5m increased average sea-levels and no further defence measures, finds that 7 of the 20 most exposed cities are in the GEMs, with an exposed population of approx. 50 million people in 2070. Also in terms of asset exposure, 8 of the 20 (and 6 out of the top-10) most exposed cities are in the GEMs, with a combined expected asset exposure of USD 12.7 trillion.

For some coastal cities in China and other cities in South and South East Asia, this means that climate change could double the number of people exposed to coastal flooding. In each of Shanghai, Dhaka, and Kolkata, the number of people and assets exposed from coastal flooding if sea levels rise by 0.5m is at least double the number of people who would be exposed without sea level rises. In total, there could be an additional 17 million people in these three cities alone who would be exposed to the risk of coastal flooding in 2070.23 But not only China,

Climate Change. Vol. 4. Cambridge University Press, 2007.

17. Brienen, R. J. W., et al. "Long-term decline of the Amazon carbon sink." Nature 519.7543 (2015): 344-348.

18. For the year 2012, fossil fuel emissions were 9.7 ±0.5 GtC, a 2.2% increase over 2011 (a gigaton is 1 billion tones). An additional 0.9 ±0.5 GtC is estimated from land-use change. However, atmospheric carbon dioxide concentration in 2012 increased by only 5.2 ±0.2 GtC. The rest was absorbed by the oceans (2.9 ±0.5GtC) or the land (2.5 ±0.9 GtC) (http://www.metoffice.gov.uk/research/news/gcb-2013).

19. Immerzeel, Walter W., Ludovicus PH Van Beek, and Marc FP Bierkens. "Climate change will affect the Asian water towers." Science 328.5984 (2010): 1382-1385.

20. Ward, John, et al. "Self-interested low-carbon growth in Brazil, China, and India." Global Journal of Emerging Market Economies 4.3 (2012): 291-318.

21. http://riskybusiness.org (retrieved Dec. 14, 2014).

22. Nicholls, Robert J., et al. "Ranking port cities with high exposure and vulnerability to climate extremes." (2008).

23. Ibid.

Increases in extremely hot days not only lead to decreased labour productivity and risks to human health and energy systems, but that during some months of the year extreme heat could even surpass the threshold at which the human body can maintain a normal core temperature without air conditioning.

Bangladesh, and India are at risk – Dasgupta et al. (2007) conclude that measured both by population exposure and by GDP exposure, Vietnam is the most exposed country to sea level rise, with more than 10 per cent of its projected GDP and population at risk.24

Disease: In the latest assessment report, the IPCC finds (with very high confidence) that "until mid-century, projected climate change will impact human health mainly by exacerbating health problems that already exist". Over the next decades climate change will increase ill health in many regions around the world but especially in developing nations with comparatively lower income. The effects include a higher likelihood of injury, long-term disability and death which stems from more frequent fires, heat waves, floods, rain-caused landslides, food- and waterborne diseases and lead to a loss of work capacity and labour productivity in vulnerable populations. In addition, the risk of mal- and under-nutrition in poor regions will increase and together with the increase of infection areas and seasons in a warming world also the risk of vector-borne diseases will increase.

While predictive studies specific to GEM countries for far-future health impacts are rare, Tanser et al. (2003) find that under BAU by 2100 South Africa would see a high increase in malaria exposure, with a near five-fold increase in person-months of malaria exposure from 28 million to 135 million person-months per annum.25

Increases in extremely hot days not only lead to decreased labour productivity and risks to human health and energy systems, but that during some months of the year extreme heat could even surpass the threshold at which the human body can maintain a normal core temperature without air conditioning. In Latin America, Africa and South East Asia, by 2100 in a BAU scenario, the combination of high temperature and humidity in some areas for parts of the year is expected to compromise common human activities, including growing food and working outdoors.

Conflict: Hsiang et al. (2011) examine the extent to which changes in global climate in the past have been responsible for "episodes of widespread violence and even the collapse of civilizations." While previous studies have only found that "random weather events might be correlated with conflict in some cases," Hsiang et al. directly associate planetary-scale climate changes with global patterns of civil conflict using data from 1950-2004. They find that the probability of new civil conflict doubles during El Niño years relative to La Niña years and hence that ENSO (El Niño/Southern Oscillation) may have had a role in 21 percent of all civil conflicts since 1950.

This finding is supported by the findings of the IPCC, which states in its recent AR5 that "climate change is projected to increase displacement of people […]" and that "…displacement risk increases when populations that lack the resources for planned migration experience higher exposure to extreme weather events, such as floods and droughts." Therefore "climate change can indirectly increase risks of violent conflict by amplifying well-documented drivers of these conflicts, such as poverty and economic shocks" (IPCC 2014).

c. Risk of heat stress (e.g. crop failure)

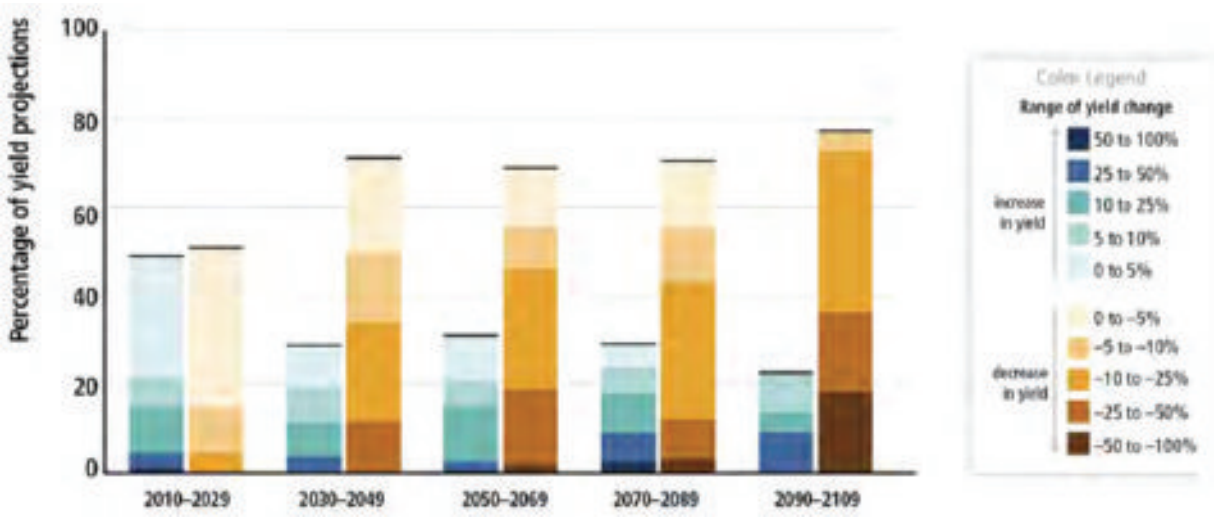
It is virtually certain that more hot and less cold temperature extremes will be observed over most land areas on daily and seasonal timescales, as global mean surface temperature increases over the next decades until the end of this century. According to the IPCC, it is "very likely that […] heat waves will occur with a higher frequency and longer duration" while "occasional cold winter extremes will continue to occur" (IPCC 2014).

Agriculture is one of the most sensitive economic sectors to climate change because agricultural production is heavily dependent on weather outcomes, especially heat

24. Dasgupta, Susmita, et al. "The impact of sea level rise on developing countries: a comparative analysis." World Bank policy research working paper 4136 (2007).
25. Tanser, Frank C., Brian Sharp, and David Le Sueur. "Potential effect of climate change on malaria transmission in Africa." The Lancet 362.9398 (2003): 1792-1798.

A global temperature increase of 4°C or more, combined with increasing food demand, would hence pose large risks to food security, both globally and regionally.

Figure 7: Summary of projected changes in crop yields due to climate change



Source: IPCC (2014): AR5

and precipitation. Hence climate change has the potential to significantly alter the sector's productivity. Lobell, Schlenker & Costa-Roberts (2011), for example, analyse climate trends and global crop production for the four most important crops since 1980 and find that that global maize and wheat yield declined by 3.8 and 5.5 percent respectively, compared to a counterfactual without changes in climate. For soybeans and rice, winners of climate change, e.g., by increased participation and beneficial change of temperatures, and losers largely balance out. In some countries analysed, the decrease in crop yields due to climate change is large enough to offset a significant portion of the increase in average yields that arise from technology, carbon dioxide fertilization, and other factors (Lobell et al. 2011).

These findings largely accord with the findings of the IPCC, which states "all aspects of food security are potentially affected by climate change, including food production, access, use, and price stability" (IPCC 2014). While the agriculture sector in some regions may even benefit from milder climate and increased precipitation for wheat, rice, and maize in tropical and temperate regions, e.g., some parts of Kazakhstan, climate change without adaptation is projected to negatively impact global production.

Overall 10 percent of projections for the 2030–2049 period show yield gains of more than 10 percent, and about 10 percent of projections show yield losses of more than 25 percent, (compared with the late 20th century). A global temperature increase of 4°C or more, combined with increasing food demand, would hence pose large risks to food security, both globally and regionally.

But agriculture is not only one of the most sensitive economic sectors to climate change – it is also a relatively important sector in GEM countries, currently accounting for about 10 per cent of the GEM economy.26 Significant

26. e.g. Hepburn, Cameron, and John Ward. "Self-interested Low-carbon Growth in G-20 Emerging Markets." Global Journal of Emerging Market Economies 3.2 (2011): 195-222.

Recent research indicates that the transition towards a low carbon economy could assist GEMs and emerging markets more generally to transform their economies toward a new technological paradigm.

reductions in crop yields are expected in most GEM countries in the BAU as well as the DC action scenario and could severely damage the GEMs economies. Based on analyses from the World Bank27 and Müller et al. (2010),28 by 2050, dangerous climate change would be expected to lead to declines in agricultural yields in eight of the nine GEMs and in the case of India, Argentina, South Korea, Brazil and Indonesia, these declines in yield could be even greater than 15 per cent. As mentioned above, some regions and economies could profit from an increase in agricultural yield due to beneficial climate developments. China, for instance, is expected to experience higher yields through more favourable climatic conditions. However, the boost to Chinese yields is not sufficient to offset losses elsewhere.

The low-carbon transition: Opportunities and threats

This section considers the economic opportunities and threats for emerging markets created by the inevitable transition to a low-carbon economy, with a focus on three particular examples – economic efficiency, productivity, and energy security (section III.1), opportunities in new markets (section III.2), and the risk of capital investment into high-carbon assets that will subsequently be "stranded" (section III.3.). The first of these is clearly an opportunity – innovation and change creates possibilities for improved efficiency and productivity that emerging markets could capture. The second two areas present threats and opportunities – new markets in low-carbon technologies, goods and services are already emerging, and as China's experience already demonstrates, capturing share in these new markets is an opportunity for emerging markets. But with the emergence of new markets comes the threat of decline in older fossil fuel value chains, and the third area looks specifically at the risk of value destruction as coal- and oil-related markets decline.

The potential policy responses that can be put in place to capture these opportunities and hedge the risks go well beyond carbon prices. Consider the following five examples. First, many countries have been adopting feed-in tariffs (FITs) for renewable energy – providing a fixed price to facilitate the financing of capital expenditure on solar panels and wind farms. Second, the clever design of cities to be compact and suitable for walking and cycling with multi-modal transport options can both, enhance productivity and lifestyles while decreasing emissions. Third, energy efficiency regulations can trigger substantial savings in energy consumption at little or even negative cost. Fourth, air quality standards can dramatically reduce the negative health impacts of fossil fuels. Fifth, pricing of natural capital (including water, biodiversity and carbon) can help send appropriate signals to the individuals and companies so that valuable natural resources are used sensibly. We consider some of these policy instruments in more detail below. Harvey et al. (2013) provide further consideration of such individual policies and how they might be combined to deliver the necessary reductions.29

Economic efficiency, productivity, and energy security

Recent research indicates that the transition towards a low carbon economy could assist GEMs and emerging markets more generally to transform their economies toward a new technological paradigm. This transformation could result in increased energy security, cleaner cities with healthier and more productive citizens, more competitive industrial sectors, and more productive agricultural sectors. Some of the GEMs have already taken significant action against climate change but accelerating and increasing these actions would result in additional economic and

27. Maxwell, Simon. "World development report 2010: Development and climate change." (2010): 299-301.
28. Müller, Christoph, et al. «Climate change impacts on agricultural yields.» (2010).
29. Harvey, H., Orr, Franklin M. and Vondrich, C. (2013), 'A Trillion Tons' Daedalus, the Journal of the American Academy of Arts & Sciences, 142(1), 8-25.

Energy efficiency has long been regarded as the most economically sensible – indeed 'no brainer' – action to take within the portfolio of climate-change related actions.

social benefits for the acting countries, in addition to the benefits from reducing the worst risks of climate.

Efficiency regulations: It is now widely observed in case studies and statistical analyses that shocks to well-established production processes and business models can lead to greater efficiencies, even if these efficiencies were in theory able to be identified and captured without the shock. This raises the following question – if there are profitable, efficiency-enhancing opportunities available, why don't firms capture them without needing external stimulus? However, management scholars and behavioural economists such as Porter (1991),30 Porter & van der Linde (1995),31 and Clark, Feiner and Viehs (2014)32 have identified a range of reasons why more 'oblique' approaches can be successful in driving efficiency gains at the level of the firm and the nation (see also Kay, 2011).33

Energy efficiency has long been regarded as the most economically sensible – indeed 'no brainer' – action to take within the portfolio of climate-change related actions. While the environmental benefits are often significantly overstated by environmentalists and engineers who tend to underestimate the significance of the rebound effect,34 it is nevertheless highly likely that some environmental benefits are derived, and more importantly the economic benefits are clearly substantial.

Economically beneficial opportunities to increase energy efficiency are widespread. They are often overlooked because of market failures such as information inefficiencies, external effects, or limitations in the capital markets. The New Climate Economy report35 finds, in accordance to other organisations such as McKinsey & Company,36 World Bank,37 and the Asian Development Bank38 that many mitigation measures related to energy efficiency could be taken which have a positive payoff and reduce emissions at the same time. In emerging markets, Hepburn and Ward (2011) identify annual economic savings of around USD 50 billion for China and USD 15 billion for Brazil alone.39 Irrespective of whether a country is concerned about climate change, these are economic measures that should be supported and promoted by policy makers in respective countries.

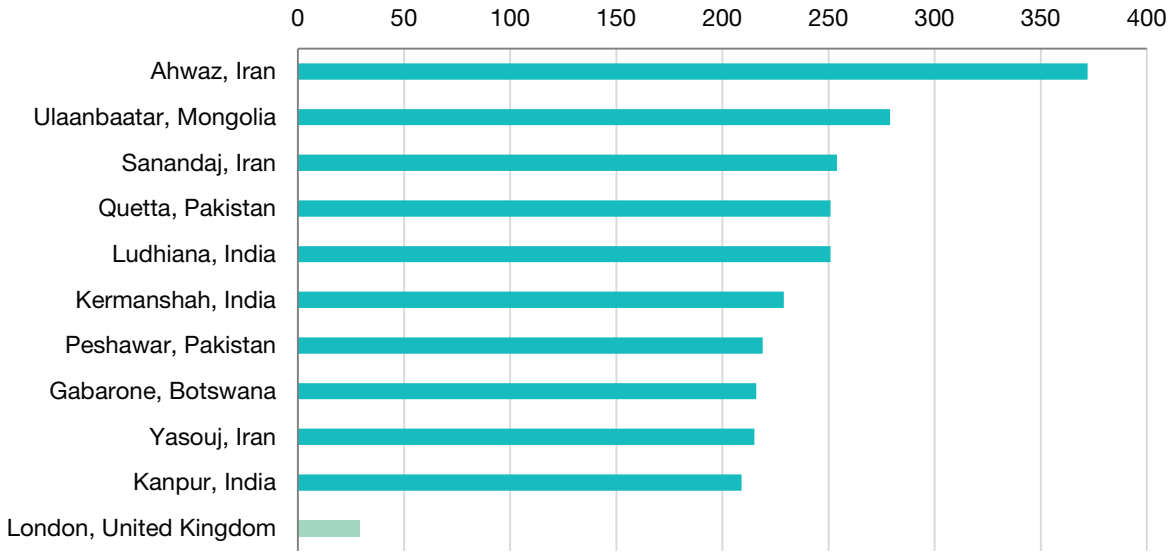
Air quality and productivity: Combustion of fossil fuels not only causes the emission of GHGs such as carbon dioxide but also releases locally active and harmful air pollutants such as sulphur dioxide, nitrogen dioxide, and especially particulate matter (PM). These air pollutants are the cause for a number of cardiovascular and respiratory diseases, including asthma, lung cancer, and chronic bronchitis. In addition to killing productive citizens, these health problems have been demonstrated to lead to greater absenteeism and even hospitalization of workers, which not only reduces their direct productivity, but increase the load on national health services, reducing overall economic productivity.

Many emerging markets continue to have a high share of coal and heavy oil in the domestic energy mix and are thus severely affected by air pollution. While apparently 'cheap', the full costs to the economy of burning such fossil fuels is rarely accounted for when decisions

30. Porter, Michael E. "Towards a dynamic theory of strategy." Strategic management journal 12.S2 (1991): 95-117.
31. Porter, Michael E., and Claas Van der Linde. "Toward a new conception of the environment-competitiveness relationship." The journal of economic perspectives (1995): 97-118.
32. Clark, Gordon L., Andreas Feiner, and Michael Viehs. "From the Stockholder to the Stakeholder: How Sustainability Can Drive Financial Outperformance." Available at SSRN 2508281 (2014).
33. Kay, John. Obliquity: Why our goals are best achieved indirectly. Profile Books, 2011.
34. Gillingham, Kenneth, et al. "Energy policy: The rebound effect is overplayed." Nature 493.7433 (2013): 475-476.
35. The Global Commission on the Economy and Climate, 2014. The New Climate Economy Report: Better Growth, Better Climate, Available at: http://newclimateeconomy.net.
36. McKinsey & Company, 2009. 'China's Green Revolution'; McKinsey & Company, 2009. 'Pathways to a Low-Carbon Economy for Brazil'.
37. The World Bank Group, 2009. 'Low-Carbon Development for Mexico'.
38. Asian Development Bank, 2009. 'The Economics of Climate Change in Southeast Asia: A Regional Review'.
39. Hepburn, Cameron, and John Ward. "Self-interested Low-carbon Growth in G-20 Emerging Markets." Global Journal of Emerging Market Economies 3.2 (2011): 195-222.

In China, as one particularly severe example, over half of the urban population lives in cities with concentrations of harmful air pollutants (especially PM) of over five times the levels provided by the WHO.

Figure 8: Top ten cities with worst air pollution (PM10)



Note: Values are annual averages in micrograms per cubic meter of air. London, which is not an especially clean European city, is included for comparison purposes.
Source: The New Climate Economy Report (2014)

about the energy mix are made. Nine out of the ten cities with the worst air pollution in the world are located in the GEMs with an annual mean concentration of five to eight times the WHO standard level of 20 micrograms per cubic meter affecting more than 50 million people,40 as shown in figure 8.

In China, as one particularly severe example, over half of the urban population lives in cities with concentrations of harmful air pollutants (especially PM) of over five times the levels provided by the WHO. The World Bank estimated over seven years ago that pollution levels at that time lead to approximately 270,000 cases of chronic bronchitis and 400,000 hospital admissions from respiratory or cardio-vascular diseases every year. It was estimated that back then up to 13 per cent of deaths of urban dwellers in China could be premature because of air pollution.41

By 2010, the World Health Organization's Global Burden of Disease report suggested the situation was already considerably worse.42 While this only measures the ill effects of the smaller PM2.5 particles (and does not include PM10), it shows the number of deaths now exceeding one million people per year in China alone. As figure 9 shows, several emerging market economies are killing very large numbers of people with dirty air.

Last but not least, the agricultural sector could benefit from mitigation action. Combustion of fossil fuels not only leads to the emission of the harmful air pollutants described above but also to the formation of low-level ozone, which reduces photosynthesis of local fauna and hence crop yields and growth of plants. This is already affecting crop yields globally and relatively recent forecasts estimate an additional USD 6-10 billion per annum in crop yield losses

40. Hamilton K., Brahmbhatt M., Bianco N., and Jiemei L. (2014) 'Multiple Benefits from Climate Mitigation: Assessing the evidence', working paper.
41. http://www.worldbank.org/en/news/press-release/2007/07/11/statement-world-bank-china-country-director-cost-pollution-china-report (retrieved, July 17th 2015).
42. http://www.who.int/healthinfo/global_burden_disease/publications/en/ (retrieved, July 17th 2015).

Emerging market economies are diverse. Some, such as Kazakhstan, Indonesia and Mexico, are countries for which fossil fuel exports are significant. These economies have a surplus of at least some forms of energy and in some respects are 'energy secure', at least in the short run.

Figure 9: Estimated deaths from outdoor PM2.5 exposure

	2.5 percentile	Median	97.5 percentile
Brazil	5,218	7,582	10,449
Canada	5,607	7,171	8,957
China	1,037,790	1,233,890	1,409,610
Germany	34,573	41,582	49,328
India	528,681	627,426	726,434
Indonesia	54,211	63,826	74,627
Iran, Islamic Rep.	28,108	32,288	36,624
Japan	50,578	64,196	79,077
Korea, Rep.	18,128	23,036	28,016
Mexico	17,797	20,496	23,307
Russian Federation	78,257	94,558	112,025
Saudi Arabia	7,321	8,550	9,667
South Africa	2,504	3,208	4,044
United Kingdom	18,854	23,373	27,996
United States	84,723	103,027	122,383

Source: Hamilton et al, 2014; World Health Organization, 2010

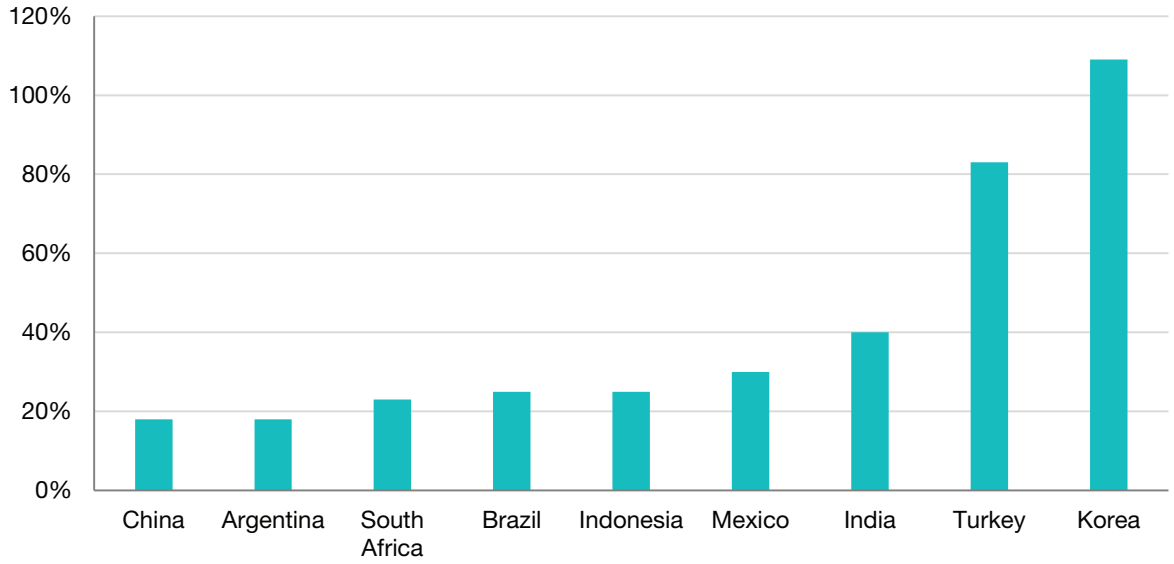
in India and China by 203043 and the impact of climate change on US agriculture is also likely to be negative.44 Old studies suggest that a 15 per cent reduction of carbon dioxide emissions in China could increase national output of rice by as much as 0.29 per cent and output of wheat by 0.68 per cent, which equals in total approximately 0.1 per cent of GDP.45 These estimates are even excluding the effects of a reduction of acid rain, which is estimated to cost the economy as much as USD 3.6 billion (2003 prices) per annum in crop yield losses.46 An important knock-on effect is that there appears to be a link between crop yields and migration. Feng et al. (2012, NBER) find that for every 1 per cent decrease in yields in the USA "corn belt" leads to a 0.17 per cent net reduction in the population through migration.47

Energy Security: Emerging market economies are diverse. Some, such as Kazakhstan, Indonesia and Mexico, are countries for which fossil fuel exports are significant. These economies have a surplus of at least some forms of energy and in some respects are 'energy secure', at least in the short run.48 The opportunity for these countries from the new, clean technologies is to deploy as much of them as possible to satisfy their own domestic energy

43. Van Dingenen, Rita, et al. "The global impact of ozone on agricultural crop yields under current and future air quality legislation." Atmospheric Environment 43.3 (2009): 604-618.
44. Fisher, Anthony C., W. Michael Hanemann, Michael J. Roberts, and Wolfram Schlenker. 2012. "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather: Comment." American Economic Review, 102(7): 3749-60.
45. O'connor, David, et al. "Agricultural and Human Health Impacts of Climate Policy in China." (2003).
46. http://www.worldbank.org/en/news/press-release/2007/07/11/statement-world-bank-china-country-director-cost-pollution-china-report (retrieved, July 17th 2015).
47. Feng, Shuaizhang, Michael Oppenheimer, and Wolfram Schlenker. Climate change, crop yields, and internal migration in the United States. No. w17734. National Bureau of Economic Research, 2012.
48. That said, while Indonesia for instance is a large net exporter of thermal coal, it is also a net importer of oil, so energy aggregates can hide specific vulnerabilities.

The transition to a low-carbon economy will require major changes in infrastructure and innovative technologies, creating new market opportunities for emerging market firms.

Figure 10: Share of imported energy for the 9 GEMs



Note: Share is calculated as fraction of imports over total primary energy supply. Not all imports in one year need to be used for supply in the same year, allowing imports to exceed 100 per cent as in the case of Korea.
Source: IEA data (2012)

needs so that in the short-run they can export more of their fossil energy (at higher prices) to other countries, until their customers also switch to clean energy.

However, many emerging markets, and indeed all of the larger emerging markets that make up the GEMs, import fossil fuels to meet parts of their energy demand. Seven out of nine GEMs now import more than 20 per cent of their total energy demand and hence are heavily reliant on these imports (see figure 10). Being reliant on the import of fossil fuels to this extent necessarily implies that their domestic economies are exposed to events outside their direct control, such as price variability or geographical and geopolitical risks in exporting countries and along fossil fuel transport routes (for instance, figure 11 shows shipping routes into China).

Increasing the share of domestic low-carbon energy sources, which do not require fossil fuels, reduces the dependence on individual exporting countries. The geographic distribution of fossil fuel resources currently gives a limited number of countries much power over the world's energy supply. Reducing the dependence on fossil fuel imports would therefore liberate the reducing countries because of the large number of different low-carbon energy technologies (such as solar, wind, hydro, nuclear, biomass, and geothermal) available.

Opportunities in new markets

The transition to a low-carbon economy will require major changes in infrastructure and innovative technologies, creating new market opportunities for emerging market firms. These new market opportunities are particularly large within energy technologies, transport, agriculture, infrastructure, and buildings. This section briefly reviews the scale of those opportunities, and provides some indication of the likely locus of comparative advantage for emerging market economies.

Various headline numbers for the scale of the low-carbon market opportunity have been advanced. The New Climate Economy Report (2014) notes that USD 90 trillion

The core advantage for emerging market firms is that much of this will be happening on their home territory, which should (for various reasons) give them a comparative advantage over firms domiciled elsewhere.

Figure 11: China oil import countries and transport routes (2011)

Country	Saudi Arabia	Angola	Iran	Russia	Oman	Iraq	Sudan	Venezuela	Kazakhstan	Kuwait	UAE	Brazil	Republic of Congo	Other
Percentage of Imports	19.8	12.3	10.9	7.8	7.2	5.4	5.1	4.5	4.4	3.8	2.7	2.6	2.2	3.3
Thousand Barrels	366,825	227,395	202,575	144,175	132,495	100,140	94,900	83,550	81,760	69,715	49,215	48,190	40,245	208,780

Created by Marcia Underwood of the Brookings Institution with data compiled from the U.S. Energy Information Agency's China Country Report 2012. http://www.eia.gov/countries/cab.cfm?fips=CH.

Source: Hepburn et al. (2014)

of investment will be needed over the next 15 years, around USD 60 trillion of this in emerging markets, and this can either be high or low carbon-intensive investments. If climate change is addressed by the private sector and governments in this time frame, then potentially all of this investment – an at average run rate of USD 6 trillion per annum – could be thought of as representing a low-carbon market opportunity, even though the incremental costs of making this investment low-carbon are relatively small. The core advantage for emerging market firms is that much of this will be happening on their home territory, which should (for various reasons) give them a comparative advantage over firms domiciled elsewhere.

Other estimates differ but are within the same order of magnitude. For instance, in a more narrow assessment of the global market opportunity for low-carbon technologies, Ward et al. (2012) conclude that by 2050, the scale of the opportunity is around USD 3 trillion per annum, USD 2 trillion of which is in new passenger vehicles and fuels, and the remainder of which is largely in new energy

Given market opportunities of such scale, and given that a lot of the action will no longer be in currently rich countries, but instead will occur in emerging markets, it is inevitable that new emerging market players will enter and displace slow-moving incumbents.

technologies and in buildings.49 They explicitly note that 'this is likely to underestimate the size of the total market opportunities as it does not include the accompanying networks infrastructure that will be required alongside these investments' – the New Climate Economy estimates include those infrastructure opportunities.

Given market opportunities of such scale, and given that a lot of the action will no longer be in currently rich countries, but instead will occur in emerging markets, it is inevitable that new emerging market players will enter and displace slow-moving incumbents. For instance, a decade ago one would not have necessarily picked China as an emerging global player in the clean energy market, other than as a ravenous consumer of other countries resources. However, today China is the leading country in the world in manufacturing solar PV, having dramatically gained market share from the United States and Germany, and contributed significantly to the 80 per cent fall in solar PV module costs since 2008.50 Chinese firms are also leaders in wind turbines, along with the USA (GE), Denmark (Vestas) and Germany (Siemens). Despite fossil prices falling in 2014, the dramatic falls in the cost of renewable energy sources have meant that renewables are increasingly economically viable alternatives to fossil fuels. For instance, a 70 MW solar plant in Chile's Atacama Desert was contracted in 2013 without subsidy.51 As a result of falling costs and government policy, more than 25 per cent of the growth in electricity generation in 2006–11 came from renewables.52

While renewable energy gets a lot of attention, market opportunities are even greater in transportation – electric cars for instance – and in low-carbon buildings. Perhaps the simplest way of communicating the sheer scale of the opportunity in transport is the potential rates of growth expected by the IEA to 2050 in these sectors. While high speed rail is expected to double in its annual rate of deployment by 2050, the annual market for biofuels is anticipated by the IEA to grow by more than a factor of 21 (i.e. 2,100 per cent), hybrid vehicles by a factor of 28, and electric and plug-in hybrids by a factor of 14,080 (i.e. 1,408,000 per cent). While these are merely calculations based on projections, and hence unlikely to be correct in detail, they do indicate the potential for the remarkable growth in these sectors.

So how should emerging markets position themselves? Ward et al (2012) note that China already looks strong across a host of different technologies; Brazil's comparative advantage seems most readily apparent in biofuels, manufacturing associated with biomass and hydro electricity generation while India's in a moderately good and improving position, especially in some low-carbon energy technologies. In general emerging markets are not merely centres for the production of clean-energy components. They are also becoming increasingly important locations for innovation activity (e.g. low-carbon energy patenting activity has accelerated rapidly within the GEMs since 2005). However, this is from a relatively low base, and one of the main challenges for emerging markets is to capture and retain strong positions in these markets in the longer-term.

Stranded carbon-intensive assets

The risk of carbon-intensive assets becoming 'stranded' (i.e. devalued or worthless because of climate mitigation policies or actions) is now being considered by fossil-fuel intensive companies and their investors. A major low-carbon economic transition involving energy efficiency, greater deployment of renewable and nuclear energy, and carbon taxation all work in the same direction – to reduce the residual demand for fossil fuels and push down coal, oil and gas producer prices53 (even if consumer prices

49. Ward, John, et al. "Self-interested low-carbon growth in Brazil, China, and India." Global Journal of Emerging Market Economies 4.3 (2012): 291-318.
50. IEA, 2014. 'Energy Technology Perspectives 2014'.
51. Ernst & Young, 2013. Country Focus: Chile. RECAI: Renewable Energy Country Attractiveness Index, 39 (November), pp.24–25.
52. International Energy Agency (IEA), 2014.
53. The only technology for which this is not true is carbon capture and storage (CCS) – likely medium-term progress in

Stabilization of the climate at any level, whether 2°C, 3°C or more above pre-industrial temperatures, effectively requires net zero emissions which implies complete decarbonisation of the economy.

are higher than cleaner alternatives). Market dynamics (e.g. within OPEC members) may further exacerbate price falls, as we have seen with the collapse in oil prices over the second half of 2014. Recent collapses in coal and oil prices reflect a range of factors beyond the low-carbon transition, including the end of the commodity super-cycle and the emergence of new sources of cheap oil and gas from shale plays. But it is indicative of what is likely to be around the corner once climate issues are addressed.

But is it really inevitable that climate change is addressed? Stabilization of the climate at any level, whether 2°C, 3°C or more above pre-industrial temperatures, effectively requires net zero emissions which implies complete decarbonisation of the economy.54 So there are two positions – either humanity is going to remain idle while extreme events rise, our cities are flooded and our food systems collapse, or at some point serious climate mitigation action will be taken. That point may come sooner or later, but our view is that eventual action is much less incredible than the scenario where we allow our civilizations to collapse, as to justify the conclusion that action is 'inevitable'. It is a question of when, not if.

Glancing at figure 12 can provide a sense of the consequences. Suppose that the internationally agreed target of limiting temperature increases to 2°C is a failure, and instead temperatures rise as much as 3°C above pre-industrial levels. This still implies that the vast majority of Earth's fossil fuel reserves and resources will not be combusted with the emissions going into the atmosphere.

Given these facts, one important question is which assets will be burnt, and which will be left in the ground. Logically, the cheapest and most socially valuable fossil assets should be extracted. Indeed, something approximating this is likely to happen as producer fossil fuel prices fall – the more expensive fossil fuel assets, and their associated infrastructure, will be 'stranded' and those assets will need to be written off. As noted in the introduction, this is far from a mere hypothetical. It has already hit various coal companies, and development of a large number of oil assets are now being re-evaluated, paused or halted altogether given the 50 per cent decline in oil prices in 2014.

What are the implications for fossil rich emerging markets? First, delay in developing a strategy could be very costly. Waiting to take action is likely to increase costs. With each year that passes, more capital is invested into old, dirty economic production processes and assets that may have to be scrapped prematurely. Second, identifying the fossil assets that have very good prospects of providing positive returns over the next few decades (often gas, for instance) is important, and capital expenditure budgets should be directed to these fossil assets rather than assets that are more likely to be stranded. Finally, for assets that are unlikely to be stranded, these would ideally be extracted as swiftly as possible before prices fall further.

What are the implications for energy importing emerging markets? Accelerating support for low-carbon innovation will reduce the ultimate cost of the eventual (and inevitable) switch to clean technologies.55 For instance, two studies suggest that if the BRIC countries (as a subset of the GEMs) were to begin rational preparation for a low-carbon economy today they could save between 25 per cent and 33 per cent of the eventual costs of that transition (Bosetti et al., 2009; Blanford et al., 2009).56 Rough calculations suggest that for India and China alone, there is the risk of economic value destruction in the order of several hundred billion US dollars for coal-based infrastructure that is currently being put in place.

CCS technologies may be one of the most important unknowns in climate economics and policy.

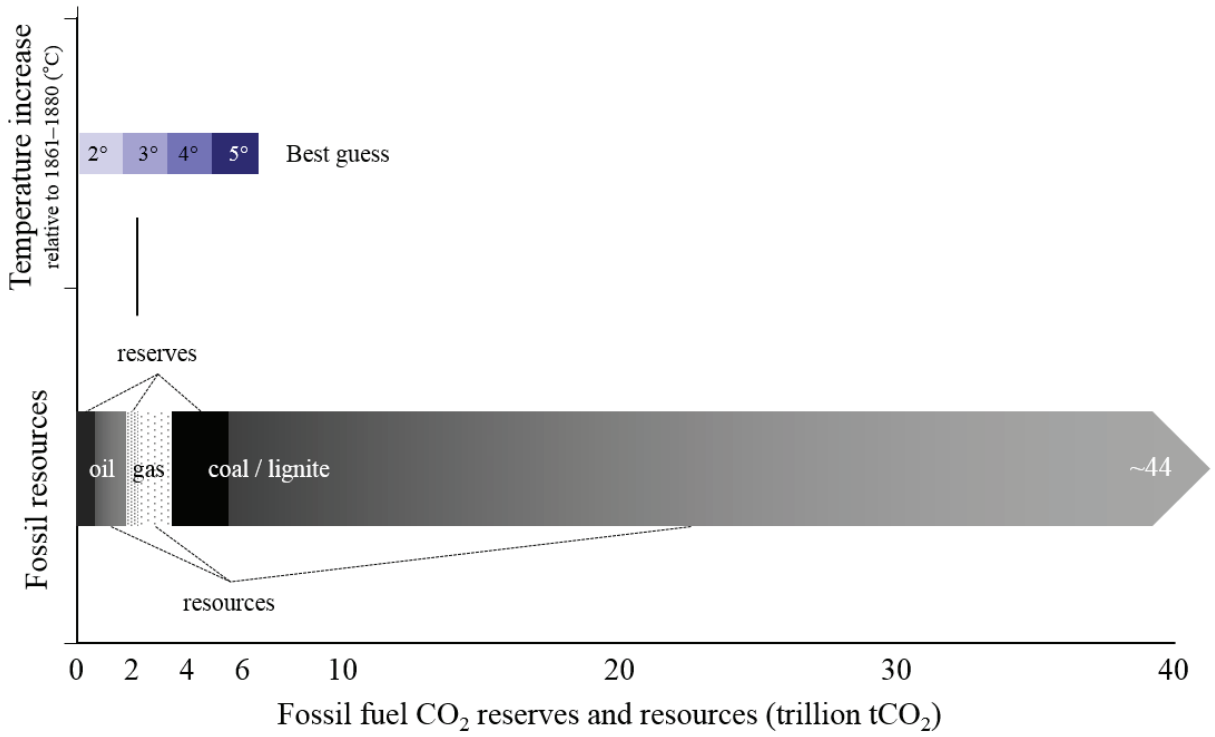
54. See for instance Knutti, R. and Rogelj, J. (2015) 'The legacy of our CO_2 emissions: a clash of scientific facts, politics and ethics', Climatic Change, DOI 10.1007/s10584-015-1340-3.

55. e.g. Aghion, Philippe, et al. "Path dependence, innovation and the economics of climate change." Policy paper. November (2014).

56. Bosetti, Valentina, et al. "Optimal energy investment and R&D strategies to stabilize atmospheric greenhouse gas concentrations." Resource and Energy Economics 31.2 (2009): 123-137; Blanford, Geoffrey J. "R&D investment strategy for climate change." Energy Economics 31 (2009): S27-S36.

Given this economic logic, it is perhaps unsurprising that emerging markets are already starting to act. China has just set out a commitment to peak its emissions before 2030 and two other GEMs have already set emissions reduction targets in absolute terms.

Figure 12: Carbon dioxide in fossil fuel reserves and resources compared to temperatures resulting from corresponding emissions



Source: Brookings Institution with data compiled from the US Energy Information Agency's China Country Report 2012

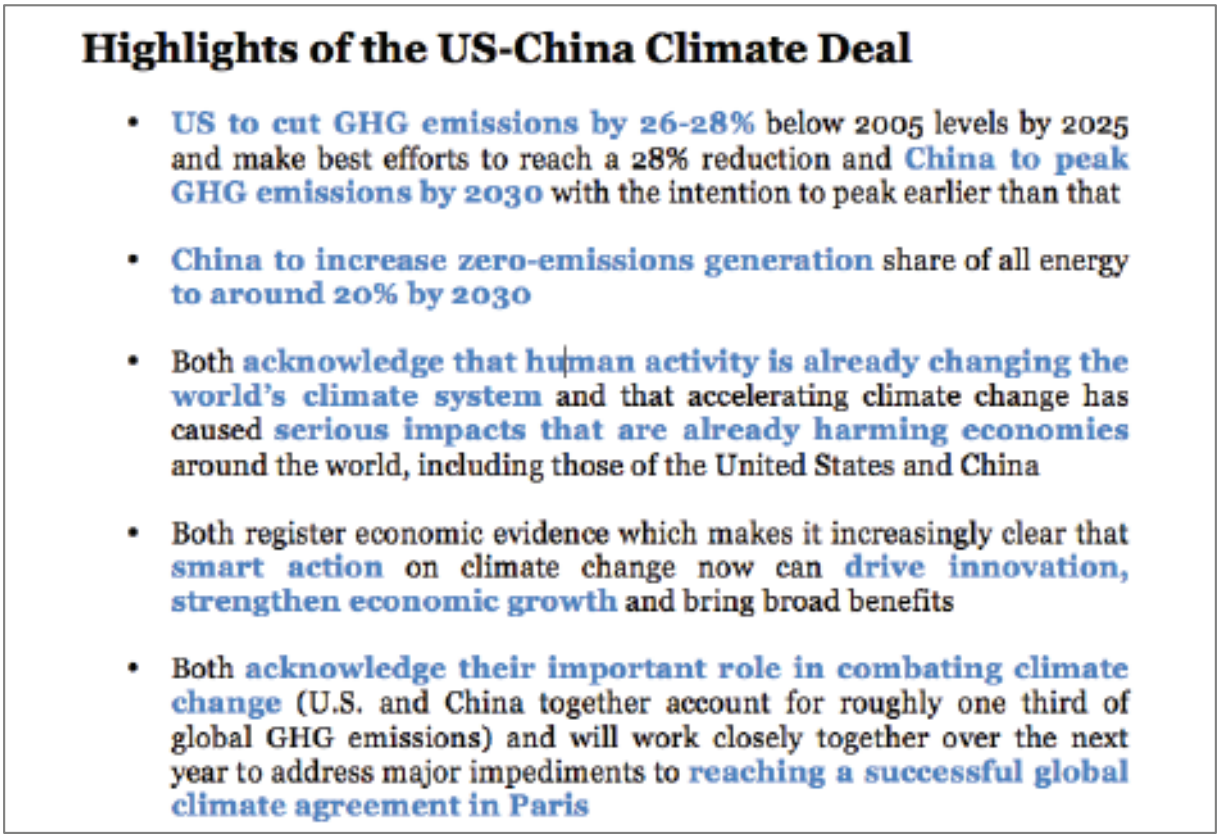
Given this economic logic, it is perhaps unsurprising that emerging markets are already starting to act. China has just set out a commitment to peak its emissions before 2030 and two other GEMs have already set emissions reduction targets in absolute terms. In November 2009, South Korea pledged to reduce its emissions by four per cent below 2005 levels by 2020, and in December 2008, Mexico announced that it will reduce greenhouse gas emissions by 50 per cent of 2002 levels by 2050. Furthermore China has begun domestic carbon trading programs, with a view to integrating these into a national scheme within the next five-year plan.

Political context

The developments in the science (see section II) and the increasing clarity over the strategic opportunities and threats of climate change (see section III) are now shifting the political context in novel ways. This section explores some of the more important recent events that suggest that after the post-Copenhagen period of reflection, climate change is now squarely back on the political agenda.

On November 11 and 12, 2014 the United States and China signed a bilateral climate agreement, which surprised many political and economic observers and commentators.

Figure 12: Highlights of the US-China Climate Deal



Source: Hepburn et al. (2015)

The U.S.-China climate deal

On November 11 and 12, 2014 the United States and China signed a bilateral climate agreement, which surprised many political and economic observers and commentators. It not only included ambitious and concrete GHG mitigation targets but also an acknowledgement that "the United States of America and the People's Republic of China have a critical role to play in combating global climate change, one of the greatest threats facing humanity."[57] With this agreement the United States commit to cut their emissions to 26-28 per cent below 2005 levels. At the same time China commits to peak its GHG emissions by or before 2030 (expectations are to peak earlier than 2030) and to increase the share of zero-emissions power generation in total energy production to 20 per cent.

57. http://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change (retrieved Dec. 14, 2014).

Awareness of climate change as a major financial risk has risen substantially over the last 12 months, with several key announcements and reports from leading financial institutions.

According to calculations of the White House the 26-28 per cent reduction means for the U.S. that it will have to double the pace of decarbonisation of its economy from 1.2 per cent per annum on average in 2005-2020 to an average of 2.3-2.8 per cent per annum over 2020-2025. For its part, this is the first time that China has ever committed itself to a firm date for peaking emissions. Moreover China has adopted a target of 20 per cent of power from zero-emissions generation (nuclear, hydro, wind, solar, etc.) by 2030 which means that China will have to install approximately 800-1,000 GW of zero-emission generation capacity over the next 15 or so years. This is approximately the current total electricity generation capacity in the U.S. and more than all the coal-fired power plants that exist in China today.58

In the same agreement both sides acknowledge the severity of the threats of already observable and future anthropogenic climate change on human economies and societies and accept their critical role in addressing this challenge and they also register that "…smart action on climate change now can drive innovation, strengthen economic growth and bring broad benefits."

The agreement drew a largely positive response from scientists and media all over the world.59 The acceleration of decarbonisation in the U.S., the first-time-ever deadline for emissions growth in China, and the fact that this was announced in a bilateral agreement between the two key powers was warmly welcomed by many commentators. Others, however, correctly pointed out that 2030 as deadline for emissions growth was too late and that without a concrete quantitative target for this peak and because of the general lack of information the whole agreement could not be evaluated properly. More needs to be done. Nevertheless, the announcement of the U.S.-China deal clearly contributed to putting climate back on the political agenda.

58. http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c (retrieved Dec. 14, 2014).
59. http://www.ft.com/intl/cms/s/0/8dfdade8-6a1a-11e4-9f65-00144feabdc0.html#axzz3Lu3oGFZR (retrieved Dec. 14, 2014).

Finance awakes: World Bank, IMF and Bank of England

Awareness of climate change as a major financial risk has risen substantially over the last 12 months, with several key announcements and reports from leading financial institutions. Authorities have realized that both the impacts from climate change and the management of the transition to a fully decarbonized economy could both have significant impacts on the global financial system, potentially good or bad.

In September 2014 the International Monetary Fund (IMF) published a working paper evaluating the self-interested level of carbon pricing in the top-20 emitting countries.60 The paper concludes that in most countries the optimal domestic carbon price is actually rather high (i.e. even ignoring global climate benefits – just comparing narrow domestic costs and benefits). The average self-interested carbon price across the top 20 emitters is calculated to be USD 57.50 per ton of CO2 (for year 2010). This is largely driven by domestic health benefits. If these top-20 countries all implemented the average self-interested carbon price, the IMF estimate that it would lead to emissions reductions in these countries of up to 13.5 per cent, corresponding to global emissions reductions of 10.8 per cent. If, instead of the average price, each country implemented its own self-interested national carbon price, the net benefits would be 23 per cent higher than implementing the uniform global carbon price. While a 10 per cent global reduction is a long way off full decarbonisation, this would be a very good start in a world in which emissions are continuing to rise each year.

The IMF findings complement a series of papers from the World Bank addressing the health impact of global air pollution, including transport-caused air pollution. One report notes that "…just a 50 per cent decrease in open field and forest burning could result in around 190,000

60. Parry, Ian, Chandara Veung, and Dirk Heine. "How much carbon pricing is in countries' own interests? The critical role of co-benefits." (2014).

In addition to the economic and financial implications of climate impacts, the financial community is waking up to the potential consequences of the transition to a lower-carbon economy.

Figure 14: Leading causes of death worldwide, associated DALYs (disability-adjusted-life-years), and burden attributable to motorized road transport 2010

		Global burden of disease		Burden attributable to motorized road transport	
	Cause	Deaths	DALYs	Deaths	DALYs
1	Ischemic heart disease	7,029,270	129,795,464	90,639	1,909,563
2	Stroke	5,874,181	102,238,999	58,827	1,148,699
3	COPD	2,899,941	76,778,819	17,266	346,376
4	Lower respiratory infections	2,814,379	115,227,062	5,670	489,540
5	Lung cancer	1,527,102	32,405,411	11,395	232,646
6	HIV/AIDS	1,465,369	81,549,177	--	--
7	Diarrheal disease	1,445,798	89,523,909	--	--
8	Road injury	1,328,536	75,487,102	1,328,536	75,487,104
9	Diabetes mellitus	1,281,345	46,857,136	--	--
10	Tuberculosis	1,195,990	49,399,351	--	--
	All other causes	24,207,527	1,682,995,639	--	--
	Total	52,769,676	2,482,258,070	1512333	79613928

Source: World Bank Group (2014)

fewer deaths annually from related air pollution, making it the second most powerful measure from a health perspective after cook stoves"61 and in a more recent report from 2014, taking a closer look at transport-caused air pollution, the authors conclude that "pollution from vehicles is the cause of 184,000 deaths globally, including 91,000 deaths from ischemic heart disease, 59,000 deaths from stroke, and 34,000 deaths from lower respiratory infections, chronic obstructive pulmonary disease, and lung cancer".62 While 184,000 premature deaths is only 0.35 per cent of all deaths, it nevertheless equals 4.1 million disability-adjusted life years (DALYs), a measure to estimate the loss of working years for the global economy by the premature death of an individual. For an overview of results of the study please see figure 14.

Following the World Bank studies, Kirk Hamilton (previously of the World Bank) and colleagues have calculated the drag on GDP from overall air pollution for the New Climate Economy report (see figure 15 below). They reach the striking conclusion that air pollution from activities also causing climate change could be slowing GDP significantly, and by as much as 13 per cent per annum in China.63

In addition to the economic and financial implications of climate impacts, the financial community is waking up to the potential consequences of the transition to a lower-carbon economy. In late 2014, Bank of England governor Mark Carney announced that the Bank of England would start an investigation into whether fossil-fuel related assets and infrastructure could be 'stranded' (written down or written off64) and these write downs could become a threat

61. The World Bank Group, 2013. 'On thin ice: How cutting pollution can slow warming and save lives'.
62. The World Bank Group, 2014. 'Transport for Health The Global Burden of Disease'.
63. Hamilton K., Brahmbhatt M., Bianco N., and Jiemei L. (2014) 'Multiple Benefits from Climate Mitigation: Assessing the evidence', working paper.
64. More precisely, stranded carbon asset are assets that have a value today based on expected future cash flows, which will

A recent report of the Carbon Tracker Initiative suggests that as much as 60-80 per cent of currently capitalized coal and oil reserves of fossil fuel companies will be stranded if the international community is successful in reaching the 2°C climate target.

Figure 15: CO2 emissions, annual premature deaths, and cost of outdoor air pollution in per cent of GDP for selected countries

	Co2 emissions			
	Million tons	Deaths	%GDP	
China	8287	1233890	9.7%	13.20%
United States	5433	103027	3.20%	4.60%
India	2009	627426	5.50%	7.50%
Russian Federation	1741	94558	6.90%	9.80%
Japan	1171	64196	4.90%	7.70%
Germany	745	41582	5.10%	7.30%
Iran, Islamic Rep.	572	32288	4.70%	6.20%
Korea, Rep.	568	23036	4.60%	7.10%
Canada	499	7171	2%	3.20%
United Kingdom	494	23373	3.70%	5.50%
Saudi Arabia	464	8550	3.40%	4.40%
South Africa	460	3208	0.60%	1.00%
Mexico	444	20496	1.90%	2.50%
Indonesia	434	63826	2.80%	3.90%
Brazil	420	7582	0.30%	0.70%

Source: Hamliton et al. (2014)

to the stability of the financial system.65 An example for potentially stranded carbon assets are global oil and coal production capacities (especially on the more expensive end of the cost curve), fossil fuelled power plants, and related infrastructure which could become stranded if climate mitigation policies are successful and global demand for fossil fuels falls, and their prices decline. Investments made today in coal plants, pipelines, etc. could potentially become stranded if the global shift away from fossil fuels towards renewable energies will be successful. A recent report of the Carbon Tracker Initiative suggests that as much as 60-80 per cent of currently capitalized coal and oil reserves of fossil fuel companies will be stranded if the international community is successful in reaching the 2°C climate target.66 This could have a significant effect on equity valuations and debt serviceability of important listed companies. While the London and New York stock exchange are especially carbon heavy, exchanges in emerging markets are also increasingly exposed to the risk of a stranding of carbon heavy assets. In Brazil for example, investments of over USD 23 billion have been made in the exploration of new oil and gas in 2012 and are factored into the market valuation of major companies, especially Petrobras, and in China companies listed at the three major stock exchanges invested as much as CNY 129 billion (USD 20.7 billion) in the exploration of new coal resources (see figure 16).

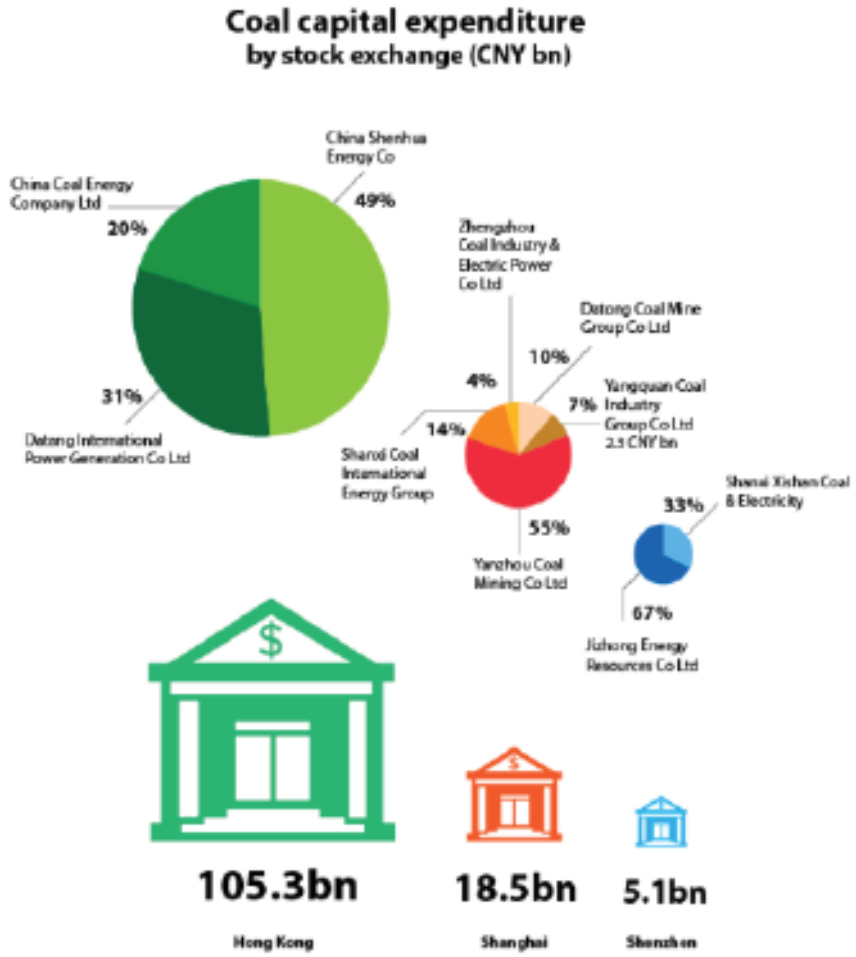
not materialize if or when climate mitigation actions or policies are implemented.

65. http://www.theguardian.com/environment/2014/oct/13/mark-carney-fossil-fuel-reserves-burned-carbon-bubble (retrieved Dec. 15, 2014)

66. The Carbon Tracker Initiative, 2013. 'Unburnable Carbon 2013: Wasted capital and stranded assets'

A UN Climate Summit, which took place in New York City in September 2014 brought together more than 125 heads of state and government officials and was as such the largest-ever climate meeting of world leaders.

Figure 16: Coal capital expenditure in China by stock exchange



Source: The Carbon Tracker Initiative (2014)

The New York Declaration on Forests

A UN Climate Summit, which took place in New York City in September 2014 brought together more than 125 heads of state and government officials and was as such the largest-ever climate meeting of world leaders.[67] The meeting itself led to some important and tangible outcomes, along with the surprising mobilization of citizens and corporations indicating that climate change has moved up the political agenda in key countries.

Perhaps the most important outcome from the summit was the New York Declaration on Forests, which proposes to cut the rate of natural forest loss in half by 2020 and reduce it to zero by 2030 at the same time restoring 150

67. http://www.wri.org/blog/2014/09/analyzing-outcomes-un-climate-summit (retrieved Dec. 16, 2014).

In addition to the action from the UN elites, major corporations, and mass movements, the centre-right of politics and business in the USA is now looking to reclaim some leadership on climate change.

million hectares of degraded landscapes by 2020 and an additional 200 million hectares by 2030, an area larger than the size of India.68 27 national governments69 and 8 subnational governments,70 including one from Brazil, supported the declaration. Surprisingly, however, it omitted the national government of Brazil. According to Izabella Teixeira, Brazil's Environment Minister, Brazil did not sign the declaration because "…unfortunately, we [Brazil] were not consulted […] but […] it's impossible to think that you can have a global forest initiative without Brazil on board. It doesn't make sense"71. Support was provided by almost 40 companies, including many international players.72 Estimates show that restoring 150 million hectares of degraded land into productivity could feed up to 200 million people by 2030, thereby raising USD 35-40 billion annually in farm incomes, strengthening climate resilience, and reducing emissions.73 Another important tangible outcome were the pledges by many countries74 to increase the Green Climate Fund to help poorer countries to invest in clean energy and mitigate risks from climate change.75

A 'climate march' associated with the meeting attracted 300-400 thousand people in New York and hundreds of smaller demonstrations around the globe (altogether including around 700,000 participants), a turnout, which was far greater than anyone, including the organizers, expected. U.S. President Barack Obama reacted to this event by saying in his Tuesday address: "Our citizens keep marching, we cannot pretend we do not hear them. We have to answer the call."76

The return of the centre-right of politics

In addition to the action from the UN elites, major corporations, and mass movements, the centre-right of politics and business in the USA is now looking to reclaim some leadership on climate change. Two reports are indicative of the angle taken, which is that we do not need to choose between strong economic growth in a market-oriented, capitalist economy and climate stability.

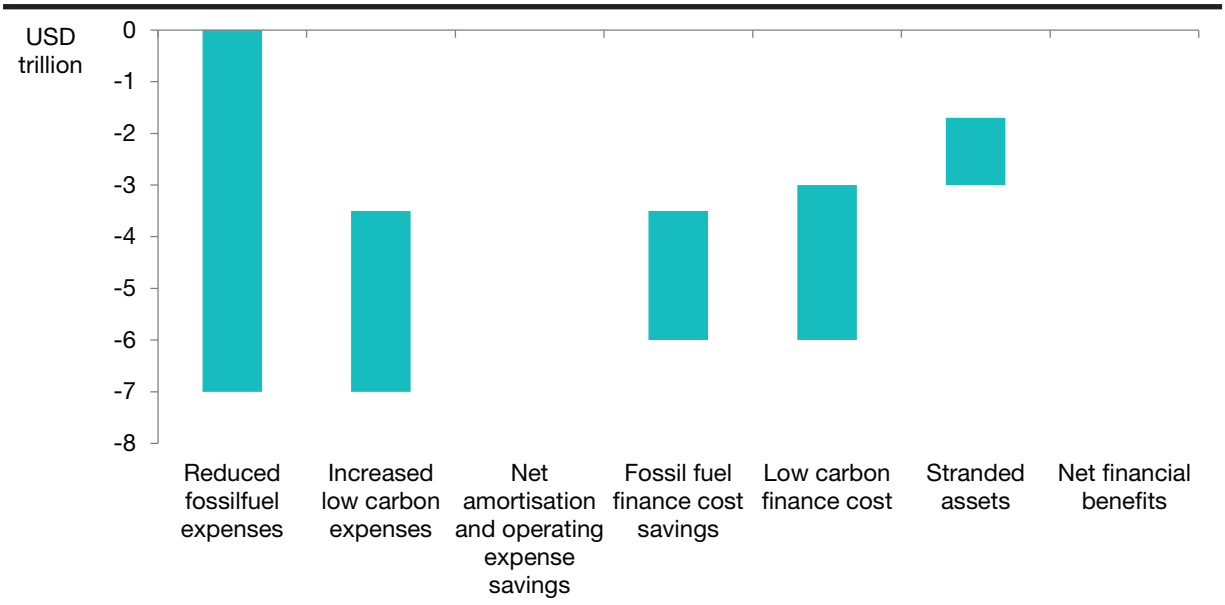
The first report, Risky Business: The Economic Risk of Climate Change in the USA, quantifies climate risk for the U.S. at a granular scale. While the analysis is not directly focused on emerging markets, if the USA were to find cross-party consensus on climate change, the implications for emerging markets could be profound. The Waxman-Markey cap and trade legislation, for instance, included a provision for 'border carbon adjustments', which would impose additional tariffs on countries exporting to the USA that did not have a reasonable strong climate policy in place.

The Risky Business report concluded that on the current emissions path, in the coming decades, climate risks would result in large-scale losses of coastal property and infrastructure. Overall between USD 66-106 billion worth of existing coastal property could be below sea level by 2050 and USD 238-507 billion by 2100 with a 5 per cent chance of damage beyond USD 701 billion by 2100 and USD 730 billion of additional property at risk during high tide.

68. http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/FORESTS-New-York-Declaration-on-Forests.pdf (retrieved Dec. 22, 2014).
69. Complete list of national governments: Belgium, Chile, Colombia, Costa Rica, Cote d'Ivoire, Democratic Republic of the Congo, Ethiopia, France, Germany, Guyana, Indonesia, Japan, Kenya, Liberia, Lithuania, Mexico, Mongolia, Nepal, Netherlands, Norway, Peru, Philippines, Republic of Korea, Togo, United Kingdom, United States of America, and Vietnam.
70. Complete list of subnational governments: Acre (Brazil), Amazonas (Peru), Catalonia (Spain), Huanuco (Peru), Loreto (Peru), Madre de Dios (Peru), San Martin (Peru), and Ucayali (Peru).
71. http://www.dailymail.co.uk/wires/ap/article-2766066/Brazil-says-no-forest-saving-plan.html (retrieved Dec. 22, 2014).
72. Companies include Asia Pulp and Paper, Kellogg's, Nestle, Johnson & Johnson, Walmart, and Procter & Gamble but also major palm oil companies such as Wilmar, Cargill, Asian Agri, and Golden Agri Resources.
73. The New Climate Economy Report (2014).
74. Countries include Germany, France, South Korea, Denmark, Norway, Mexico, Luxembourg, and Indonesia.
75. http://news.nationalgeographic.com/news/2014/09/140924-united-nations-climate-change-summit-world/ (retrieved Dec. 16, 2014).
76. http://www.whitehouse.gov/the-press-office/2014/09/23/remarks-president-un-climate-change-summit (retrieved Dec. 16, 2014).

The report suggests that some states in the Southeast, lower Great Plains, and Midwest could lose between 50-70 per cent in average annual crop yields (corn, soy, cotton, and wheat) while simultaneously warmer temperatures and carbon fertilization could improve agricultural productivity and crop yields in the upper Great Plains and other northern states.

Figure 17: Projections net financial cost and benefits from investments in low-carbon technologies



Source: The New Climate Economy Report (2014)

The report also anticipates that extreme heat waves across the U.S. will lead to decreased labour productivity and risks to human health and energy systems – even in a relatively rich country, not all activity can occur air-conditioned indoor environments, with the productivity of workers in construction, utility maintenance, landscaping, and agriculture, likely to be most affected. During some months of the year the report concludes, "Extreme heat could surpass the threshold at which the human body can no longer maintain a normal core temperature without air conditioning".

Finally, the report suggests that some states in the Southeast, lower Great Plains, and Midwest could lose between 50-70 per cent in average annual crop yields (corn, soy, cotton, and wheat) while simultaneously warmer temperatures and carbon fertilization could improve agricultural productivity and crop yields in the upper Great Plains and other northern states. These major shifts in agricultural productivity from lower to higher latitudes are expected to be observed in other parts of the world, including in emerging market economies.

The second report, the New Climate Economy Report: Better Growth, Better Climate, takes an explicitly global perspective. Chaired by the centre-right former President of Mexico, Felipe Calderon, the fundamental idea of the report is that "future economic growth does not have to copy the high-carbon, unevenly distributed model of the past" but that there is "huge potential to invest in greater efficiency, structural transformation and technological change in […] the economy". Thus driving economic growth and climate action are complementary, because of the multiple benefits of a low-carbon path, including cleaner air, greater energy efficiency, energy security, and resource productivity.

The report identifies the next 15 years as critical for the future of the world's energy systems since the world is currently undergoing a deep structural transformation. The choices made in the rapidly urbanizing emerging markets over the next 15 years will determine whether, globally, we

Emerging markets cannot afford to ignore climate change.

lock on to high- or low- carbon intensive growth in the long term. By 2030 the UN expects 1 billion additional urban dwellers77 and the commission expects that USD 90 trillion of investments will be made over that period in cities, buildings, energy and transport systems. This can be made at little additional (and sometimes even lower) cost in clean and efficient infrastructure and in stimulating innovation. One analysis by the New Climate Economy report, shown in figure 17, even suggests that savings through reduced fossil fuel expenses in a low-carbon economy outweigh increased low carbon expenses, financing costs and the stranding of assets significantly, resulting in more than USD 1.5 trillion of net financial benefits for the global economy.

Conclusion

Emerging markets cannot afford to ignore climate change. Their future prosperity will depend both upon how successfully they take advantage of the opportunities and manage the risks created by the transition to a low-carbon economy, and how successfully and cost-effectively they are able to reduce their own emissions and to enjoin other countries to do similarly. While the short-term implications are not on the scale of the global financial crisis or a new global trade deal, they merit serious and sustained attention. In the longer term, the changes in climate could require us to literally "redraw the map", and to manage significant levels of migration from environmentally stressed to more habitable environments.

Although the United Nations processes have been underway now for 20 years, there has been a shift in narrative over the course of 2014-2015. It is now more-widely recognized that a major motivation for reducing greenhouse gas emissions is enlightened self-interest. Policies in the enlightened self-interest of large countries could potentially take us quite some distance towards a stable climate and a prosperous future. This is due to the substantial economic and health benefits of reducing local air pollution, the benefits from innovation, and the reduced risk of stranded assets. Furthermore, countries such as China, India and Brazil are large enough that they can shift incentives for governments and firms within smaller countries. With the right leadership from large countries, smaller countries might find they want to gain access to a club of clean economies, rather than need any persuasion to join. Yet many policies in both rich and emerging market economies still currently destroy economic value and harm their own citizens, rather than promoting higher economic growth and productivity while reducing climate risk.

The direct policy implications for emerging market countries which are not only in the very own interest of these countries but will also bring the international community forward in achieving its climate goals are to clean up the air, support innovation in the energy and agricultural sectors, and to intelligently deploy infrastructure with a view to future climate policy and impacts to preserve option value and reduce the risk of stranded assets. USD 60 trillion will be spent on infrastructure in emerging markets in the next 15 years to support larger and more urbanized populations. This investment could promote compact, clean, resource-efficient cities, with significantly lower health care costs and higher worker productivity from lower air pollution and greater wealth generated from innovative effort in clean technologies that are likely to continue to become cheaper.

With a view to the longer-term climate impacts, it is worth repeating that the early impacts of global warming are now beginning to be observed. Because of the lags in the climate system, the impacts we will observe over the next couple of decades are now largely locked in, even if we don't know precisely what will happen. With continued emissions of around 10 billion tons of carbon every year, the atmosphere is holding an ever-increasing stock of greenhouse gases, so further changes in the climate are expected to accelerate. Once certain tipping points are reached, there is a real risk of environmental change becoming much more difficult to limit to manageable levels.

77. UN (2014): World Urbanization Prospects, the 2014 revision.

Emerging markets have a critical role to play in reducing these risks of higher temperatures and extreme events.

Emerging markets have a critical role to play in reducing these risks of higher temperatures and extreme events. Three quarters of the growth in the combustion-related global emissions between 2002 and 2007 came from GEMs (Ward et al, 2012). Only the rich countries and the GEMs, with their high emissions, have the scale to make a material impact on climate outcomes. Comparatively, GEMs have the greater incentive to act, as the damages they will suffer without action are notably greater. In particular, China, India and Brazil alone account for around 50 per cent of the temperature benefit that the GEMs can achieve collectively (Ward et al, 2012). Without a reduction in emissions in both emerging markets and rich economies, the risks of these catastrophic outcomes cannot be reduced to reasonable levels. The economic damage from climate change suffered by GEMs if they take action is significantly smaller, although still not negligible.

Overall, there are very significant economic implications of climate change for the emerging market economies, both positive and negative. The appropriate strategic response will inevitably vary from one country to another – emerging economies vary in their endowments, size, geography and economic structure. However, we would broadly identify the following crosscutting implications:

- Avoid stranded assets. Investing billions of dollars into old technology, high-carbon assets involve the risk that they will have to be scrapped before the end of their useful life. Economic analysis of new investments in energy infrastructure should factor in this risk – which could be in the hundreds of billions of US dollars for a country like China – and incorporate the value of option embodied in low-carbon assets to meet future (tighter) climate targets at lower cost.
- Increase productivity and energy efficiency. Increasing the amount of economic value generated from each unit of energy clearly generates wealth and also appears likely to boost international competitiveness of some sectors. Some sectors are more important in one country than another. For instance, important sectors include textiles and glass manufacture in China; sawmilling, paper and non-ferrous metals in Brazil; and iron and steel and chemical manufacturing in India (Ward et al, 2012).
- Strengthen low-carbon innovation. Emerging markets are currently stronger in manufacturing and deploying emerging clean technologies than in generating them. While short-medium term success in supplying low-carbon technologies is likely to be possible through the lower cost bases, these advantages may erode over time. Longer-term technological leadership is likely to require successful innovation activity.
- Work together to reduce catastrophic risks. The risk of catastrophic climate change cannot be reduced to tolerable levels without the collaboration of at least Brazil, China, and India along with the USA and EU. Cooperating on low-carbon growth could yield significant benefits to all emerging market countries. The key is developing a club that other countries would want to join.

The Emerging Markets Forum was created by the Centennial Group as a not-for-profit initiative to bring together high-level government and corporate leaders from around the world to engage in dialogue on the key economic, financial and social issues facing emerging market countries.

The Forum is focused on some 70 market economies in East and South Asia, Eurasia, Latin America and Africa that share prospects of superior economic performance, already have or seek to create a conducive business environment and are of near-term interest to private investors, both domestic and international. Our current list of EMCs is shown on the back cover. We expect this list to evolve over time, as countries' policies and prospects change.

Further details on the Forum and its meetings may be seen on our website at http://www.emergingmarketsforum.org

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