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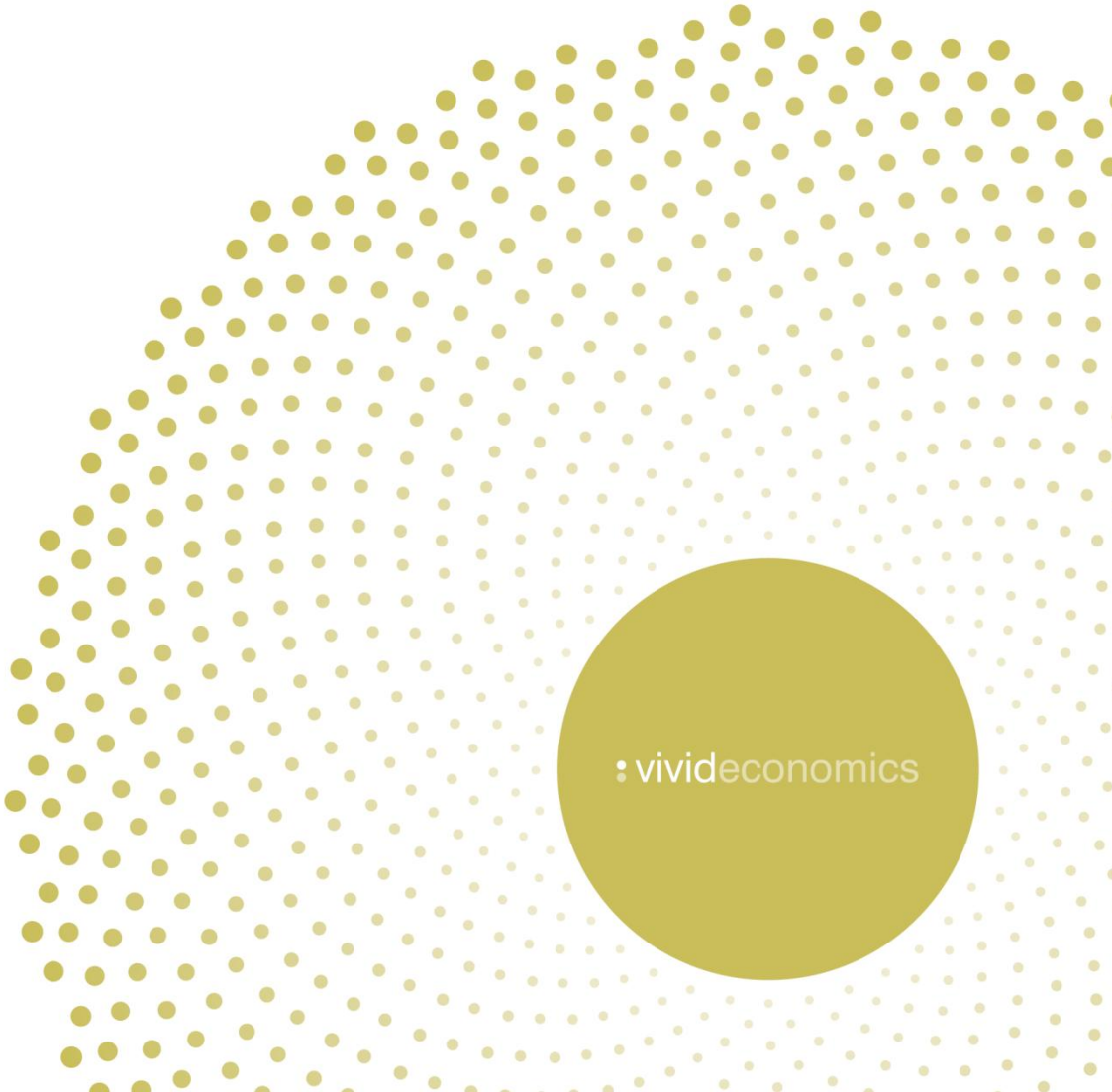
Promoting Economic Growth when the Climate is Changing



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Promoting Economic Growth when the Climate is Changing

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Contents

1 Introduction and Summary

This report addresses the links between economic growth and climate change. Inclusive, pro-poor growth is a central plank in the development strategy of most aid agencies. The report asks to what extent existing growth policies are compatible with the adaptation needs of developing countries under climate change.

Despite a growing evidence base, there is still a lot of uncertainty about the impacts of climate change on developing countries and on their ability to grow and on the pattern of their growth. Even more tentative is our understanding of how economic growth may alter the vulnerability of poor countries to climate change.

Low-income countries are much more vulnerable to climate change (e.g., World Bank, 2009a) largely due to an insufficient ability to adapt. Deficiencies in health and sanitation systems, poor levels of primary education and underdeveloped state institutions, among other factors, make it more difficult for poor countries to deal with climate risks (Tol and Yohe, 2007, Barr et al., 2010). In the jargon of the adaptation literature, poor countries have an "adaptation deficit" or lack "adaptive capacity", but the problem could equally well be described as a development deficit (World Bank, 2009b).

The implication is that growth and, more generally, development, is an important aspect of any attempt to reduce vulnerability to climate change (Klein and Persson, 2008, McGray et al., 2007). Nevertheless, the question remains how current growth strategies should be adjusted to account for climate change, especially given the impacts that climate change is likely to have on the growth process. *The stipulation is not that growth per se reduces vulnerability, but that the right kind of growth does.* The aim of this report is to develop a clearer understanding of what this "right kind of growth" may be.

The report has four sections. Section 2 recapitulates the current thinking on growth and development. It establishes nine features that are commonly associated with rapidly

growing economies.

Section 3 introduces climate change, with two questions in mind. The first question is about the repercussions of climate change on economic growth. To what extent will climate change hold back growth? The second question is about links in the reverse direction, i.e. how will economic growth alter (reduce or increase) vulnerability to climate change.

Section 4 draws policy conclusions from the various links between climate change and growth. The section takes the nine drivers of growth introduced before and asks to what extent climate change will change their importance and, by implication, which of the nine should receive more policy attention.

Section 5 looks at two particular issues in more detail. First, it asks whether climate change, and climate variability in particular, alters the common view on specialisation and comparative advantage as drivers of growth. Second, it asks whether climate change affects the role of the state and whether the current paradigm of private sector-led growth needs to give way to a more statist development model.

The report finds that there are very strong overlaps between growth policy and adaptation policy. Climate change accentuates many of the market and public policy failures that motivate growth policies and hence increases the general case for these measures. Of nine key factors for strong growth, six are also associated with good adaptation. They are:

— a healthy natural capital stock, which is key to environmentally sustainable growth and also increases the adaptive capacity of ecosystems;

— good human capital, which enhances labour productivity as well as people's ability to respond to climate change;

— strong institutions, which improve the business environment for investors and increase society's ability to deal with extreme weather events;

— access to markets, which promotes export-led growth and helps to share the burden of adverse local climate events;

— access to credit, which boosts investment and helps to smooth the effect of extreme

climate events;

— competitive markets, which underpin economic efficiency; they are also believed to be more adaptable to climate shocks, although there is little evidence to confirm this view.

The remaining three factors associated with strong growth are less central to adaptation but critical adjustments may be required in the way they are approached:

— a sound infrastructure is key to economic growth, but its design will have to change to make it "climate proof" and suitable to a warming world; there may also be a need for dedicated adaptation infrastructure;

— macroeconomic stability underpins investment and business confidence, but may be affected by fiscal demands from adaptation and disaster recovery;

— firm performance and productivity drive private-sector-led growth; increasing productivity is also key for adaptation, particularly in agriculture, but it must not come at the expense of higher susceptibility to shocks.

It is difficult to judge the relative importance of these nine factors *a priori*, as this will be country-specific. Sometimes the main issue will be diversification in agriculture, other times it may be rampant development in flood risk zones or constraints in health care systems. This reflects the nuance that is already recognised in growth policy: growth diagnostics (see section 2) stress that constraints to growth vary from country to country. Both adaptation and growth strategies have to be decided case by case.

Nevertheless, it is possible to draw out some broad-brush implications for how development strategies may have to change. Three repercussions in particular stand out:

— *More emphasis on natural capital*: The management of natural resources and ecosystems, 'natural capital', has to have a higher priority in growth policy. This is a well established, but often neglected tenet of sustainable development. Climate change further increases its importance.

— *More awareness of risks:* Efforts to stimulate entrepreneurship and competitive markets

must take a risk management perspective, recognising that providing incentives to maximise expected productivity and growth may expose poor people to unacceptably high risks.

— *More emphasis on collective action*: Climate change highlights and amplifies the importance of a range of market imperfections (and policy failures) that warrant more emphasis on the promotion of effective collective action, including by the state

Before turning to the detailed analysis, an aside is in order. It concerns low carbon growth. The focus in this paper is on the impacts of climate change impacts, adaptation and the need to make growth "climate resilient". There is obviously a parallel challenge, which is to decouple greenhouse gas emissions from growth. It has been argued elsewhere (Bowen and Fankhauser, 2010) that poor countries should embrace a low carbon growth path, even though their contribution to the greenhouse gas problem has been very small.

There are several reasons for this. First, tackling many of the market and government failures that stand in the way of low-carbon development would enhance productivity and well-being in the countries themselves. 'Green growth,' in the sense of growing while sharply lowering greenhouse gas emissions, is another aspect of growth that takes into account the erosion of 'natural capital'.

Second, if a global deal is eventually achieved, technological progress around the world will be redirected towards low-carbon opportunities. If developing countries are ultimately to share in growth from this source through trade and the diffusion of innovations, their growth will have to be 'green' too.

Third, developing countries offer the world many relatively cheap options for reducing emissions (such as afforestation). Exploiting these options makes sense on global efficiency grounds, but it also opens up important new revenue streams for developing countries.

These arguments are central to the debate on sustainable growth in low-income countries. However, in line with the literature, this report treats emission reduction and climate resilience as separate, while recognising that the distinction is often futile in practice.

2 Current Approaches to Growth

This section reviews the current thinking on economic growth and development. The academic and policy literature on the topic is in broad agreement. There has been a move away from the blanket approach of the Washington Consensus, which stressed the advantages of leaving markets to their own devices (Williamson 1990), towards a more individualistic analysis of individual or groups of countries and the constraints that they face. There has also been an increased recognition that kick-starting growth in itself is not necessarily enough for poverty reduction and development, and that the focus needs to be on achieving sustained inclusive growth over a number of decades. The current approach to growth can be summarised in nine key factors commonly associated with sustainable, fast growing economies. We introduce them at the end of the section.

2.1 The theory of economic growth and development

There is broad agreement that growth is important for development, but the economic literature has moved forward from the Washington Consensus. Authors such as Rodrik and Hausmann (e.g. Rodrik, 2004a, 2010, Hausmann, 2006) have argued that whilst there are some first-order fundamentals to kick-starting growth, there are a number of ways of achieving them, and some of these involve more activist public policy.[1]

Government policy needs to ensure macroeconomic stability, provide adequate protection for investors, open up to the world economy and promote social cohesion, solidarity and political stability. Unlike the implications of the Washington Consensus though, these fundamentals can be achieved in a number of different ways, as countries such as China have shown (Rodrik, 2004b). Leading on from this Hausmann et al. (2005) have developed their growth diagnostics approach to growth and development policy, where the most

[1] Payne and Phillips (2010) provides an excellent analysis of how theories of development have evolved over the past 200 years, emphasising the current heterodoxy in academic discourse.

binding constraint on growth is identified and removed (rather than trying to reform everything at once). This process is dynamic, as the removal of one constraint will result in another one binding, but the authors argue that by applying this method, sustained growth can and has been achieved by developing countries.

Other authors such as Collier (e.g. Collier, 2006a) and Sachs (Sachs, 2003) have highlighted other factors that limit growth, particularly in African countries. Collier argues that geography (both physical and human) has played a key part in the relatively poor performance of African countries over the past 60 years. The fragmentation of the continent as a result of colonisation and a relatively diverse human population has resulted in small countries that are limited by scale effects. Coupled with this, the physical geography of many African countries presents its own challenges, particularly for the land-locked resource-poor countries, which are entirely dependent on their coastal neighbours for access to international markets and therefore the opportunities for growth. Thus African countries have unique problems that need to be incorporated into any development policy.

Empirically growth has been the biggest driver of poverty reduction in the past 60 years (Easterly, 2002). Yet most development economists agree that the impact of growth on poverty is indirect and depends on a number of factors. The type of growth countries achieve (standard or inclusive) and the implementation of other policies, e.g. basic healthcare provision for the rural poor, are as important to poverty reduction as growth per se. Similarly, Kanbur (2010) emphasises empowerment as a central factor for poverty reduction.

A lot of work has concerned the role specific interventions and reforms play in promoting growth. The reform of institutions has perhaps attracted the most attention in recent years with Acemoglu et al. (2001) and Rodrik et al. (2004), among others arguing that the institutional environment is the key determinant of income levels.[2] Others have focused on openness to trade (Winters, 2004), with productivity spillovers from trade and FDI as the key transmission channels. Industrial policy has again become an issue. Until recently, the orthodoxy was that active interventions in specific industries may create distortions and should be avoided. More recent papers (e.g., Hausmann and Rodrik, 2006) have challenged this view, highlighting that structural change (moving from agriculture through low to high

[2] Although Collier and Hoeffler (2009) have argued that for some countries in Africa, democracy may actually be a hindrance to growth and development.

value added manufacturing) is essential for sustained growth. However, the consensus remains that policy interventions should focus on general reforms, and that the market should be the driver of successful industry development (Pack and Saggi, 2006).

2.2 Nine factors of growth

The growth policies of most development agencies are based on this broad academic consensus – with differences in emphasis. Growth policies are built into an overall goal of poverty reduction and achievement of the MDGs, in recognition of the key role growth plays in achieving development outcomes. It has been the biggest driver of poverty reduction in the past 20 years. The emphasis tends to be on inclusive (that is, pro-poor), private sector-led growth. Such growth has to be underpinned by macroeconomic stability, competitive markets, openness to trade and regard for the natural environment.

The theory of growth and development and the operational approach to growth in the development community suggest that there are number of features that can commonly be associated with sustainable, private sector-led growth. In this paper we distinguish nine such drivers of growth (inspired by DFID, 2009 and World Bank, 2005). They are introduced in Box 1. There are a number of links and causalities among the nine (e.g. competition leads to productivity), which we have not tried to disentangle. The point is that all nine are present in dynamic, fast growing economies.

Box 1: Nine essential factors of economic growth

Sufficient Capital

1. *Natural capital*
This includes clean water, clean air, healthy ecosystems and natural resources (fish, forests, minerals). The sustainable management of natural capital is essential for long-term growth, including the maintenance of fish stocks, forest resources and soil fertility for agriculture. A key challenge is helping developing countries solve market and policy failures that lead to the overexploitation of natural resources.

2. *Infrastructure*
This includes transport infrastructure (road, sea, air, rail), communication and information assimilation systems, municipal services, electric power grids, and so on. Infrastructure feeds into all aspects of growth. An important area for intervention is the correction of market failures such as network externalities and coordination issues.
Box 1, cont.

3. *Human capital*
This covers good primary, secondary and tertiary education, as well as improving health outcomes. By improving the labour input into production, human capital improvements directly increase output and therefore growth. The market tends to under-provide these services, as there are significant positive spillovers, thus creating a role for governments, NGOs and development agencies.

Sound business environment

4. *Macroeconomic stability*
A stable macroeconomic environment is essential for business confidence and private investment. Price and currency stability also ensures that the price mechanism transmits necessary information to the private sector. Key policy challenges include sound public finances, low inflation and a stable exchange rate.

5. *Institutional and regulatory framework*
This broad category is key for private sector development and includes the rule of law, low administrative barriers, absence of corruption, sound regulation and political stability.

Easy Access
6. Access to markets
The empirical literature finds a strong positive correlation between export and income growth, suggesting that openness to regional and world markets is essential to development. At the micro level, better access to the national economy increases opportunities in poor and remote areas, encourages private sector development and the efficient allocation of labour across sectors.

7. Access to capital
A stable banking sector and access to both credit and risk capital is a pre-condition for private entrepreneurship, investment and growth. A key policy challenge is access to credit for start ups and micro, small and medium-sized enterprises, which are often excluded from traditional financial markets. Access to foreign investment can also spur growth by transferring new ideas and technologies.

Box 1, cont.

High productivity

8. *Competitive markets*
Competition drives efficient, dynamic economies. For the private sector to lead growth, there has to be an incentive to innovate and expand into new markets. Low barriers to entry, a level playing field, and the absence of monopoly market power are an important part of this, and may require policy intervention to achieve (although some market power may be desirable to encourage innovation, as argued by endogenous growth models).

9. *Firm performance*
Private sector-led growth depends on firm performance. Although competition is a key way to stimulate this, there may be a need to intervene and increase agricultural productivity, industrial productivity and resource efficiency via outside research, increasing access to the latest relevant technology, business education programmes etc. In many situations this factor will increase endogenously with experience, but intervention could speed up this process.

Source: Vivid Economics.

3 Growth and Climate Change

This section introduces climate change into the economic growth equation. Economic growth and climate-change impacts are closely linked in developing countries, with causality running in both directions, from climate change impacts to growth and from growth to climate vulnerability. In what follows we review the main links between climate change and economic growth.

3.1 The links between growth and climate change

Economic growth and climate-change impacts are likely to be closely linked in developing countries, with causality running in both directions. The linkage is well demonstrated in the World Bank's most recent World Development Report (World Bank, 2009a). On the one hand, climate change will affect several of the potentially important drivers of economic growth, such as capital accumulation, infrastructure provision, human health and productivity growth in energy and agriculture sectors. These adverse impacts are likely to put a strain on governance and institutions. Climate change is also likely to alter the composition of growth because of its uneven sectoral, geographic and social impact. Finally, resources that could have been used (more productively) elsewhere to stimulate growth will be absorbed by efforts to adapt to climate change.

On the other hand, growth can change the profile of climate-change risks faced by developing countries. It can influence the ability of firms, households and public bodies to adapt to climate change. Adaptation strategies are often guided by a country's development and growth path. Economic growth itself may be part of an adaptation strategy, implicitly or explicitly, since richer societies tend to be less vulnerable to adverse climate events. Some have even argued, that promoting economic growth, and hence adaptive capacity, with development aid is likely to be more effective than spending resources on mitigation (Tol,

2005, Schelling 1992, 1997).[3] However, growth that is blind to the risks of climate change can also increase vulnerability, for example if it is based on climate-sensitive activity (e.g. water-intensive crops) or located in high-risk areas (e.g. the development of flood plains).

A third link between economic growth and climate-change impacts is the growth of greenhouse gas emissions generally associated with growth. It is sometimes argued that climate change should not be a major concern for low-income countries, because they have been responsible for only a very small share of past greenhouse gas emissions and have a strong claim over whatever remains of the atmosphere's greenhouse-gas carrying capacity. However, that argument is untenable in the long run if policy-makers are successful in promoting development – and, indeed, in the short run when considering the development of countries like Brazil, India and China, where a large proportion of the world's poor still live.

3.2 How climate change can affect economic growth

3.2.1 Modelling the macroeconomic impacts of climate change

Many analyses of climate change impacts, growth and adaptation at an aggregate level have adopted the standard neoclassical growth model associated with Ramsey, Cass and Koopmans (see, for example, the canonical work by Nordhaus such as Nordhaus and Boyer, 2000, and Nordhaus, 2008; and, amongst others, Fankhauser and Tol, 2005, and Lecocq and Shalizi, 2007a). This model is relatively easy to solve and provides a useful organising framework but it has drawbacks as a framework for considering the broader development challenge facing poorer countries. For example, it neglects endogenous technical change, economies of scale and scope and sectoral detail and in particular, the potential limits to substitutability between manufactured and 'natural' capital, an omission that can lead to serious underestimates of the costs of climate change (Sterner and Persson, 2008).

There is little consensus about how the basic model should be elaborated. Some modelling work has incorporated endogenous technical change (Nordhaus, 2002; Kohler et al., 2006) and knowledge spillovers (e.g. Bosetti et al., 2006). However, this work has rarely been tailored to the particular question of how growth in developing countries might be affected

[3] Growth can also be enhanced by efforts to bring climate change to a halt but these issues are not considered in this report.

by climate change and suffers its own pitfalls (see Nordhaus, 2008). Many models of the costs of halting climate change do not incorporate climate change impacts explicitly at all, instead taking as given an exogenous goal of climate change policy such as a target level for the concentration of greenhouse gases in the atmosphere. These models of mitigation costs cannot be used to address fully the impact of climate change on growth. Given the shortcomings of much of the 'mitigation' literature for our purposes, it is useful to start with the neoclassical growth model to sketch out some of the more important potential links.

Population growth, productivity levels, technological progress, capital depreciation, time preference and the form of the production function are all treated as exogenous in the basic neoclassical model. These parameters provide the channels through which climate change can affect growth, first by simply affecting the level of output and, second, by reducing the rate of growth of factor inputs (such as the working population and the capital stock) and the pace of technical progress. Thus, for example, the evidence suggests that climate change is likely to reduce population growth where vector-borne diseases become more prevalent. By increasing morbidity, climate change can impair cognitive development and the efficacy of education. Climate change is likely to reduce agricultural productivity, especially in tropical countries (where it is impossible to switch to crops and farming practices already developed in significantly hotter countries, because there are no such countries). Climate change is likely to accelerate the depreciation of infrastructure capital and increase the risks of loss of plant, equipment and buildings to weather-related disasters.

In the basic neoclassical model, the long-run equilibrium rates of growth of consumption per head, capital per head and output per head are all equal to the rate of technical progress, emphasising the importance of the possible impacts of climate change on productivity growth. For example, climate change may make it more difficult to find and import techniques appropriate to climate-affected local conditions from technologically more advanced countries. Climate change may divert investment resources from generating innovation in the economy as a whole (and learning how to use innovations from elsewhere) towards designing tools for adaptation (e.g. new crop varieties or tillage techniques) and low-carbon energy (e.g. solar power). Alternatively, climate change may spur innovation with economy-wide productivity benefits.

Climate change impacts can also have a medium-run impact on growth by changing the equilibrium capital-labour ratio. Suppose, for example, that climate change leads to more

rapid depreciation of capital, because buildings are damaged more frequently by storms and floods. That reduces the equilibrium capital-labour ratio. In the short to medium term, the capital stock grows more slowly to bring down the ratio, so that there is a transient negative effect on growth even without any change in the rate of technical progress. But the story is more complicated if the rate of saving is determined endogenously. Real interest rates could adjust to cushion the fall in the long-run ratio or exacerbate it.

3.2.2 Are growth effects quantitatively important?

Using Nordhaus' DICE model to analyse global growth under a range of assumptions, Fankhauser and Tol (2005) found that the impact of climate change on output via reduced growth is larger than the direct 'levels' effect. Hence adaptation that reduces the impact of climate change on output should boost growth directly and indirectly. However, both effects were small (totalling less than a 0.2 percentage point reduction in the per capita global annual growth rate by 2205 and very much less in the short run).

This result from a theoretical growth model is different from recent empirical evidence about the historical impact of climate on growth. Dell et al. (2008, 2009) found that, in poor countries over the period 1950 to 2003, a 1°C rise in temperature in a given year tended to reduce economic growth in that year by 1.1 percentage points, and the effects on growth tended to be persistent. The estimated temperature effects over 10 or 15-year horizons were similar to the annual panel data estimate, with the implication that these effects represented changes to growth rates, not simply 'level' effects on income.[4] Unless offset by some other factor, such temperature effects would be sufficiently large to produce a much steeper relationship between temperature and income across countries than is actually seen in the data.

The obvious offset is adaptation; their results implied that, eventually, adaptation offset about half the negative effects of temperature variation on income. The authors found a similar (but weaker) relationship in state and local data.

[4] The authors also observed that across countries in 2000, national income per capita fell 8.5% for each degree Celsius rise in mean annual temperature. Temperature alone could explain 23% of the cross-country variation in income.

3.2.3 *Enriching the basic model*

The basic model neglects some of the key drivers of growth emphasised in many modern empirical growth studies (e.g. increasing returns to scale; market size, human capital accumulation; learning by doing, endogenous R&D; see, for example, Barro and Sala-i-Martin, 1995, Aghion and Howitt, 1998). Yet the literature has paid relatively little attention to the issue of endogenous technical change so far (Lecocq and Shalizi, 2007b, found that only two of the nine climate-change models that they survey incorporated endogenous technical change). In Fankhauser and Tol's attempt to address this problem, climate change was treated as reducing the output available for investment in human capital or R&D, thus reducing productivity growth. That amplified the impact of climate change on output through reduced growth, although, as with their other results, the effect was small.

Another way in which climate change can affect output beyond the first-round impacts is through general equilibrium adjustments, allowing for effects through trade and factor markets, possibly subject to their own market imperfections. For example, Bosello et al. (2007) used a static computable general equilibrium model to calculate the impacts of sea-level rise caused by climate change. They found that general equilibrium effects increased the impact of climate change on welfare, but not necessarily in every economic sector and region. Direct costs, they concluded, were "a bad approximation of the general equilibrium welfare effects."

Jorgenson (1998) also illustrated how the ultimate incidence of climate change impacts can be different from first-round impacts, because of adjustments in relative prices and the structure of the economy. Reilly (2008) focused on general equilibrium effects via international trade. He argued that adverse impacts on agricultural productivity may benefit farmers if the global demand for their agricultural outputs is price-inelastic. The welfare costs may not be borne by producers in the directly affected country sector but by non-farmers (e.g. the urban poor for whom food accounts for a large part of their spending) and may indeed be (at least partially) shifted to other countries. These studies demonstrate that shifts in production and consumption patterns are forms of adaptation by firms and households in response to price and income signals created by climate-change impacts. They suggest that adaptation may take place on a much wider scale than microeconomic studies of direct impacts often imply.

3.2.4 *The role of natural disasters*

Climate change is likely to increase the frequency of extreme weather events, floods and

other climate-related disasters. Such disasters can have a significant adverse effect on growth in the short run (Noy, 2009, and Raddatz, 2009), for example, have provided surveys and new empirical results recently. Raddatz concluded that the incidence of natural disasters had increased during the past four decades. Natural disasters, especially climatic ones, had had a moderate but significant negative effect on real GDP per capita. He calculated that, at a conservative estimate, the macroeconomic cost of a climatic disaster affecting at least half a per cent of a country's population reduced real GDP per capita by 0.6%. Such a disaster had taken place in his sample once every four years on average, but once every three years since 1990. Droughts and extreme temperatures had the biggest effects (windstorms and floods being less damaging). Lis and Nickel (2009) also showed how natural disasters tend to have an adverse impact on government budget deficits.

Such short-run shocks can also reduce endogenous growth, for example, by cutting short the education of a cohort of children. Landon-Lane et al. (2009) found that at the time of the great Dust Bowl in the USA in the 1930s, the climatic stress hit the banking system, impairing financial intermediation and recovery for a prolonged period. Thus climate-related disasters can have long echoes through the financial system. Hornbeck (2009) drew attention to another aspect of the great Dust Bowl: adjustment was drawn out for a long time and was primarily through migration out of the region most affected, not through inward capital flows, changes in agricultural practices or a movement of resources into industry.

Hallegatte et al. (2007) argued that the long-term growth models commonly used in climate-change economics cannot capture the adverse effects of such short-term shocks. They showed how, if the frequency of extreme events passes some threshold, economies can fall into a downward spiral in which they do not have the capacity to make good productive capacity lost. The argument is reminiscent of the work of Collier on poverty traps (e.g. Collier, 2008). The implication is that adaptation needs to take account of the whole frequency distribution of possible climate-change impacts, not just the mean. Impacts in the 'bad' tail of the probability distribution ought to be guarded against, because they can have devastating effects on growth over the longer term.

Policy actions and characteristics that make economies more resilient in the face of short-term shocks can help guide adaptation. For instance, Hallegatte and Ghil (2008) pointed out that economies may be able to respond more effectively to natural disasters if they have underutilised resources available. Hence, perhaps surprisingly, the costs of climate change

and adaptation may be reduced by the presence of Keynesian unemployment or surplus labour, neither of which features in the standard growth models. They argued that this is why some reviews of the costs of natural disasters have not found them to be particularly high (see, for example, Hochrainer, 2009). However, these studies take no account of different stages of development, the difference in the ability to obtain insurance against natural disasters or the scale of previously underutilised resources, so the results for the poorest developing countries need to be treated with caution.

3.2.5 Adaptation as a partial offset of the adverse impacts of climate change

Adaptation comprises activities carried out to reduce the adverse economic impacts of climate change. General equilibrium models stress the adaptations made by firms and households to their investment and consumption patterns in response to market signals (often labelled 'autonomous adaptation'). But climate change also affects the need for public goods like flood protection, investments in public health and provision of information about likely climate change impacts, and hence warrants directed adaptation by the public sector. The costs of adaptation can be regarded as an integral part of the economic costs of climate change (see Agrawala and Fankhauser, 2008).

Because adaptation entails costs, it is unlikely to be cost-effective to try to offset all the impacts of climate change. If, there are decreasing returns to adaptation, the remaining adverse effect on growth is likely to be bigger in developing countries, where, on the whole, impacts are greater. The net adverse effect from climate change is also likely to be larger when global temperatures have risen more.

This conclusion need not hold, however, if climate change prompts adaptation that generates ancillary benefits (e.g. reduced local pollution, more total agricultural research). However, if these ancillary benefits are significant, this raises the question of why they have not been carried out already? One possible answer is that many poorer countries' institutions and governance arrangements are inadequate to manage externalities and public goods properly and have pervasive market malfunctions. Therefore, the difficulty is to correct those problems, now made more costly by the threat of climate change.

The likely aggregate costs of adaptation, and hence the extent of the potential 'crowding out' of poverty-reducing growth that could otherwise be stimulated, are very uncertain (see Fankhauser, 2010). 'Bottom-up' estimates are scarce and tend to focus on the direct (first-

round) impacts in the most vulnerable sectors. However, the 'top-down' model estimates vary a lot and are not supported by good micro foundations. They suggest that the desired level of spending on adaptation may (far) exceed the desired level of spending on mitigation, particularly for developing countries. Some forms of adaptation are likely to yield benefits for all probable climate changes while others will be much more impact-dependent. Growth can promote adaptation by providing more resources and a less vulnerable economy, but may also make some adaptation requiring changes to public goods and networks (e.g. changes to urban infrastructure) more difficult. Hence policies to promote growth and adaptation need to be complementary; growth needs to be 'climate-resilient.'

3.3 How growth can cushion climate-change impacts

One implication of empirical studies of the macroeconomic impacts of climate change is that economic growth generally helps to reduce the adverse effects of climate change. The pattern is not uniform, however, and there are examples of economic development that increase vulnerability to climate events.

Vulnerability to climate change is a function of two main factors (see e.g. Barr et al., 2010): (i) the *physical impact* a country faces and (ii) its *adaptive capacity*, that is, its ability to deal with a climate shock. Economic growth almost always increases the adaptive capacity of people. (The same is not true for ecosystems, whose adaptive capacity may be impaired by over-exploitative development). A society's ability to cope with climate events is highly correlated with basic development indicators such as income, education and institutional quality.

However, depending on its pattern, economic growth can either increase or decrease the physical impacts of climate change. Diversification away from agriculture into manufacturing, for example, is likely to reduce the severity of climate change impacts (as we will see further in section 5). In contrast, agricultural expansion that increases reliance on scarce water resources could increase potential impacts, as would economic development in hazard zones (e.g., flood plains or low-lying coastlines).

The net effect of these two effects is unclear a priori. However, the empirical evidence suggests that the positive effects, on adaptive capacity in particular, tend to dominate. Thus Dell et al. (2008, 2009) found that, over the past fifty years, higher temperatures significantly

reduced economic growth rates, not just the level of GDP, in poor countries but not rich ones.[5] That did not appear to reflect solely the facts that poorer countries tend to be hotter and more dependent on agriculture. For poor countries, higher temperatures appeared to reduce agricultural output, industrial output and aggregate investment while increasing political instability. Decadal or longer shifts in climate had persistent impacts on growth in poor countries despite the time to adapt to their consequences. Raddatz (2009) concluded that, on his definition of a climate-related disaster,[6] each one in a low-income country had led to a decline in per capita GDP of 1%, compared with 0.5% in middle-income countries and 0.25% in high-income countries. Using a more theoretical approach, Noy (2009) also found that certain development indicators had been associated with a lower GDP loss from a given climate-related disaster, including GDP per capita, literacy, strong institutions, trade openness and depth of financial markets.

There is further evidence from case studies that poverty tends to exacerbate the costs of climate change (see Bowen et al., 2009, O'Brien et al., 2008). Benson and Clay (1998) argued that the consequences of the 1991-92 southern African drought suggested a U-shaped relationship between development and vulnerability to climate change: the economic impact of climate-related shocks such as drought was higher for economies that had moved from a 'simple stage' of water-intensive agriculture and subsistence sector to an 'intermediate stage,' characterised by labour-intensive low-technology manufacturing, but vulnerability was lower where economies had become more diversified and developed.

Economic growth can also increase resilience by removing poverty-related gaps in adaptive capacity; the poorest within a country are least able to adapt. Menon (2007) analysed Malawi's famines in 2001/2002 and then in 2005, concluding that, because of deep structural poverty over the years, farming households had contributed to the deterioration of soil by failing to invest in land inputs. Poverty had impaired people's ability to adapt. We will return to many of these examples in the following sections.

[5] Countries were defined to be 'poor' if they had below-median purchasing-power-parity-adjusted per capita GDP in the first year that the country entered the data set.

[6] Raddatz defined disasters as events that affect at least half a percent of a country's population, causes damage of at least half a percent of GDP or results in more than one fatality per 10,000 people.

4 Revised Approaches to Growth

This section aims to tease out which aspects of the existing approach to economic growth may have to be reviewed in light of climate change and the need to adapt. We look at both revisions resulting from the need to adapt and risks to growth from climate change.

Section 2 distinguished nine key drivers that are generally associated with sustainable, private sector-led growth. They were grouped into four categories: sufficient capital, a sound business environment, easy access and high productivity. The rest of the section addresses how these nine conditions are affected by climate change. The conclusion is that climate change generally worsens already present market failures and, as a result, more policy action is needed to counter this and achieve climate resilient growth. That is, in most of the nine areas, climate change reinforces the case for policy intervention. However, in many cases changes in the policy approach may be needed to account for climate change.

4.1 Sufficient capital

4.1.1 Natural capital

The key task for governments in this area is the responsible management of natural capital so that it can be used sustainably in production. Climate change reinforces this imperative. Adding climate change to existing pressures on ecosystems could speed up their destruction and the loss of biodiversity (TEEB, 2008). Removing baseline pressure by managing natural resources sustainably would strengthen the resilience of ecosystems and increase their ability to adapt naturally to climate change.

This would have direct economic benefits that can be valued (for example, increased fish catch adjacent to marine protected areas) as well as a number of intangible benefits that are more difficult to quantify (e.g., watershed protection and microclimate regulation; see TEEB, 2008). In fact, healthy ecosystems can themselves contribute to adaptation (e.g. coastal protection through mangrove forests or wetland zones). Hornbeck (2009), analysing the 1930s Dust Bowls, shows how environmental degradation, in this case over-farming, can

have significant economic effects and trigger deep structural change (many farmers were forced off the land and left unemployed).

These benefits are disproportionately felt by the poor, who rely on subsistence farming, animal husbandry, fishing and informal forestry (TEEB, 2008) which makes the preservation of ecosystems and biodiversity a key part of poverty reduction.

Policy Implications: Traditional growth policies tend to neglect the environmental impacts of growth, but it is a key aspect both for adaptation and sustainable development. The development community may have to better understand the economic value of ecosystem services and step up safeguards for their protection. .

4.1.2 Infrastructure

A reliable infrastructure underpins growth and development. Climate change does not alter this relationship, but governments and development agencies must ensure that the physical capital is resilient to both the expected higher temperatures and the increase in climate variability. Factoring in climate change (e.g. in the specification of water reservoirs and draining systems) will make infrastructure more expensive, with a potential cost to short-term growth. However, doing this proactively will ensure that the life-time costs involved in adapting to climate change are minimised (World Bank, 2009b) while allowing firms to continue to benefit from reliable infrastructure services.

Coupled with this, there may have to be an increased focus on certain areas of infrastructure, such as urban infrastructure, where socio-economic pressures and climate change are mutually reinforcing. The World Bank argues, for example, that the current development path of towns and cities is not sustainable, and attention needs to be given to the drainage systems and construction methods of public buildings (World Bank, 2009b). Similarly, the provision of housing for city dwellers may become more important, particularly for coastal cities. The lack of adequate infrastructure and service provision in slums makes their residents particularly vulnerable to extreme climate events such as floods.

Finally, there may be the need for further dedicated adaptation infrastructure, such as sea defences and flood protection. Studies of the cost of adaptation guesstimate that adaptation may add 10-20% to the cost of climate sensitive infrastructure (see Fankhauser, 2010).

Policy Implications: The need for infrastructure investment over the coming decades is enormous. Climate change does not alter this need but may increase its costs. Climate change may also affect the

planning process, for example, where infrastructure is built and how it is designed. Factoring climate change into the design of such long-lived investments – and accounting for climate uncertainty -- will be key to keeping down costs.

4.1.3 Human capital

Two areas of human capital are of particular concern for countries dealing with a changing climate – education and health.

As climate changes, there will be a need to increase people's ability to cope with shocks and uncertainty: this can be helped by more and better education. Toya and Skidmore (2007) have shown that education results in better adaptation decisions and as a result it increases resilience to climate shocks. This finding is particularly strong for the education of women, suggesting more work in this area will be beneficial (Wheeler et al., 2010).

In addition to general skills there will be a need to increase climate-specific know-how and information. The work of Di Falco et al. (2010) on Ethiopia shows how powerful better knowledge about climate change can be. Farmers who were trained and had access to accurate climate and weather information made better decisions about what types of crops to plant, in particular opting for varieties that were not dependent on the highly volatile annual rainy season.

Conversely, it is possible that climate shocks may adversely affect human capital accumulation. Evidence from rural India shows that those born during floods in the 1970s were 19% less likely to have attended primary school (UNDP, 2007). Similarly, Crespo Cuaresma (2009) finds that as the risk of natural disasters increases, the accumulation of human capital (measured as secondary school enrolment rates) falls. He hypothesises that this is because the expected benefit falls as pupils are more likely to die or be excluded from the economy by a shock. This implies that more will need to be done to counteract the negative impact of climate change on this important area for development.

Another cause for concern is worsening health outcomes as the climate changes, particularly if it gets warmer and wetter. This will lead to a rise in the occurrence of tropical diseases such as malaria (Parry et al., 2007), which not only limit a country's ability to develop but also their capacity to deal with climate shocks. Expansion of preventative health projects may become crucial to achieving both climate change adaptation and long run development.

Policy Implications: Education and health are key to improving resilience to climate shocks and adaptation to climate change. Improvements in both areas are also priority development goals. Climate change increases the case for intervention in these areas, in addition to climate change-specific policies in this area. But additional stress from global warming will also make it more difficult to achieve existing targets for health and education targets under the MDGs.

4.2 A good business environment

4.2.1 Macroeconomic stability

The case for macroeconomic stability is not a priori affected by climate change, but there is evidence that climate change may affect aspects of macroeconomic stability, such as fiscal sustainability. Government budgets may become more pressurised if the frequency of extreme events increases and funding is required for emergency services and reconstruction. Thus governments will need stronger fiscal positions to counter this risk, potentially affecting the definition of "fiscal sustainability".[7] Fiscal pressure may be compounded by a temporary fall in revenues in the aftermath of a disaster. There are also related management challenges. Governments will need to make clear their intended degree of emergency coverage after a disaster to ensure that the private sector does not impose unnecessary moral hazard and underinsurance costs (Heipertz and Nickel, 2008).

A second potential issue is related to capacity and the economic cycle. Hallegatte and Ghil (2008) develop a theoretical, short run model of an economy affected by climate shocks, and show that some output flexibility may be good in the face of a negative climate shock. The market sends price signals that trigger reconstruction, which limits the loss in output.[8] However, if the shock hits the economy in a boom, when there is little spare capacity to rebuild, output may fall over the medium term. The policy implication clearly cannot be to maintain slack in the economy. A more likely remedy would be access to foreign labour and capital resources that can be deployed in periods of full capacity utilisation, but much more research is needed to establish what level of economic flexibility may be desirable.

A third, more speculative issue is the importance of price stability if the private sector is relied on to drive adaptation and mitigation to climate change. For this to work, prices must

[7] This may take the form of adequate access to international capital flows and maintaining a sustainable borrowing position, rather than governments having to run budget surpluses or build up stocks of buffer savings.
[8] This analysis is based on a Keynesian view of the world, where slack factors of production can be redeployed relatively easily when demand is stimulated (in this case by the need to rebuild following the climate shock). .

signal shifts in (real) relative prices, and price signals may be blunted in the presence of high inflation and currency fluctuations.

Policy Implications: Climate change neither increases nor decreases the importance of macro-economic stability, although it is possible that a higher probability of extreme (and costly) climate events may make fiscal sustainability both more important and more difficult to achieve. Factor mobility and access to foreign goods, labour and capital (including international finance) may help to cushion climate shocks in times of full capacity utilisation. This point will be returned to in the openness to capital section.

4.2.2 The institutional and regulatory framework

The empirical literature analysing the impact of climate shocks at the macro level find that better institutions result in a faster, more efficient response to the shock and that the shock itself does less damage in terms of output. This is true for both long run growth rates (Noy, 2009) and short cycles (Hallegatte and Ghil, 2008), suggesting that institutional reform and capacity building will stimulate both poverty reduction and resilience to climate change.

Dell at al (2008, 2009) find that countries with higher income levels are not only less affected by climate shocks, but their long run growth rates are less affected by changes in the climate (as captured by average temperatures and precipitation rates). Their results suggest that support for institutional reform directly helps by increasing adaptability within the economy, and indirectly increases adaptability by increasing income levels (thus reducing a country's vulnerability to climate change and shocks).

At the micro level, broadening the definition of institutions to include information transmission and networks, we have seen above how the rate of adaptation increases when farmers have access to better information and that as a result productivity and output increases on average (di Falco et al., 2010). This suggests that interventions which improve information flows, and agents understanding of the information will have a positive impact on both growth and climate change resilience (this relates back to the points made about human capital above).

Policy Implications: Climate change strengthens the case for institutional policies and capacity building, which has both growth and adaptation benefits. An open question is whether the two objectives require different types of capacity or institutions. This is an issue for further research,

although it is likely that strong institutions will generally evolve automatically to tackle new problems such as climate change as they arise.

4.3 Easy access

4.3.1 Access to markets

There is some evidence that openness to trade makes economies more resilient to climate shocks by reducing producers' reliance on domestic markets and vice versa (Noy, 2009). However, this relationship may depend on the type of shock, as a climate event that cuts off a country from world markets e.g. a cyclone that destroys a major port may have the opposite effect. Gassebner et al. (2010) find that natural disasters have a negative impact on trade flows in the short run, reducing both imports and exports (the effect is worse in countries with a bad political regime), which suggests that both effects may operate and the type of shock is crucial in determining the outcome.

A counter argument to trade openness is that while it can reduce risks (see above) the degree of specialisation that may result can expose countries to excessive risks. The extent of this risk may depend on GDP levels and economic structure. The risks of specialisation may be higher in low income countries, which can be highly specialised and typically focused on agricultural outputs. In contrast middle income countries have generally diversified and moved into industrial products. This issue is covered further in section 5.

Access to markets also increases resilience to climate shocks at the micro level. A study by Carter et al. (2007) on subsistence farmers who have fallen into poverty traps suggests that access to markets significantly increases the resilience of households to climate shocks (see Box 2). This implies that work to integrate the rural poor into the economy has both climate change and growth benefits.

Policy Implications: From an adaptation point of view, the degree of openness needs to be carefully managed, with both positives and negatives coming from reliance on international markets. It may be that expanding financial markets to provide insurance for specialised producers and encouraging diversification at both the micro and macro level are needed to accompany openness to trade.

4.3.2 Access to capital

Openness to capital markets has been shown to increase climate resilience, through inflows for reconstruction. However, over-reliance on inflows prior to the shock can result in the

opposite effect, as capital flight after the shock worsens the country's capital account position (Noy, 2009).

Box 2: Climate Change and Social Adaptation

Supporting social adaptation, that is, access to finance and jobs during crisis, in the face of climate change and variability can be an important area for development (UNDP, 2007). In the drought of the late 1990s poor households in Ethiopia had had to make distress sales of assets (mainly livestock), which undermined their efforts to maintain agricultural production (Carter et al., 2007). Retaining their livestock ('asset smoothing') was difficult because they were very close to the poverty trap threshold and did not have access to land or credit markets to allow them to buy alternative, more 'climate-resilient' assets.

Market access and social adaptation policies can help to overcome this problem, in particular access to labour markets outside of agriculture, which reduces farmers' reliance on agriculture income. As a result they can rebuild/retain their capital stock in the face of climate shocks, and thus avoid climate-induced poverty/low human development traps. A second potential solution is the implementation of insurance for social protection (UNDP, 2007). An example of success in this area is the Ethiopian Productive Safety Net Programme, which provides income (cash or food) to meet any food gap caused by a poor harvest. This ensures that poor families are not forced to liquidate their existing assets or reduce investment in human capital, thus increasing their resilience to climate shocks and maintaining their positive development path.

A further benefit of access to international capital is the ability of governments to access international funds to rebuild after climate disasters. This could replace the need for domestic buffer stock saving in case re-building is necessary, and funds designed specifically for this purpose should be established by development agencies (see discussion on macroeconomic stability above).

A strong domestic financial system and access to domestic capital are equally important. Resilience to climate shocks will require domestic financial firms to be fully diversified, in particular not overly reliant on the vulnerable agricultural sector. Hornbeck's (2009) study of the Dust Bowl shows how over-specialisation of the financial system makes it vulnerable to climate shocks and how this can have both level and growth rate effects on income. The level

effects come through the immediate losses suffered by the banks, and the growth rate effects through the potential loss of financial intermediation if banks fail, which limits investment within the economy.

At the micro level, the key question is what role micro-finance can have in encouraging resilience and adaptation. The impact of microfinance on growth is unclear, in part because it does not address the issue of the "missing middle", that is access to credit for borrowers graduating from micro-programmes. However, Agrawala and Carraro (2010) argue that, *a priori*, micro-finance may be a good solution to climate change. It can reach the poorest members of society, provides them with financial services to adapt to climate change and can also provide a platform for other interventions e.g. education provision. They also argue that many of the micro-finance initiatives currently being undertaken are implicitly tackling climate change e.g. investment in crop diversification, support for disaster relief etc.[9]

At the same time, many of the projects financed by micro-finance institutions are vulnerable to climate change. Agrawala and Carraro estimate that 70% of the micro-portfolio in Bangladesh could be affected by climate change, and usually negatively so. This could make micro-finance institutions vulnerable to climate shocks via their geographically-concentrated client base, and may create the need for more regionally-diversified / national micro-finance institutions supported financially by development agencies.

Policy Implications: Broadly speaking climate change reinforces the need for better access to capital. At the macro level access to funds for reconstruction is likely to become more important. Micro-finance can help to increase the adaptive capacity of low-income households, although its impact on growth is unclear.

4.4 High productivity

4.4.1 Competitive markets

The conventional wisdom is that free markets are more shock resilient and induce greater adaptation in agents (see e.g. Noy's results for openness to trade and resilience to shocks reported above). Another example of this are the diversification benefits offered by non-farm activity for the very poor (Carter et al., 2007). Here a competitive market allows farmers to

[9] The authors find that 43% of the micro-finance portfolio in Bangladesh and 37% in Nepal is 'win-win' for climate change and development.

diversify their income away from farming, thus reducing their reliance on output which is very vulnerable to climate shocks. Benson and Clay (1998, 2004) find that this transmission channel is also important at the macro level. Bangladesh has managed to reduce the impact of climate shocks and increase adaptation on its macro economy by diversifying away from agriculture into the garment industry.[10]

Competitive markets are also thought to be more flexible and able to react quickly to changing circumstances. This happens through a combination of market entry and exit and the response of existing firms to market signals. Flexibility is an important aspect of good adaptation, given widespread uncertainty about climate change impacts and the likely increase in climate variability.

Despite this, it is not clear that competitive markets are always beneficial. Hausmann and Rodrik (2006) have argued that the market may fail to provide all the necessary capabilities to move into new sectors, and as a result government intervention may be necessary. There may also be dynamic market failures, as diversification today may only benefit future generations. These questions will be returned to in chapter 5, but more research will be necessary to fully establish the role of competition in adaptation.

Policy Implications: It is generally assumed that competitive markets will increase flexibility and, as such, help adaptation, but there is little empirical evidence. The question is related to the broader debate about how to encourage diversification away from agriculture to develop economically. More research is needed to answer these questions.

4.4.2 Productivity

Whilst economic growth is supported by productivity improvements in all sectors of the economy, the majority of climate change work has focused on agriculture.[11] The agriculture sector will be among the most affected by climate change. That is, it will suffer a loss in productivity, which can in part be reversed through adaptation.

[10] As with other studies, the authors also find that better access to micro-finance, stronger institutions and improved financial management have also helped improve resilience.
[11] The impact on the rest of the economy should not be forgotten, though, and in particular the effect of extreme events on productivity as a result of work interruptions and damage to productive assets.

Work in this area has highlighted that adaptation is essential to ensuring that subsistence farmers can cope with climate change (di Falco et al., 2010). Most of the adaptation measures studied are low-cost managerial adjustments such as changes in crops or planting dates. Hansen et al. (2009) also show that investing in water infrastructure that ensures a stable supply (dams etc) smoothing out crop production and increasing the probability of a successful harvest.

This suggests that efforts to boost agricultural productivity through low-cost operational measures may well generate a win-win situation. Increased agricultural productivity can also help to ease potential food shortages and pressure on food prices, whether they are brought about by climatic factors, increased food demand or competition for land from biofuels.

However, there is a risk that some productivity measures could increase vulnerability to climate change, for example if they entail increased reliance on scarce water resources. Farmers will have to optimise their expected return, bearing in mind different possible climate outcomes, but they will also want to reduce the risk of a failed harvest. We will return to this issue in the next section.

Policy Implications: Many development agencies have downscaled their support for agriculture. However, there is a growing need to improve agricultural productivity both to meet growing food demand and deal with the consequences of climate change. Support should aim to improve both productivity and resilience in agricultural crops.

5 A Closer Look at Two Dilemmas

Section 4 suggests that "the right kind" of economic growth is a good way of reducing the vulnerability of poor countries to climate change. In most cases, climate change reinforces the need to strengthen the determining factors of growth. Yet there are trade-offs. Most of them occur at the level of implementation and as such are not picked up by the macro-analysis of section 4. The development of flood plains, coastal zones and other risk areas is a case in point. This section highlights two issues where there might be trade-offs between the pursuit of economic growth and the need for adaptation at the macro-level:

— G*rowth through specialisation vs. risk mitigation through diversification*: The question here is whether an approach to growth based on specialisation and comparative advantage is still desirable in a world where climate variability increases the risk of certain vulnerable activities and business practices 'natural capital', a major challenge for developing countries (see section 4).

— *Private sector-led growth vs. public sector adaptation*: The question is whether adaptation will increase the role of the state, given that much of what is required appear to be classic state functions, and whether that contradicts the predominant view that economic growth is best led by private investment.

5.1 Specialisation vs. diversification

Economic theory suggests that economic integration and open markets will result in welfare-enhancing specialisation. At the level of countries (macro level) this is illustrated by trade theory, which predicts gains from trade a result of specialisation on areas of comparative advantage. Similar effects are at work at the level of individual workers and firms (micro level), who can take advantage of economies of scale by focusing on one task and trade with other agents to purchase a wider variety of goods.

Both the macro and micro theory suggests that there are at least *level effect* benefits from

specialisation. Specialisation leads to a one-off improvement in the level of output or welfare through an increase in (static) efficiency. However, here may also be a *growth rate effect* if specialisation encourages innovation or learning-by-doing. This improvement in dynamic efficiency will reinforce the initial shift and the value of specialisation.

The theory of comparative advantage does not imply that rich economies are more specialised than poor economies. In fact, most advanced economies are well diversified, but populated by specialised firms that are competitive in an array of sectors. Resource-rich economies are a notable exception. Developing countries in contrast are often highly specialised in one or two sectors (Imbs and Wacziarg, 2003), in part because the capital base to establish areas of international competence is lacking.

Climate change, and the increase in climate variability it might bring, present a new challenge to both economies and individuals seeking to specialise. Many developing economies are concentrated in sectors that are vulnerable to climate change, in particular agriculture. In some cases this reflects a comparative advantage (e.g. for coffee growing), often it is a reflection of poverty and the prevalence of subsistence farming.

Either way, the concentration on climate-sensitive activities increases the vulnerability of these countries to climate change. From an adaptation point of view, it may be desirable to diversify away from vulnerable sectors or products, even if it means losing a comparative advantage. The example of Bangladesh shows how effective diversification away from vulnerable activities can be (Box 3).

Farmers may decide themselves to move away from high-risk crops, especially if adequate risk-coping strategies are not available (Dercon, 2002). However, they are as likely to switch to less profitable practices as they are to diversify away from agriculture. Although diversification away from agriculture tends to go hand-in-hand with economic development, the process may not be fast and effective enough. There are market and information failures that prevent agents and countries from taking advantage of risk-minimisation strategies.

The question then is how public policy can encourage a diversification process that is beneficial from a climate change point of view and consistent with most countries' growth and development path. Unfortunately, the development literature does not offer much guidance. A number of policy options have been proposed, but as yet no preferred approach has emerged.

Box 3: Impact of Climate Shocks on Bangladesh

The importance of diversification in reducing the impact of climate shocks is highlighted by the experience of Bangladesh. Benson and Clay (1998, 2002, 2004) traced from 1966 to 1998 the incidence of natural hazards and the state of agricultural, non-agricultural and total GDP in Bangladesh.

Before 1998, floods and cyclones had had a direct negative impact on GDP. However, in more recent years, the impact had been less stark because of greater dependence on the garment export industry, better access to micro finance by the poor, damage management programmes and improved financial management in a crisis.

During the flood of 1998, sectoral diversification, effective use of Bangladesh's Food Account and fiscal measures reduced the multiplier effects of climate shocks in the long run. Despite the worst flood in Bangladesh since the early 1940s, agricultural GDP and food grain production during 1998 were double the pre-disaster forecast and stayed high.

There is a renewed interest among some authors in industrial policy, which might be one way of encouraging structural change. Rodrik and Hausmann (Rodrik, 2004a, Hausmann and Rodrik, 2006) in particular have championed industrial policy as a solution to a number of market failures that prevent developing countries from reducing their dependence on agriculture. The presence of collateral constraints and asymmetric information, moral hazard in the training of workers, learning-by-doing spillovers and coordination failures are identified as areas of policy interventions and barriers to diversification.

Similarly, if industrial sectors exhibit economies of scale, theoretical arguments have been made for infant-industry protection. Collier (2006a) points out that East Asia was only able to industrialise and capture new industries (such as car manufacturing) by keeping their wage costs low enough to compensate for insufficient economies of scale in production.

However, other authors are unconvinced by the usefulness of industrial policy (e.g. Wood and Mayer, 2001, Wood, 2003). They argue that the potential for governments to make things worse, by correcting one market failure by introducing another, is high. They advocate broader institutional improvements and general private sector development as the best way to stimulate a market-driven, rather than government-imposed, diversification.

In a similar vein, many of the micro-level policies discussed in section 4 are advocated as promoting market-driven diversification. The expectation is that improving human capital, for instance, may open up opportunities for individuals outside of the agricultural sector. Similarly, access to markets and lower barriers to entry may make it easier for individuals to generate non-agricultural income, insulating them from climate shocks (Carter et al., 2007).

Most of these approaches have been applied in practice, with various degrees of success. Development agencies are well aware of the risks to countries that rely too heavily on agriculture, both in terms of climate variability an other shocks. The broad conclusion is that diversification does not happen automatically. However, as yet no clear approach has emerged on the best way of encouraging it. As climate change will make this debate much more important, there is a case for a closer review of the interventions that have already been conducted to establish which ones have worked and why.

5.2 Private sector-led growth vs. state-led adaptation

In the prevailing growth paradigm growth is led by the private sector. Private investment, entrepreneurship and innovation are the main drivers of economic growth. This contrasts with adaptation, which is generally perceived to be a predominantly public sector activity.[12] This perception may well be wrong. Most adaptation will probably be carried out by private agents, i.e. households and firms, and not by the state. Nevertheless, there is a strong role for the state and, more generally, for collective action. It is therefore a valid question to ask whether public adaptation will crowd out private investment, and whether this could affect long-term growth.

To understand the role of collective action in adaptation it is useful to recapitulate the core functions of governments. The state is usually called upon to (i) provide public goods, such as infrastructure, security and the regulatory framework; (ii) protect vulnerable population groups; and (iii) correct failures in the functioning of markets, such as the presence of monopolistic power.

Climate change does not change this basic understanding of the role of the state. But it could

[12] In the debate on climate change finance, for example, the implicit assumption is that private financing will be available for mitigation (e.g., through carbon markets) but public finance will be required for adaptation. See World Bank (2009).

potentially alter the balance between public and private activity because dealing with climate change requires large quantities of the kind of services governments are expected to provide (Cimato and Mullan, 2010):

— Many adaptation measures are public goods. Examples include emergency services, flood protection and research into new medicines and cultivars.

— An important part of adaptation is the protection of climate-sensitive infrastructure, such as water and sewage systems. These are generally provided (or at least commissioned) by the state. There is evidence that climate-proofing infrastructure may be the most expensive aspect of adaptation (Fankhauser, 2010).

— Vulnerable population groups, such as the poor and the elderly, are disproportionately affected by climate change and will look to the state for protection and a safety net.

— There is need for training and better information. Insufficient knowledge is a major barrier to private adaptation, especially about climate change impacts on particular regions or industries.

— Regulation may be required to address externalities in private adaptation, such as the impact of flood protection on settlements downstream, and issues like asymmetric information about the implementation of building standards.

Some of these failures are arguably temporary and may only require short-term intervention by the state. Knowledge sharing and information are likely to fall into that category. Others concern existing state-functions that do not need to be expanded, only implemented differently. Building regulation would be an example. Nonetheless, there will be an increased demand for public investment.

There is a theoretical case that more public investment in adaptation might crowd out more productive private activity, that adaptation spending might replace other forms of productive investment to the detriment of long-term growth. The first study to look at this effect was Scheraga et al. (1993), a general equilibrium analysis for the United States. It concluded that "*increased construction activities lead to a redirection of spending away from consumption toward public and private investment*" (p.121), but the impact on consumption was

modest. The study also observed increasing prices, and hence lower demand, for food products, lumber, tobacco and textiles as a result of lower crop yields because of climate change. The effect was again small, but it was regressive, hitting low income households most.

There have been few subsequent studies and the few that exist do generally not report higher-order macroeconomic effects (e.g., Bosello et al., 2007, 2010). Perhaps the most relevant set of studies is by the World Bank, which used general equilibrium modelling to assess adaptation options in seven developing countries (World Bank, 2009b). The World Bank studies again suggest that adaptation costs – whether public or private - may be too small to have noticeable economy-wide effects on aggregate.

However, there may well be countries where this result does not hold and where climate change is so prevalent that (public) adaptation affects the economic structure of a country. Small island developing states could conceivably fall into this category. In these cases, there is the added complication that external financial assistance to the public sector might create Dutch Disease – the risk that the inflow of adaptation capital and demand for adaptation services raises wages and appreciates the real exchange rate to the detriment of other economic, especially export focused, activities (e.g., Collier, 2006b).

There are mitigating factors. As Collier (2006b) points out, the way finance is channelled and administered can go a long way to reduce these risks. For example, if demand for adaptation services and capital inflows were compensated by an increase in imports, macroeconomic stability should be preserved. Equally, the risk of Dutch Disease is weakened if an economy does not run at full capacity. In that case, public adaptation spending would provide a Keynesian-style boost to the economy.

In principle it is also possible to structure some adaptation investments, particularly in infrastructure, as public private partnerships. This would be another way of preserving the balance between public and private investment. The World Bank records between 200 and 300 new private infrastructure projects in developing countries each year. The total investment commitment in these projects since 1990 exceeds $1.6 trillion.[13] However, in practice, the experience with private sector participation in infrastructure is often mixed, and

[13] See http://ppi.worldbank.org/.

it is unclear whether the private (rather than public) provision of infrastructure has had any noticeable impact on growth.

Although climate change does not redefine the role of the state, it may result in an increased emphasis of collective over private action. Climate change highlights and amplifies the importance of a range of market imperfections and policy failures that warrant more emphasis on the promotion of effective collective action, including by the state. But further research would be needed to establish how, if at all, this affects the balance between public and private investment and whether this has any impact on growth.

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