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Green growth: an assessment

Alex Bowen* and Cameron Hepburn**

Abstract 'Green growth' is almost tautologically required for global welfare to rise in the long run. Economic growth is desirable, not least because over 1 billion people still live in conditions of poverty. Undermining the ecological basis for human civilization will damage human welfare and further undermine economic growth. There are large adverse environmental externalities from economic activity that affect human welfare directly and indirectly through lower measured output. Finding ways to tackle these externalities will enhance wellbeing and allow continued growth of GDP while preserving aggregate natural capital. However, achieving this goal presents societies with major challenges. The composition of GDP is likely to have to change significantly, with more emphasis on new ideas and less on increased material throughputs. The role of the state in a 'green growth' transition will have to go beyond internalizing externalities to 'get prices right'. The necessary transformation will be large, system-wide, and structural, so the state must also provide, at the least, overall strategic direction. Innovation will be central to any successful strategy, as will be dealing with the distributional consequences of stronger environmental policies, particularly in developing countries. Organizing the appropriate collective action at the right levels in the face of inadequate information, while ensuring that the appropriate governance arrangements are in place, will not be easy. Policy experimentation is needed, with more rigorous *ex post* evaluation and, where successful, rapid dissemination of the results.

Key words: growth, green growth, sustainability, natural capital, externalities, environmental policies, policy evaluation

JEL classification: O44, Q56, Q58

I. Introduction

The phrase 'green growth' holds out the promise of economic progress hand in hand with preservation of the environment. Achieving green growth has become a central objective of international organizations such as the Organization for Economic Cooperation and Development (OECD), World Bank, and other multilateral development banks (see, *inter alia*, OECD (2011*a*), World Bank (2012), and ADBI/ADB

* Grantham Research Institute on Climate Change and the Environment, London School of Economics, e-mail: a.bowen1@lse.ac.uk

** Institute for New Economic Thinking at the Oxford Martin School, Oxford Smith School, Grantham Research Institute at the LSE, and New College, Oxford, e-mail: cameron.hepburn@new.ox.ac.uk

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(2013)) and the *raison d'être* of a new international organization, the Global Green Growth Institute. It has been invoked frequently in macroeconomic policy discussions, as when the Managing Director of the International Monetary Fund (IMF) argued in June 2012: 'we must start with the basics—from a platform of restored economic stability and growth. From that base, we can achieve green growth and inclusive growth—the building blocks of our sustainable and equitable economic future' (IMF, 2012).

The term has been in use for some time. Although the well-known Brundtland Report, *Our Common Future* (World Commission on Environment and Development, 1987), which did much to popularize the term 'sustainable development', did not refer to 'green growth', the phrase was used around the same time. For instance Colby (1989) claimed: 'The positive vision of eco-development is for "green growth" and integrated co-evolutionary development of humans and nature.'[1] So the idea of green growth is at least 25 years old. But it has notably moved up policy-makers' agendas over the past few years. This has happened for three main reasons.

First, growth is seen as an important political imperative at a time when many countries have recently experienced recessions and rates of growth are below long-term averages. The recession of 2008–9 was 'the deepest post-World War II recession by far' (IMF, 2009), with output *per capita* declining in countries representing around three-quarters of the world economy. The recovery since the trough has been slow, with the most recent IMF *World Economic Outlook* stating that 'global growth is in low gear . . . and downside risks persist. . . . Aside from new cliff events, a growing worry is a prolonged period of sluggish global growth' (IMF, 2013).

Second, growth is more widely viewed as key to improving the outlook for very poor people around the world and for promoting the development of low-income countries. Growth—at least, if it is of the right type—is regarded by more development economists as a proven way of lifting people out of poverty (see, for example, World Bank, 2002; Adams, 2004; Collier, 2007). The fraction of the world's population surviving on $1.25 a day or less (a World Bank poverty line) more than halved between 1981 and 2008, but was still over 22 per cent—some 1.5 billion people—when the world economic crisis hit.

Third, the threats from human-induced climate change have brought one particular aspect of the environment into the headlines and on to the agendas of politicians worldwide. Greenhouse gas emissions so clearly give rise to an enormous economic externality—'the greatest market failure the world has seen' according to Stern *et al.* (2007)—that policy-makers have had to pay attention to the potential for significant damage from environmental consequences of economic activity. But climate change is by no means the only adverse environmental consequence of economic growth. The loss of biodiversity, the increasing scarcity of fresh water, and the health impacts of pollution, notably from air-borne particulates and hazardous chemicals, are all important (OECD, 2012). Angel Gurria, the Secretary-General of the OECD, argues that 'the erosion of our natural environmental capital will increase the risk of irreversible changes that could jeopardize two centuries of rising living standards' (OECD, 2012).

[1] In political discourse, too, the term was in use by the 1980s. UK political parties contrasted 'green growth' and 'no growth'. In 1989, a Conservative politician, Michael Howard, argued that 'Green growth, rather than no growth, must become the watchword of the Conservative Party' (Guardian, 1989).

Is it true that growth can persist in the long run—and even be increased in the short run—alongside policies aimed at reducing the degradation of the natural environmental and natural capital? This paper and this issue of the *Oxford Review of Economic Policy* consider this and related questions. In so doing, this assessment explores the definitions of the term 'green growth' (section II), its feasibility in theory (section III), the government policies that might support green growth (section IV), and the appropriate sequence for their implementation (section V).

The paper concludes that green growth of some form is almost tautologically required for improved global welfare in the long run—undermining the ecological basis for human civilization will not promote welfare, but economic growth is clearly necessary in poorer and still emerging economies. Specifically, there are currently large adverse environmental externalities from economic activity that affect both the consumption and production side of economic activity—they reduce human welfare directly and indirectly through lower measured output. There are potentially large beneficial spillovers from more innovation and smarter infrastructure provision that would support green growth; if these are captured, it is more likely in practice that green growth will actually be achieved.

What policies could plausibly deliver 'green growth'? It is clear that the transition to greener growth requires, at a minimum, correcting prices for environmental externalities. Whether there is a much greater role for government is contested, but there is certainly a case that in addition to 'getting the prices right', government must set the strategic direction of the economy—prices can only be assessed as being right or wrong given a particular, a priori, development path. Finally, a major transition of the sort required to take the notion of green growth seriously would threaten many incumbent interests—political economic analysis is essential to identifying which elements of the transition might realistically be feasible and how they might be tackled. Creating a political coalition powerful enough to override those interests, or generating enough surplus from policy shifts to buy them out, is critical to the practical implementation of 'green growth' policies.

II. What is green growth?

Defining 'green growth' requires defining 'growth', defining 'green', and defining the connection between them. There are a variety of official and unofficial definitions, but the definition we adopt in this paper is that green growth means increases in economic activity in the long term and possibly short term, without reducing aggregate natural capital. This section unpicks the reasons for that definition, looking at the range of different possible definitions from first principles.

The word 'growth' implies the question 'growth of what?' and the answer is conventionally assumed to be gross domestic product (GDP). More broadly, growth might be defined as corrected economic growth, using a measure such as (genuine) net national product (NNP). More broadly still, growth might imply growth in human wellbeing, or prosperity, or some other similar concept. In this paper, we focus on the narrow definition of economic growth, measured by GDP. This is not because we consider GDP growth to be the only appropriate social objective. On the contrary, Hamilton and Hepburn (2014)

set out the case for focusing on changes in wealth, and it is well-known that GDP is not an appropriate proxy for welfare, especially in richer countries (Stiglitz *et al.*, 2009).[2] Michael Jakob and Ottmar Edenhofer (2014, this issue) propose instead a variant of the OECD dashboard approach, focusing on the management of a portfolio of capital stocks, some of which are common pool resources and others public goods. They argue that welfare diagnostics need to be developed to establish the minimum amounts of each of these capital stocks essential for welfare. However, GDP growth is currently the objective of greatest interest to policy-makers at the present time, and it is therefore what most commentators are referring to when discussing 'green growth'. Indeed, green growth has had more success as an environmental discourse than concepts such as 'sustainable development' precisely because it is more narrowly focused on the core interest of policy-makers.

The 'green' part is perhaps more controversial, with various possible definitions. It might refer to preserving or enhancing aggregate natural capital within a specific area, or possibly the planet as a whole. Aggregate natural capital would include environmental and resource-based assets such as ecosystems, biodiversity, a habitable climate, fertile soil, and sub-soil natural resources. This is (increasingly) understood and reported within national accounts.[3] An alternative definition (which may be less or more stringent) is the protection or enhancement of critical natural capital stocks that are vital to human welfare. Under this rule, the quantity (and even the value) of aggregate natural capital stocks might be allowed to decline, provided that critical natural capital stocks that provide minimum conditions for human flourishing are protected. We tend to prefer the notion of protecting the value of aggregate natural capital. In all cases, 'green' must be understood to imply much more than just 'low carbon'.

Finally, the connection between the two concepts must be specified. Does 'green growth' refer to the idea that by protecting or enhancing aggregate natural capital, conventionally measured growth would be faster than it otherwise would be? Or at least not slower? Or does it imply that while protecting such natural assets slows conventional growth, it need not halt conventional growth altogether? And are these ideas purported to apply to the short term (several years) or the long term (several decades)? The 'standard' version of green growth holds that there is a trade-off between lower growth in the short run, and higher growth in the long run. But could the 'strong' version of green growth apply, namely that addressing green objectives could increase growth in the short term as well?[4]

[2] A good example is the impact of pollution on morbidity and mortality, where efforts to put a value on quality-adjusted life-years have aroused controversy. Some aspects of the environment are public goods, non-rival in consumption, with personal valuations varying widely. The response of the OECD has been to take a 'dashboard' approach to assessing progress towards green growth, using a multitude of indicators, while also considering how policies have affected the most familiar indicator, GDP (OECD, 2011*b*). Another aspect of the measurement challenge is how to assess sustainability—should that be a separate exercise or should the growth metric attempt to capture the use of non-renewable natural resources itself? Scholars have attempted to account for the use of natural resources and the environment by calculating the depreciation of 'natural capital', allowing them to estimate net national product (Hamilton and Hartwick, 2014; Hamilton and Liu, 2014). This approach has drawbacks, not least in attempting to combine in one figure estimates of many different forms of natural capital, the substitutability of which is uncertain and the valuation of which depends on one's ethical framework.

[3] See papers in the 2014 spring issue of the *Oxford Review of Economic Policy* on 'Wealth', including Hamilton and Hepburn (2014), Hamilton and Hartwick (2014), and Helm (2014).

[4] This latter claim is referred to as the 'strong' version of green growth by Jacobs (2013).

There are various other definitions of green growth that are often a little vague. All definitions typically capture the idea of a growing economy (in terms of the value of goods and services produced) that protects natural assets and resources. For instance, Jacobs (2013) defines it as GDP growth that also achieves 'significant' environmental protection. According to the OECD, 'green growth' means 'fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies' (OECD, 2011*a*). According to the World Bank, green growth is

> growth that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters. (World Bank, 2012)

There are three notable aspects of these 'green growth' definitions. First, they bear some relation to the diffuse notion of 'sustainable development', best understood as the Brundtland Report's definition, 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987). According to the OECD, however, green growth is not merely a more modern update to or a replacement for sustainable development, but rather should be considered as a subset, more narrowly focused on fostering the necessary conditions for 'economic growth consistent with resilient ecosystems' (OECD, 2011*a*). This is contested, as discussed below. The World Bank definition is less explicit about the goal of sustainability, as it does not set out what it means by efficiency or what metric should be used in minimizing adverse impacts over time, but the organization's website at the time of writing makes clear its attachment to the objective of sustainable development.

Both OECD and World Bank definitions of green growth involve more emphasis on growth, and less emphasis on social dimensions, compared with their interpretations of 'sustainable development'. Hence the World Bank has a report on 'inclusive green growth' (as distinct from mere 'green growth'). Stefan Dercon (2014, this issue) explores whether green growth can be pro-poor, or whether there are fundamental trade-offs to be addressed. Similarly, Justin Lin and Jintao Xu (2014, this issue) and Kirit Parikh (2014, this issue) make clear the importance of poverty reduction to national policymakers in developing countries. It would be surprising if the ordering of the objectives were otherwise, given that political incumbents need to deliver increases in material living standards to retain power.

Second, the definitions encompass both natural resource use and environmental impacts, going well beyond a concern solely with climate change. Thus any treatment of green growth has to address the question of the long-run limits to growth and the desirability and feasibility of ever-rising global GDP. Are tough constraints on material throughputs in the production process and the disposal of waste products necessary to deliver green growth?

Third, the definitions of the international institutions are established with a normative purpose. They take it for granted that green growth is good and is an admirable aspiration for a nation state. The design of development and growth policies follows accordingly. The debate about the form such policies should take is reviewed in more depth below, but it is worth noting here that the various proposals advanced to raise the

rate of green growth often entail a move away from *laissez-faire* principles and imply large-scale, persistent, and pervasive collective action at various levels (whether state-led or driven by groups within civil society). That considerably complicates the political economy of green growth.

III. Theory: can 'green' and 'growth' align?

To what extent is green growth, defined as continued GDP growth that preserves aggregate natural capital, possible, and how is it likely to compare with business-as-usual growth? Views vary enormously. Some see the conversion of natural capital into other forms of capital as a central feature of economic growth, and hence regard 'green growth' as a form of growth that is slower and less desirable than conventional growth. Others argue that promoting green growth can improve both environmental performance and economic well-being in the long term, and sometimes even the short run as well. A contrasting argument is that 'green growth' is an oxymoron, because economic growth will inevitably undermine itself by destroying the environmental conditions necessary for its persistence. Both economic and ethical perspectives affect the judgements made.

The foundations for the most pessimistic point of view started to be laid down at least as far back as Jevons' concerns about the UK running out of coal (Jevons, 1866), and were given a boost in the 1970s by authors such as Schumacher (1973) and Meadows (Meadows *et al.*, 1972). A large area of analysis has developed exploring the possibility of 'the steady-state economy' (Daly, 1992), and 'prosperity without growth' (Jackson, 2009). These perspectives tend to claim that the erosion of natural capital and the excessive exploitation of sinks for waste products will ultimately stop growth of welfare in general and ultimately stop GDP growth as well, as manufactured capital will not be able to substitute for these losses.

A less pessimistic view is taken by those who put more weight on the possibilities of decoupling material throughputs from growth of GDP and of substituting manufactured capital and various intangibles (e.g. the stock of knowledge) for natural capital. As Hepburn and Bowen (2013) observe, GDP is not synonymous with material output and there is scope for exploiting the increasing returns associated with some types of knowledge and some public goods to maintain GDP growth in the face of increasing real relative prices of raw materials.[5] The growth of the 'weightless economy' (Coyle, 1998; Quah, 1999) entails a change in the composition of GDP but not necessarily lower conventional growth. A related, but different, concept is that of the 'circular economy' (Pearce and Turner, 1990; Ellen MacArthur Foundation, 2012), in which resources are recycled, waste minimized, and the ecological footprint of economic activity contained. Material loops could in theory be closed while economic value provided in society continues to increase as we go about our lives in different and smarter ways. As Bernanke (2008) pointed out, between 1975 and 2007, the energy required to produce a given

[5] It may be easier to maintain welfare growth than GDP growth as material throughput slows, because of the various goods and services that are omitted from GDP. However, as noted in section II, we prefer a definition of 'green growth' in which 'growth' refers to growth in conventionally measured GDP.

amount of output in the United States fell by about half. Bernanke argued that 'this improvement in energy efficiency is one of the reasons why a given increase in crude oil prices does less damage to the US economy today than it did in the 1970s'. Primary energy consumption in the USA was lower in 2013 than in 2000, despite a 25 per cent increase in real GDP.

Jackson (2009) correctly observes that there is no hard evidence that economic activity and environmental pressure can be comprehensively decoupled in such a manner. However, the historical record of increasing resource use with increasing levels of GDP is not necessarily a guide to the future. Some forms of environmental damage have slowed with increased GDP. Public policies to encourage decoupling have been tried rarely and fitfully, so it is worth investigating whether well-designed policies could achieve the degree of uncoupling needed. And a core feature of any major transformation of the economy is that it moves into unknown territory.

(i) Standard green growth

There are (at least) two variants of the green growth argument. The first 'standard' version of green growth supposes that addressing environmental problems will deliver a short-term reduction in economic growth (compared with a counterfactual) but a higher long-run rate of growth (Jacobs, 2013). This view is illustrated by what might be regarded as the consensus view about the economics of climate change. Both Nordhaus (2008) and Stern *et al.* (2007), for example, argue that it is worth putting up the real relative cost of (currently) carbon-intensive goods and services today and investing more now in low-carbon technologies and R&D in order to reduce expected climate-change impacts and the tail risks of catastrophic climate outcomes. In other words, some sacrifice[6] to material consumption is warranted in the near term to increase potential output over the longer term and reduce downside risks to long-term growth. This view is consistent with the quantitative projections made by large-scale climate-economy modelling teams. These models generally forecast that optimal climate-change policies would lead to a very slightly lower rate of growth of consumption and, in some cases, of GDP over the next 50 years, but that this is more than compensated for by higher expected growth (and in some cases lower-variance growth) over the long term. These projections imply complete decoupling of greenhouse gas emissions from economic growth in time (as new low-carbon technologies kick in), and suggest that appropriately designed policies could preserve the Earth's capacity to act as a carbon sink at an adequate level, while continuing to grow economic output.[7]

However, management of climate change is only one aspect of green growth. Depending on countries' starting points (for example, with respect to endowments of manufactured and natural capital), it may be sensible for policy-makers to increase exploitation of the environment, as Sjak Smulders, Michael Toman, and Cees Withagen (2014, this issue) demonstrate. They point out that it may be optimal for growth to

[6] Short-term costs include higher real energy costs, lower energy productivity, and a raised cost of living, particularly for low-income families, who tend to spend a disproportionate share of their income on energy services.

[7] Some modelling exercises rely on carbon capture and storage or geo-engineering to stabilize the concentration of greenhouse gases in the atmosphere. It is a moot point whether these satisfy the requirements of 'strong sustainability' (Neumayer, 2003).

overshoot the 'green' steady-state growth rate with reversion to that state thereafter. The efficient transition may entail going green slowly, even when the level of environmental degradation is high and irreversible. They also stress the importance of the heterogeneity of natural capital and the need to take adjustment costs seriously when new policies are applied. Natural-resource-augmenting technical innovations are crucial for sustaining growth. Dercon (2014) fears that green growth policies may hinder the alleviation of extreme poverty by slowing developments that have been proved to help the poor. Access to energy, cheap fertilizers, and movement of the rural poor to urban carbon-intensive manufacturing work are examples of poverty-relieving factors that could be inhibited. Hence the short-term welfare costs of temporarily lower growth may be higher than anticipated. Dercon is also concerned about environmental objectives usurping the primacy of poverty alleviation in aid policies.

(ii) Strong green growth

More optimistic still are proponents of what Jacobs (2013) calls the 'strong' version of green growth—the proposition that environmental protection is not merely compatible with continued economic growth, but at a slower rate, but could increase growth compared with the counterfactual in the short term as well as the long term. The strong version depends on one or more of the following propositions (Bowen and Fankhauser, 2011).

First, 'strong' green growth might occur in an economic downturn, if being 'green' requires additional gross investment in low-carbon plant, equipment, and infrastructure, along with more spending on R&D and innovation. This extra investment (by the public or private sector) might boost output in an economy with a deficiency of aggregate demand. This 'green Keynesianism' is subject to the critiques from real business cycle theorists and sceptics about the size of the investment multiplier (see the discussion in Bowen and Stern (2010)). And its relevance is bound to be limited across time and place. For instance, now that economic growth has resumed in many countries, governments tend to be more concerned to reduce public debt/GDP ratios than to increase Keynesian stimuli, while there has been little success yet in persuading the private sector that there are sufficient attractive green investment opportunities to match the increase in *ex ante* private saving associated with deleveraging.

Second, green policies could increase short-run growth by eliminating related market failures. Environmental problems tend to arise when natural capital is incorrectly priced, but they also involve market failures such as sub-optimal levels of R&D, poor provision of infrastructure, slow formation of new networks, and 'short-termism' in the provision of private finance. If these market failures are tackled, according to this argument, there are potential bigger and more immediate gains available. These include reductions in health damage from particulate air pollution, improvements in transport infrastructure, and more general reforms that promote economic efficiency. These reforms could boost growth in the short run, for example, by reducing morbidity, increasing labour force participation, and raising productivity. The Global Commission on the Economy and Climate (2014) claims that these sorts of structural reforms can deliver 'better growth' and 'better climate'. However, delivering these outcomes in practice is difficult, for the usual reasons of political economy and government failure.[8]

[8] On the challenges of political economy, see Collier and Venables (2014).

Moreover, a weakness of the 'correcting other market failures' argument is that it is not always clear why this would stimulate growth over the medium term, as opposed to generating a one-off increase in economic activity.

Third, a Schumpeterian perspective on growth suggests that entrepreneurs' anticipation of the long-run transition to green growth might itself generate short-term innovation and investment as firms try to establish a competitive advantage in the new products and services required. The economic and structural transition required is so large, and dependent on innovation (Aghion *et al.*, 2014), that if the necessary investments in technology were actually made, it is not impossible that shorter-term growth rates could increase. While this may not necessarily enhance welfare in the short run, the argument is that additional economic activity would appear in higher short-run GDP numbers. Having said that, even models focused on endogenous innovation suggest that there could be short-run costs (Aghion *et al.*, 2014).

IV. Roles of the state and the market

The push for 'green growth' leads rapidly to questions about the respective roles of the state and the market in the economy. Specifically, beyond putting a price on environmental externalities, including greenhouse gas emissions, is there a sensible role for the state in promoting collective action to manage the transition to a 'greener economy'?

(i) Horizontal and vertical policies

The issues with respect to green growth are similar to those raised by more general debates about public intervention in markets. These have been discussed, for instance, in the literature on industrial policy (e.g. Weiss, 2011; Mayhew, 2013).[9] As Mayhew (2013) points out, economists have tended to have a preference for horizontal industrial policies—that is, policies that affect all firms across the economy, as opposed to vertical policies that apply to specific firms. The most obvious equivalent set of horizontal policies for green growth are, again, simply about 'getting prices right' by imposing Pigovian taxes and subsidies to internalize the external environmental costs.

However, some environmental problems are more difficult to tackle in this horizontal fashion, because adverse impacts vary widely by time and location or because the physical processes involved are difficult to model. Optimal taxes and subsidies would vary with firm characteristics and other variables, some of them not easily observed—the same price for all players would be inappropriate, because the goods or bads being produced have different values. One response to this is to keep things simple and uniform and at least 'get prices less wrong', even if first best prices are not practical or are undesirable because they would leave the government prone to gaming.[10]

[9] One difference, however, is that environmental policies are often designed to affect households' behaviour directly as well as that of firms.

[10] Policy-makers also have to be aware of the difficulties of Pigovian pricing in a second-best world (Lipsey and Lancaster, 1956–1957)—for example, if there is widespread market power among energy suppliers or if some jurisdictions disagree about underlying valuations of environmental impacts.

(ii) Industrial policy

However, this might not be enough. Addressing some environmental challenges such as climate change will require a system-wide transition built upon substantial research and development, innovation, and the deployment of a completely new set of infrastructures (Aghion *et al.*, 2014). Some have therefore argued that, in addition to relatively market-friendly policy instruments such as taxes and subsidies, policy is required to raise rates of innovation and to direct inventors' and entrepreneurs' energies towards reducing exploitation of natural capital (Rodrik, 2014, this issue). Innovation is seen as central to reducing the costs of 'going green', thus allowing the transition to green growth to be faster and cheaper. It also drives the creation of new sources of comparative advantage. This perspective is consistent with the neo-Schumpeterian arguments promoting green industrial policy to initiate a burst of competitive investment in low-carbon production. But horizontal innovation policies are difficult, if not impossible to find. Choices about which technologies to support need to be made.

Daron Acemoglu, Philippe Aghion, and David Hémous (2014, this issue) argue that industrial policy is required to work against the 'lock-in' of dirty technologies embodied in the capital stock that is reinforced by path-dependent technological progress. The transition to green growth requires not just general support for innovation but also targeted support for green innovation. Industrial policy in this case has to have 'vertical' elements, focused on, for example, promoting low-carbon technologies that are not yet cost effective without some government intervention and on transforming productive processes in the sectors most responsible for environmental damages. The system-wide nature of energy, resource, and land-use choices, it is said, requires a more holistic approach to policy reform than provided by green taxation alone. That in turn requires collective judgements about certain broad features of the future structure of the economy—not so much the 'picking winners' that has been decried in analyses of past industrial policy, as picking broad paths of development. In particular, future paths ought to be consistent with more environmentally sustainable growth. Experimentation is necessary along the way because the pay-offs to support for innovation are likely to be skewed. Rodrik (2014) points out that good industrial policy must tolerate some failures—appropriate risk taking inevitably implies that failures will occur. A portfolio approach to support for innovation should be adopted, so industrial policy, while necessarily not horizontal, should be as broadly targeted as possible.

Yet this perspective gives rise to its own questions, such as how to avoid the informational inadequacies, the failures to take the appropriate collective action, and the rent-seeking associated all too often with the industrial policies actually implemented in the past. The political economy of policies for growth matters. Mayhew (2013) argues that the political climate may be more conducive to vertical industrial policy at the moment, partly as a result of the recent global financial crisis and recession. These have tended to bring the merits of 'light touch' regulation and *laissez-faire* into question, while fiscal austerity has led politicians to seek to narrow the focus of any interventions, targeting subsidies more closely and finding ways to claw back rents created by horizontal policies.

(iii) Country differentiation and experimentation

The papers in this issue suggest that the political economy of growth differs markedly across countries, depending on (among other factors) level of income per head, endowment of natural resources, the credibility of governments' policy commitments,

the governance of public agencies, and the extent of competition in markets (see the papers by Lin and Xu, Parikh, and Dercon). The likelihood of a transition to green growth in the near term varies across countries, and the form it takes would also be expected to vary. In one country, policies may be implemented 'top down' by conventional instruments such as taxes, subsidies, and regulation, or by less conventional ones such as buy-outs of polluting firms. In another, the direction might be developed by social experimentation, perhaps triggered by lawsuits, public protest, and other actions by civil society, including debate and ethical example. Optimal policies in this setting are difficult to define much in advance. Policies are likely to be revised in the light of experience and emerging evidence, and the risk is that governments fail in this process to preserve their credibility and to minimize adjustment costs.

The fact that trial and error, monitoring, and learning are necessary does not sit comfortably with the fact that a change in course in several environmental areas is now urgently needed. To contain the global mean temperature increase since pre-industrial times below 2°C, global greenhouse gas emissions ought to peak in the very near future and then decline at around 5 per cent per year until 2050 (Arnell *et al.*, 2013), and even then some 'net negative' emissions will be required. Yet emissions from fossil fuels have accelerated since 2009 and are running at well above the average rate of the 1990s.

Given the urgency, it would be helpful for major economies to increase the pace of experimentation with green growth policies now and evaluate them rigorously, so that others have successful models to follow. While the advanced industrial economies can best afford to shoulder the risks to conventional growth, Lin and Xu and Parikh show that China and India are also experimenting with greener policies as complements to continued fossil-fuelled expansion. Different countries are trialling different aspects of policies, with the EU an early adopter of cap-and-trade to limit greenhouse gas emissions, China and the Republic of Korea in increasing green research and development, Costa Rica in re-afforestation and biodiversity. The variable pace of policy change is unlikely to guarantee cost-effective environmental action across countries where environmental problems are transnational in nature, so it will be important for lessons learnt to be disseminated widely and quickly, for instance through the international development banks, the IMF, and OECD.

(iv) Political economy of vested interests

In all countries, a key aspect of the political economy of green growth is the damage to the interests of the owners of fossil resources. A large proportion of fossil fuel reserves booked by firms and governments will have to be kept in the ground (or sequestered back underground after combustion) to avoid mean temperature increases of above 2°C. And this is not to mention all the fossil resources (a wider concept than reserves) that must also remain underground. It may be difficult to reconcile the current market value of some fossil fuel companies with this observation (see Carbon Tracker, 2013). Concentrated vested interests in a few sectors can often obstruct policy initiatives, while collective action across many countries to achieve a broadly comparable carbon price worldwide is very difficult to achieve. Politicians representing areas with a high dependence on carbon are likely to be resistant to strong measures against climate change (see Cragg and Kahn (2009) for US evidence). Paul Collier and Anthony Venables (2014, this issue) propose a strategy for tackling this problem head-on with respect to coal: a

direct supply-side policy to close down the global coal industry step by step, through a combination of compensation and moral suasion. Questions remain about how expensive this would be and how owners of other fossil fuel stocks would react. It may be that policies that address both the supply-side and demand-side measures simultaneously (such as carbon pricing) would be more effective than either approach by itself. However, it is difficult to escape the conclusion that collective action across all major emitters will be required for both supply- and demand-side policies, and that the politics is critical.

(v) Distributional implications

One vitally important element of the political economy of green growth is the distributional implications of the kind of structural transformation that is envisaged. Dercon (2014) raises concerns about the impact on the poor of the current generation. Similar worries in a more attenuated form have been expressed about the impact of carbon pricing on income distribution in the advanced industrial countries (see, for example, Gough *et al.* (2011), Advani *et al.* (2013)). While carbon pricing by itself is not necessarily regressive (Sterner, 2011), low-carbon energy policies may nevertheless restrict access of the poor to energy services in the absence of mitigating national policy or climate-related financial transfers at the international level.

At the national level, if any mitigating policy is put in place, it is unlikely to resemble theoretical lump-sum transfers. Energy use varies greatly even within income classes in the same country because of differences in household composition and the quality of the housing stock, so the lump sums required would be highly variable. At the international level, current arguments between countries suggest that transfers may be even more difficult. Dercon concludes that 'development aid, earmarked for the poorest countries, should only selectively pay attention to climate change, and remain focused on fighting current poverty reduction, including via economic growth'. His emphasis on prioritizing conventional growth echoes the argument of Smulders *et al.* (2014) that, depending on countries' initial endowments, it may be desirable to build up manufactured capital at the expense of environmental capital. But Dercon's argument also rests on the assessment that adequate additional funding from rich countries will not be forthcoming to undertake cheap mitigation opportunities in developing countries—therefore the aid that is available should give priority to poverty alleviation.

(vi) Transitional considerations

One role for the state is to attempt to mitigate the negative short-run consequences of the transition to green growth. Such a major transition implies a rupture with the past, with potential societal costs that governments may want to mitigate. For instance, a Schumpeterian 'investment mania' might develop into new, risky, clean technologies, as with canals and railways in the nineteenth century and dotcoms in the late twentieth, with the risk of subsequent financial crashes.[11] Even if the transition is steadier, it will inevitably

[11] A Schumpeterian business cycle might also undermine the deliberate and credible long-term policies that are likely to be required to develop cleaner technologies (as seen with the sharp reductions in subsidies for renewable energy in several European countries recently; see the discussion in Time (2012) and EC (2013)).

involve some industries going out of business and new industries emerging. Projections of the benefits of policy-induced structural transformation should be weighed against the inevitable costs, such as the destruction of the economic value of newly obsolescent capital ('stranded assets'), retraining, relocation, and job-search costs for workers, and the dislocation of communities based on the exploitation of fossil fuels (e.g. Polish mining towns, Tanzanian charcoal burners). There is a role for good policy in minimizing the damage of these structural transitions associated with dealing with large-scale market failures.

(vii) Counter-cyclical green policies

As noted above, supporters of 'strong' green growth may hold that the state should make opportunistic use of low factor utilization in downturns to increase public investment (rather than consumption) on the transition to low-carbon technologies and products (Bowen and Stern, 2010). The focus would be upon public investment that the private sector by itself is likely to under-provide at any time (e.g. transport infrastructure). However, there are several criticisms of this approach. Governments may find it difficult in practice to ensure that public investment spending is directed to the 'right' projects, and that spending takes place according to the planned timeline—projects often turn out not to be as 'shovel ready' as expected. Other goals, particularly job creation, may be temporarily elevated further above environmental goals so that the objective of green growth is demoted.

(viii) Summary

The role of the state in a 'green growth' transition goes beyond internalizing externalities to get prices that are less wrong. The transformation is large, system-wide, and structural, so at the least the state must also provide overall strategic direction. Innovation is at the centre of the process, and the well-understood positive externalities imply another role of the state that, unfortunately, cannot be fulfilled just through the price system. While supporting innovation in general, through the patent system for instance, is an important government function, there also an argument for preferential support to cleaner, rather than dirty, innovation, because of path dependency, lock-in, and system-wide effects. However, problems of asymmetric information and a chequered track record of central government—notwithstanding that some failure is inevitable and indeed *ex ante* optimal—suggests that investment choices should be made in as decentralized way as possible and public intervention should follow the principle of subsidiarity. Finally, the state arguably has a role to play in managing the distributional implications and smoothing transitional shocks. In short, achieving economic growth that protects natural capital will almost certainly not occur without an important role for the state.

V. Conclusion

While the concept of green growth has existed for around 25 years, its definition varies from institution to institution and is often vague. In this paper, we have preferred the idea of the continuation of GDP growth while aggregate natural capital is preserved.

In theory, there is no reason for green growth to be impossible. However, it is undeniable that in practice at present the two objectives—additional GDP growth and the protection of natural capital—are often but not always at odds with each other. Whether we will in practice manage the transition to green growth remains to be seen. It may be one of the most important economic questions of this century.

What is required is little less than a transformation in current modes of production and consumption. But it does not necessarily follow from this that the state needs to become highly interventionist. Large changes can occur from a small number of well-specified policies, such as a carbon price. Indeed, green growth requires the state to intervene to correct a small number of very significant market failures. But first-best solutions from the economist's textbook are likely to be difficult to design and inadequate in practice. Policy experimentation is needed, with more rigorous *ex post* evaluation and, where successful, rapid dissemination of the results.

Addressing major systemic environmental problems like climate change and biodiversity also demands that the state set a clear strategic direction, as in other policy areas. Whether the role of the state goes beyond sorting out the prices and setting the overall direction is debatable. Collective action is required at several scales, not least international, raising demanding problems of governance. Asymmetric information poses serious challenges. Greater innovation would appear essential to keeping the costs of transformation down, which is in turn required for green growth to be politically attractive. But direct support for clean innovation is both questioned in theory and difficult in practice, because politicians hate 'failures' despite their inevitability.

Extending further, social policies are likely to be required to help compensate potential losers, especially powerful losers, if the structural transformation is to occur. And the least well-off losers arguably have a greater claim to support. Developed economies will want to reduce the labour market disruption and other costs of the induced structural adjustment.

A growth model where environmental problems are addressed and aggregate natural capital is preserved is likely to imply a world in which the structures of economies and societies are very different than under 'business as usual'. Moving to such a model does not necessarily imply that, in the near term, people would experience a rapid change in their lifestyles and consumption possibilities. But if green growth does occur, one might reasonably expect human civilization to look rather better in 2050 than it otherwise would. The industrial revolutions of the past also often transformed the world gradually, but with profound consequences. Time will tell whether we are on the cusp of another such transformation.

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