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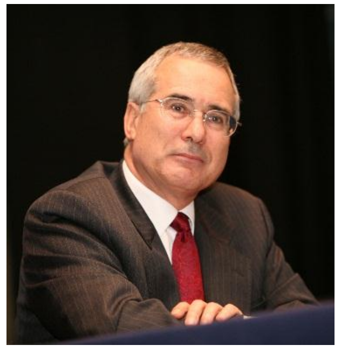
Mr. Fergus Green and Mr. Nicholas Stern



Mr. Nicholas Stern

President of the British Academy; IG Patel Professor of Economics and Government, London School of Economics and Political Science

Member of the Council, Phase V

Since 2007, Lord Nicholas Stern has served as IG Patel Professor of Economics and Government at London School of Economics and Political Science, Chairman of LSE's Asia Research Center, and Chairman of LSE's Grantham Research Institute on Climate Change and the Environment. In July 2012 he was elected President of the British Academy, which becomes effective in July of 2013.

Previously, Lord Stern has held such posts as Head of the Government Economic Service from 2003 to 2007, Second Permanent Secretary to Her Majesty's Treasury from 2003 to 2005, and Director of Policy and Research for the Prime Minister's Commission for Africa, from 2004 to 2005. He also led the Stern Review on the Economics of Climate Change from 2005 to 2006. From 2000 to 2003, he was the World Bank Chief Economist and Senior Vice President of Development Economics. From 1994 until late 1999, he served as the Chief Economist and Special Counsellor to the President European Bank for Reconstruction and Development.

Before 1994, Lord Stern taught and conducted research at a number of universities around the world. He was knighted for 'services to economics' in June 2004.

China Council for International Cooperation on Environment and Development

Towards Sustainable Growth for China: Domestic Reform and International Cooperation

Mr. Fergus Green and Mr. Nicholas Stern

CCICED Council member

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Centre for Climate Change Economics and Policy
Grantham Research Institute on Climate Change and the Environment
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The Authors

Fergus Green is a Policy Analyst and Research Advisor to Professor Stern at the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science and at the Centre for Climate Change Economics and Policy.

Nicholas Stern is the I.G. Patel Professor of Economics & Government and Chair of the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science and Chair of the Centre for Climate Change Economics and Policy.

Notes and acknowledgements

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Towards Sustainable Growth for China: Domestic Reform and International Cooperation

1. China's Growth Path and Global Climate Change: A Critical Decade; A Decisive Year

China's new development model

President Xi has remarked that China's current model of economic development is "unbalanced, uncoordinated and unsustainable"[1] and China's leadership has signalled its intention to "accelerate the transformation of the growth model, … make China an *innovative* country" and "promote more *efficient*, *equal* and *sustainable economic development*" (CCCPC 2013, emphasis added; see also Zhang 2014). Indeed, achieving this structural transformation will be essential for China's long-term economic prospects in a world that is increasingly natural resource-constrained, efficiency-focused, globalised and concerned with inequality.

China has already shown the world how quickly it can change. In the past 30 years, China's gross domestic product (GDP) grew at around 10% per year on average,[2] hundreds of millions of people were lifted out of poverty, and China's urban population grew by half a billion people.[3] This growth has been an extraordinary achievement. But it has been unequal, and has come at great cost to China's environment and the natural resources on which its population depends. Current patterns of urbanisation, structures of governance, and fiscal arrangements are locking in polluting and inefficient physical infrastructure and unsustainable social patterns that will be difficult and costly to alter.

Two great transformations

China will need to address these challenges in the context of an extraordinary structural transformation in its economy and society. In the next decade, it is likely that economic growth will lead to a doubling of China's GDP (associated with a 7% p.a. growth rate), and another 350 million residents will be added to China's cities, placing great pressures on city infrastructure, energy systems and land-use patterns (MGI 2009). It is thus a critical decade; a decade that will effectively determine whether and how China will realise the sustainable development model to which it aspires. Within this decade, the next year is decisive: the decisions China makes as it develops its 13th Five Year Plan (2016–2020) will have a powerful influence on the actions it takes in the next decade.

The world must also accelerate a second great structural transformation — toward a zero carbon economy within this century — if it is to manage the grave risks of climate change effectively.[4] In the

[1] The remarks were made in President Xi's address to the CPC Central Committee at its Third Plenum in November 2013 (see The Economist 2013).
[2] China's average annual GDP Growth (current USD) in each of the three decades from 1980 was 9.75%, 9.99%, and 10.29%, respectively (World Bank 2013).
[3] Between 1978 and 2012, China's urban population "increased by more than half a billion people" (World Bank/DRC 2014, Supporting Report 1, p 88).
[4] Scenarios associated with stabilizing GHGs at levels that would give a >50% chance of holding warming to within 2 ℃ above pre-industrial levels entail reducing emissions to roughly zero by the end of this century;

context of a growing global economy, emissions per unit of output will need to fall by a factor of 7 or 8 over the next four decades.[5] Change on this scale implies a new "energy industrial revolution" involving transformative, innovation-led growth and discovery (Stern 2014). And China, whose annual CO_2 emissions have grown to more than one quarter of the global total, will be central to this great transformation, too[6] — and it is already showing leadership.[7]

On climate change, the world also finds itself at the start of a critical decade and a decisive year. Due to the "ratchet effect" by which annual flows of greenhouse gas (GHG) emissions add to the existing concentrations in the atmosphere, and due to the lock-in of emissions-intensive capital and infrastructure, the actions taken by the world in the next decade will effectively determine whether we succeed. And the forthcoming Paris climate change conference in December 2015 will set the pace for global emissions reductions in the next decade and beyond. This crucial period of global climate discussions will conclude around the time that China is likely to be finalising its 13th Five Year Plan.[8]

This extraordinary confluence of two great transformations — China's next wave of structural changes and reforms, and the low-carbon transition — provides China's new cohort of leaders[9] with an historic opportunity to tackle both challenges together, laying the structural foundations for environmentally and climatically sustainable growth and prosperity.

The historic opportunity for countries at all income levels to tackle together the global equivalents of these two transformations was a key theme of the report, *Better Growth, Better Climate* (GCEC 2014), produced by the Global Commission on the Economy and Climate, which is chaired by the former President of Mexico, Felipe Calderon, and Co-Chaired by Stern. *The Better Growth, Better Climate* report (Global Report), released in September 2014, was greatly assisted by strong input from Chinese researchers and policymakers — the Commission itself included two Chinese members, Chen Yuan and Zhu Levin, and Tsinghua University was one of eight associated research partners. A separate China Report was also prepared by Tsinghua University that applied the themes from the Global Report to China. Accordingly, the present paper reflects a number of the insights from both the Global and China reports (though all references here are to the Global Report).

Structure of this paper

The paper is structured as follows. Part 2 sets out a framework for simultaneously fostering strong, high quality growth in the short-medium term and tackling the long-term challenge of climate change.

"likely" scenarios for staying within 2 ℃ (>66% chance) require zero emissions *before* the end of the century (IPCC 2014).

[5] Supposing world output were to grow by a factor of three over the period 2013 to 2050, if total emissions need to be cut by a factor of around 2.5 by 2050 (on one plausible pathway to a 50-50 chance of 2 ℃: Bowen and Ranger 2009) then emissions per unit of output would have to be cut by a factor of 2.5 x 3 = 7.5 by 2050.

[6] China emitted 28% (~10GT) of total global CO_2 emissions from fossil fuels and cement in 2013 (Global Carbon Project 2014). Assuming non-CO_2 GHG emissions are about 17% of CO_2 emissions (as they were in 2011: see WRI 2014) we can infer that China's CO_2e emissions would have been roughly 11.7GT in 2013, meaning they are likely to have exceeded 12GT in 2014.

[7] See Green and Stern (2014) Part 5; NDRC (2013); and GCEC (2014) for examples.

[8] China's 12th Five Year Plan (2011–2015) was debated by the party leadership at the fifth plenary session of the 17th Central Committee of the Communist Party of China (CPC) in late 2010 and approved by the National People's Congress on 14 March 2011.

[9] President Xi Jinping and Premier Li Keqiang began their period in office in March 2013.

Part 3 then highlights four key areas for domestic reform and international cooperation: (a) cities; (b) innovation, especially in zero carbon energy technologies; (c) finance and the cost of capital for infrastructure; and (d) carbon pricing, particularly coal taxation and international cooperation to phase-out unabated coal. Part 4 concludes.

2. A Framework for Better Growth and a Better Climate

A useful framework for thinking about structural change for better growth and a better climate involves promoting investment in three "key drivers of change" — resource productivity, green (low-carbon and climate-resilient) infrastructure, and innovation — across the three critical systems of cities, energy and land-use (GCEC 2014). This will require specific institutions, policies and investments focused on these drivers and systems, along with international cooperation and domestically-appropriate carbon pricing, which will play a supportive, cross-cutting role (see Appendix).

To illustrate this framework, let us consider how a continued and accelerated shift toward innovative, green industries, particularly in low-carbon energy technologies and associated networks, with widespread deployment within China, could help deliver *strong growth*, *higher quality growth*, and *large emissions reductions* at the same time.

Strong growth

China has had rapid growth with a high savings/investment rate over the past three decades. In broad macroeconomic terms, the aim of China's structural transformation is to maintain high, if somewhat lower, rates of economic growth (above 7% GDP/year) while reducing its savings/investment rate and growing its consumption share of GDP (12FYP; CCCPC 2013).

One way of expressing the challenge of increasing the share of consumption while maintaining growth is that China should be seeking to increase the efficiency of capital as it reduces its investment rate (Stern 2011; Green and Stern 2014).[10] This pertains to the first driver of change: resource efficiency. And one way of increasing the efficiency of capital is to reallocate capital away from lower value-added heavy industries and toward higher value-added, innovative industries.[11] In this regard, China is championing seven "strategic emerging industries", three of which — "energy efficient and environmental technologies", "new energy", and "new-energy vehicles" — are explicitly "green", and the remainder of which will be critical to the green economy.[12] If the government's targets for

[10] That is, China should be looking to lower its incremental capital output ratio (ICOR). See Green and Stern (2014) Part 2 for discussion.

[11] Other ways are discussed in Green and Stern (2014) Part 2. Most significantly, they include structural change towards industries with a lower capital requirement, especially towards services. Investments in the energy efficiency and environmental services sectors, in particular, would yield a "double dividend" for productivity, since not only is that sector itself likely to use capital more efficiently than the current average, but it will also help *other* industries use energy and other natural resources more efficiently. See Green and Stern (2014) Parts 2 and 3(a) for discussion.

[12] The remaining four industries are: information technology; biotechnology; advanced equipment manufacture; and new materials. The important role of these industries in a green economy is discussed in Perez (2010, 2013) and GCEC (2014).

expanding these seven industries can be achieved,[13] then China's capital allocation should become more efficient, on the assumption that these modern industries make efficient use of capital and are "less heavy" than the average of existing activities.

Investments in innovative, green industries, and in the domestic deployment of the infrastructure they produce, will also help China achieve sustainably strong growth in the medium-long through the infrastructure and innovation channels of the growth framework outlined above. Two effects of clean technology innovation are important in this regard.

First, clean technology innovation can bring strong returns in the form of dynamic cost reductions in energy infrastructure/systems. These investments will likely help clean technologies gain sustained price advantages over higher-carbon incumbents, thereby increasing energy productivity and growth over the medium-long term (GCEC 2014; Aghion et al. 2014). China has already helped to drive large price reductions for solar photovoltaics (PV) and onshore wind and it has established major shares in the global markets for these technologies (Bazilian et al. 2012; GCEC 2014). These cost reductions have helped to make clean energy technologies cost-competitive with fossil fuel incumbents in many parts of the world (GCEC 2014).

The benefits to growth for China of renewable energy infrastructure relative to fossil fuel-based generation infrastructure could be particularly high when considering full lifecycle costs, including fuel costs, given China's increasing reliance on fossil fuel imports. Consider the energy security challenges associated with China's coal use. Were China's coal demand to grow at or around the average rate experienced over the last decade, then China would become increasingly reliant on coal imports, and increasingly exposed to international coal price rises — which, owing to China's size in the coal market, could become acute as China's domestic production peaks — and to coal price volatility (Wang et. al. 2014). Such exposure would prove costly and disruptive to China.[14] Increased renewable energy deployment in China, among other things, is contributing to the recent deceleration of China's coal demand (Garnaut 2014), meaning that such costs and disruptions could be mitigated.

The second likely growth-enhancing effect of clean technology innovation in China is in the form of knowledge spillovers. All innovation produces knowledge spillovers into other sectors of the economy, as new knowledge is applied to yet further innovation. There is evidence that suggests the knowledge spillovers from green innovation are likely to be higher for clean technologies.[15] In other words the infrastructure and technologies developed and diffused through today's green policies and investments (e.g. decentralised renewables, battery storage, electric vehicles, smart electricity grids, the internet of things, etc.) are likely to spur yet further innovation and growth in related families of technologies and services. As Aghion and colleagues (2014) point out: "The importance of this effect cannot be underestimated". Moreover, there is evidence to suggest that a high proportion of such spillovers are captured within the country of the original innovation (Dechezleprêtre et al. 2013); Dechezleprêtre and

[13] The Government has set targets for the growth of the contribution of these emerging industries to China's GDP: the industries are expected to grow 20% each year from a base of around 2% of GDP in 2010 to 8% by 2015 and 15% by 2020 (State Council 2012).
[14] See Green and Stern (2014) Part 3c for discussion.
[15] Using data on 1 million patents and 3 million citations, Dechezleprêtre et al. (2013) find that spillovers from green innovation are over 40% greater than in conventional technologies (in the energy production and transportation sectors).

Glachant 2014), meaning China can be confident that local knowledge spillovers from green innovation will be significant.

Better quality growth

Strong investments in the three drivers of change across cities, energy systems and land-use will also bring growth that is of a higher quality — in the form of reduced local air, water and land pollution, less congestion and waste, and improved human health and well-being — an important aim of China's new development model.

To illustrate, focusing again on clean energy innovation and infrastructure, consider the benefits that low-carbon substitutes for coal-fired power generation would bring to China through reduced air pollution. The mortality impacts of PM2.5 pollution exposure in China, a large portion of which come from coal use, have been estimated at 9.7-13.2% of China's GDP in 2010 (Hamilton 2014). Local air pollution also has a longer-term effect on growth, by driving away the talented entrepreneurs and globally mobile professionals, from both China and abroad, who will be increasingly important to the service-driven, high-value-added growth model to which China aspires. All of these impacts have become clearer in recent years as a result of better data.

Accordingly, measures to peak and phase out coal and to increase the share of low-carbon generation within China's energy mix (alongside energy efficiency and electricity grid improvements) would dramatically reduce the health and environmental costs of air pollution and help to cultivate the attractive, people-centred cities that will drive China's sustainable economic transformation.

Climate change mitigation

The same policies and investments in clean energy innovation and infrastructure deployment that will be good for the quality and quantity of China's growth will also be good for global climate mitigation (which will have yet further benefits for China's long-term growth in the form of reduced exposure to climate risks/damages). Three effects of these policies and investments on GHG emissions are likely to be important.

First, the accelerated deployment of clean energy infrastructure (alongside other measures) will increasingly displace coal in China's energy mix, with the potential to contribute strongly to future Chinese emissions reductions (Garnaut 2014; Teng and Jotzo 2014; Green and Stern 2014). This is of global significance, since China's coal use is a major source of the world's GHG emissions: around one fifth of the world's CO_2 emissions from fossil fuel combustion in 2011 came from Chinese coal.[16] Should China's coal use continue to grow into the 2020s, it will be extremely difficult for the world to hold to <2 ℃ warming.[17]

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[16] In 2011, coal was responsible for more than 80% of China's 8GT of CO_2 emissions from fossil fuel combustion, which were in turn around a quarter of the *world's* fossil fuel combustion CO_2 emissions (IEA 2013a). See Green and Stern (2014) p 23.

[17] To illustrate, Bowen and Ranger (2009) calculate that the available 2030 global budget is around 32-33GTCO_2e on a mitigation scenario for a 50-50 chance of holding to 2 ℃. China's emissions levels were more than 10GTCO_2e in 2011 (WRI 2014). As explained by Stern (2012), if China is at 15GTCO_2e in 2030 — a conservative assumption based on post-2000 emissions growth rates — that would "leave" around 15-16GT for the remaining 7 billion people projected to be on the planet in 2030, or just over 2 tonnes per capita (excluding

Second, Chinese clean energy innovation, across the innovation chain, will have global climate benefits in the form of both knowledge spillovers and "learning by doing", contributing to global technology price declines that make clean technologies more economically attractive globally (as well as in China, as discussed earlier). China's role in global solar PV and onshore wind markets has already significantly driven down global prices for these technologies, with global climate mitigation benefits (Grau et al. 2012; Wang, Qin and Lewis 2012).

Third, high ambition from China on clean energy innovation and infrastructure deployment of the kind discussed above, combined with wider measures to peak and phase-out coal, could help to foster higher-ambition climate mitigation from other developed and emerging economies. This dynamic effect could dramatically improve the payoffs to China of high ambition on climate change through both further global reductions in climate risks, and deeper markets for China's low-carbon technology exports.[18] As China develops its plans in this regard, communicating these clearly to other countries could play an important role in generating higher ambition from other countries in the lead up to the Paris climate conference.

3. Four key areas of Focus for Domestic Reform and International Cooperation

Here we explore the domestic policy and institutional reforms, and associated international cooperation, across four critical areas of policy for achieving strong and better growth and a better climate.

a) Cities

The urban form and transport infrastructure of cities are extremely long-lived assets that create very long-term "path-dependencies" with respect to land-use, transportation, and resource utilisation (Rode and Floater 2013; MGI 2009). Given the extraordinary urbanisation that will occur in China in the coming 10-15 years,[19] the urban planning decisions, and associated policy and investment choices, China makes today and over the next decade will have long-lasting implications for growth, productivity, GHG emissions, pollution, amenity and social welfare. As the effects of climate change increase, putting pressure on already scarce resources like freshwater, affecting food production, raising sea levels and worsening natural disasters, it will be critical that China's cities are also built to be resilient to these effects.

Achieving sustainable growth in China's cities will require domestic reforms with regard to city planning and city-level governance and finance. First, China's city planning will need to be based on a

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China, world emissions per capita in 2012 were a little over 7 tonnes). But the much more likely outcome is that the global budget would be exceeded and the world would move experience still more dangerous warming (Stern 2012). The New Climate Economy report uses a core mitigation scenario involving reductions to 42GTCO_2e by 2030, based on the IPCC's median scenario for a 66% chance of holding to 2°C, which assumes much steeper reductions after 2030 and the application of negative emissions technologies in the second half of this century (see GCEC 2014 and IPCC 2014). Even for this more lenient (pre-2030) 2 ℃ scenario, emissions in China of 15GTCO_2e in 2030 would be 36% of the 42GT level.

[18] See Green and Stern (2014) Part 5 for discussion. See also Ward et al. (2012).

[19] By 2025, it is expected that China's cities will be home to nearly one billion people, with another 350 million urban residents relative to 2010 levels, and produce over 90% of China's GDP (MGI 2009).

model of spatially compact, medium/high density cities, tightly linked by mass transit systems (Rode and Floater 2013; GCEC 2014). Further planning elements will be needed to make China's cities "people-centred" (see Chen et al. 2008; UCI 2013). For China, this phrase connotes an emphasis on the provision of essential public services, particularly education and healthcare, and residential registration (hukou) reform (Xinhua 2014a, 2014b; CCCPC 2013). To be comprehensively people-centred, cities must also build strong communities and contain other attractive features, including public green spaces, attractive streetscapes, low pollution levels, safe walking and cycling infrastructure, accessibility to employment opportunities, and facilities for social and cultural interaction (see, e.g., Gehl 2014; GCEC 2014). China has acknowledged the need to move strongly in this direction (see, e.g., Xinhua 2014a; World Bank/DRC 2014).

Existing fiscal and governance structures at the city level, which rely too heavily on land conversion and land financing, are perversely incentivising unsustainable urban sprawl (World Bank/DRC 2014). In order to provide high quality public services to existing and new urban residents, to invest in sustainable infrastructure, and to incentivise sustainable spatial development, fiscal and governance reform is urgently needed at the local/city level (World Bank/DRC 2014). Two key fiscal reforms could help in this regard: a broad-based property tax (which would also lay the foundations for a viable local government bond market to help raise finance for urban infrastructure investment); and fiscal measures to internalise the costs of local urban externalities, particularly those associated with transport (e.g. congestion) (Green and Stern 2014; GCEC 2014). Respectively, these measures could raise revenue in the order of 1-1.5% and 0.5% of China's GDP (Green and Stern 2014).

There is increasing scope for international cooperation among city governments, too. Organisations such as the C40 cities network are playing a valuable role in spreading knowledge and good practice on sustainable and low-carbon urbanisation across many of the world's largest cities, and they are increasingly facilitating collaborative projects among members (C40/Arup 2014).[20]

b) Clean Energy Innovation

As discussed in Part 2, innovation in clean energy will enable China to build a low-carbon economic model with strong and high quality growth. Here, we suggest some policy measures and institutions that China could take to foster innovation in clean energy (and in other "green" areas).

By innovation, we mean the full innovation chain, from basic and applied research, through to development, demonstration, and deployment of new products and technologies — and also new services and process. Innovation in general is hampered by market failures along the innovation chain.[21] *Low-carbon* innovation is further undermined by its particularly high capital requirements

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[20] In China, Beijing, Hong Kong, Shanghai, Shenzhen and Wuhan are members of C40 cities (see http://www.c40.org/cities).

[21] These include: positive externalities; public goods aspects of knowledge/technology; imperfections in capital markets and risk-sharing; network infrastructure; and coordination problems. The problems associated with underinvestment can become more acute as technologies proceed into development, demonstration and early scale commercial deployment, just as the need for capital increases — the so-called "valley of death".

(especially for low-carbon energy generation) and by the mispricing of many existing goods and services central to climate change (especially the under-pricing of GHG emissions[22]).[23]

To induce low-carbon innovation, it is therefore important to introduce a range of broad and targeted policies, and to get the policy mix right. Theory (Acemoglu et al. 2012), modelling (Fischer 2008; Fischer & Newell 2008) and empirical evidence (Popp 2006) show that an effective and efficient low-carbon innovation strategy would combine two complementary sets of policy instruments:

- one policy, or set of policies, to price, and/or regulate for, the GHG externality and other environmental externalities associated with fossil fuels (this is discussed in the next section); and
- another set of policies and institutions to target each link in the innovation chain (discussed in the remainder of this section).

China's current strengths lie in the final part of the innovation chain: adapting and improving on technologies developed overseas, and achieving cost reductions through deployment at scale and incremental manufacturing and process innovation (Zhi et al. 2013), which it fosters through a wide range of support mechanisms across these areas (CPI 2013). This approach has achieved real successes (Zhi et al. 2013), particularly in solar PV, wind, and high-speed rail.

As China's industrial structure evolves in line with its aspirations for higher value-added, high technology industries, and its skills advance relative to others, China will increasingly need to move towards the middle and first parts of the innovation chain, combining its later-stage deployment policies with a stronger "upstream" focus on R&D, and on demonstration and early stage deployment (Green and Stern 2014; Grau et al. 2012).

The case for China focusing increasingly on the middle part of the innovation chain is strengthened by the urgent need — globally and in China — to bring down the costs of technologies with a high-potential for both cost reductions and emissions reductions, so as to enable competitively priced emissions cuts over the medium-long term (IEA 2012b). These include: solar PV technologies; concentrating solar power technologies; battery storage; electric vehicles; and the associated network infrastructure (enhanced electricity grids and vehicle charging infrastructure) (IEA 2012b, 2013b; Grau et al. 2012). The size of China's internal market gives it a special — arguably unparalleled — advantage of scale and, therefore, a critical role in the global effort to scale-up these technologies and bring down their costs. Two types of government support for the deployment of these technologies (in addition to carbon pricing) will continue to be important policy and institutional levers: "market pull" mechanisms such as feed-in tariffs; and financial support through China's state banking network for innovative firms and for clean energy infrastructure projects (Green and Stern 2014; GCEC 2014; Mazzucato 2013).

[22] In addition to the under-pricing of GHG emissions, these include the mispricing of: natural capital and ecosystem services; energy (in)security; worker health and safety issues associated with fossil fuels; public health impacts of fossil fuels (especially air and water pollution); amenity impacts of fossil fuels; and natural resource scarcity and rents.
[23] The OECD and IEA have thus described low-carbon technology R&D as "twice a public good" (Philibert 2004); they could have gone further than "twice".

Regarding the first part of the innovation chain, for China to succeed in channelling its growing technical sophistication toward breakthrough innovations in low-carbon energy over the longer term, it will need to foster the strategic, institutional, financial and cultural conditions required for this kind of innovation (Zhi et al. 2013; Cao et al. 2013). For example, China could establish well-funded energy research laboratories, modelled on those in the US, that are supported by a long-term (10+ years) research strategy[24] that empowers scientists and research managers with the academic freedom to take risks, fail and learn, and evaluates their performance accordingly (Anadon 2012; Zhi et al. 2013; Cao et al. 2013).[25] These institutions would be most effective if embedded within energy innovation clusters[26] that provide a legal and financial environment conducive to indigenous, early-stage innovation.[27]

Both of these parts of the innovation chain (early-stage R&D; and the demonstration and early-stage deployment of innovative technologies), provide important opportunities for international cooperation. The Global Commission on the Economy and Climate (2014) has argued that:

- the governments of the major economies should at least triple their investment in the research and development of clean energy technologies, with the aim of exceeding 0.1% of GDP per country, and should better coordinate the direction of these investments;
- all governments should engage in trans-national networks of energy innovation "incubators" — public-private partnerships that would incubate low-carbon innovation in clean energy technologies and associated business-models — with hubs based in developing countries and focused on the development and diffusion of clean energy technologies in locally-specific development contexts.[28]

China could play a leading international role on both of these fronts.

c) Finance and the Cost of Capital for Infrastructure

Over the next decade and beyond, China will need to make very large investments in infrastructure in cities and energy systems (and to some extent in land-use systems). The Global Commission on the Economy and Climate has shown that, with modest amounts of additional investment, this infrastructure could be low-carbon, and would bring strong local returns in the form of resource efficiency, reduced local air and water pollution, lower congestion and better health and well-being (GCEC 2014).

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[24] Basic research needs to be supported by innovation policy strategy that is stable across Five Year Plans (e.g. for at least a decade). Zhi et al. (2013) identify shifts in priorities and levels of risk-tolerance from plan to plan as a key hindrance to the success of past basic research initiatives in China.

[25] Zhi et al. (2013) identify the need for a culture of "higher risk-tolerance and a longer-term view", and for this to be reflected in managerial structures such as researcher performance evaluations. They also highlight the need to "[i]Increase the level of participation of scientists and entrepreneurs in the process of designing projects and awarding tasks."

[26] For example, Shanghai, Shenzhen, Suzhou and Beijing.

[27] The US-China Clean Energy Research Centre, which focuses on energy efficiency, carbon capture and storage, and electric vehicle technologies, has a Technology Management Plan to manage intellectual property rights, embodying an attempt to build China's core research capabilities while providing reasonable returns to innovators.

[28] These could be modelled on the Consultative Group on International Agricultural Research (CGIAR) — a transnational collaborative network of 15 research centres focused on agricultural innovation and dissemination targeted at developing countries. See www.cgiar.org.

An influential determinant of whether green infrastructure attracts financing over higher-carbon alternatives will be the cost of capital. The cost of capital is particularly important for renewable energy infrastructure: even though the levelised costs of energy are often lower for renewable energy than for fossil fuel generation, it is more capital intensive (fossil fuel-based generation has lower up front capital costs but much higher operational costs due to the need to purchase fossil fuels). For newer and more innovative types of green infrastructure projects more generally, especially where these are dependent on government policy, capital costs also tend to be higher because investors perceive greater policy risks and may have less experience in financing such projects.

China's state development banking institutions are already playing a globally significant role in financing renewable energy at a low cost of capital (GCEC 2014). Such institutions can reduce perceived risks, share and pool risks, and build specialised skills in green infrastructure projects. The continuation of low-cost financing for green infrastructure projects in both cities and energy systems will be crucial to China's sustainable growth plans.[29] Two new institutions, the Asian Infrastructure Investment Bank (AIIB) and the BRICS-led Development Bank, could provide further low-cost financing for green infrastructure in and beyond China.

The AIIB and BRICS Bank are important examples of international cooperation among Asian countries and among emerging market economies, respectively. It would be strongly in China's interests to work with other member countries and donors to ensure that the lending and investment policies and practices of these institutions are inherently "green", i.e. that they: (i) prioritise finance for green infrastructure and leverage private finance towards this goal (and that the institutions possess the requisite skills and capacity in green financing); and (ii) refrain from financing high-carbon projects and strategies (unless there is a clear development rationale without viable alternatives) (GCEC 2014). In this way, these international institutions could become strong forces for sustainable growth in Asia and emerging markets.

In partnership with other multilateral, regional and state development banks (and green investment banks), these new institutions could form part of a global network for green infrastructure investment. This would present China with an important opportunity to provide leadership in the developing world as a financier of sustainable growth. Whether developed countries lend support to the AIIB and BRICS Bank, through funding and otherwise, will be a critical test of their sincerity in supporting climate finance initiatives in the developing world.

d) Pricing Carbon; Taxing Coal

Domestically-appropriate forms of carbon pricing have an important role to play in achieving strong, high quality and low-carbon growth in China. Appropriate and well-designed mechanisms to price carbon can have two important domestic effects (see Ahmad et al. 2013; Green and Stern 2014):

- Sending a clear policy signal to producers and consumers to induce structural change and innovation away from high-carbon industries and products, and toward low-carbon substitutes, across the economy;

[29] In future, local government bond issues could become an important source of funding for local green infrastructure (see Wildau 2013).

- Providing an additional source of government revenue, which can be used to invest in green innovation and infrastructure, to offset reductions in less efficient taxes, and to provide assistance to low-income households and workers in order to help them manage the transition to a low-carbon economy.

For China, an attractive option for both effectively reducing emissions and raising government revenues in the medium-term is a tax on fossil fuel energy sources, particularly coal, that puts a price on both the local pollution costs and the global carbon costs.[30] It could take the form of an excise that roughly approximates the social cost of these impacts (Ahmad and Wang 2013).[31] The IMF has estimated the potential benefits of fossil fuel energy taxation for a number of countries, including China. It finds that an appropriate corrective tax on coal in China, reflecting both health costs from local pollution and a conservative measure of the global carbon externality,[32] would be around US$15 per gigajoule (Parry et al. 2014).[33] At this level, the IMF estimates that such a coal tax would reduce pollution-related deaths by two-thirds, cut CO_2 emissions by one-third, and raise revenues of more than 6% of GDP (Parry et al. 2014).

Such a tax would also have important international effects politically, not only sending a message about the seriousness of China's emissions reduction efforts, but also helping to catalyse global efforts to phase-out unabated coal. The Global Commission on the Economy and Climate (2014) has recommended that all countries phase out unabated fossil fuel power generation by 2050, with developed countries ending, and developing countries strongly restricting, new-build coal-fired power generation. Were China to use a coal tax, alongside direct regulatory measures, to achieve a phase-out of domestic coal consumption within the coming two-three decades (see Green and Stern 2014), the global effect on, emissions, on other countries' climate policies and on the politics of climate change would likely be transformative.

In China, especially in the short-medium term, China's policy mix for addressing coal will continue to involve regulatory and direct control mechanisms. While less efficient than well-designed market mechanisms, direct measures have the advantage of being clear and certain as to the scale and timing of change, which can bring down the costs of structural change — these are important advantages, given the urgency of reducing the local and global impacts of China's coal consumption (Green and Stern 2014).

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[30] The central government is currently finalising plans to reform the existing coal resource tax by moving from a production-based to a value-added method of taxation, following a similar change to oil and gas taxation that occurred in 2011. This is a sensible first step (it is the use of coal that is the source of emissions), and the government has, encouragingly, stressed the importance of going further, taxing resource rents and environmental and carbon externalities more effectively (CCCPC 2013). Taxation of externalities could be a critical element of a three-part tax structure for fossil fuel resources encompassing value-added, rent, and externalities taxation.

[31] Excises that target environmental and carbon externalities have the dual advantages of: (i) a greater environmental focus than a pure excise on production or consumption of some good; and (ii) lower complexity and administration costs than a pure emissions tax or emissions trading scheme (Ahmad and Wang 2013). In the medium term, a national carbon emissions trading scheme could play a role in pricing the GHG emission externality directly.

[32] US$35 per metric ton of CO_2 (Parry et al. 2014).

[33] Corrective tax estimates are for 2010 and, to facilitate cross-country comparisons, are expressed in 2010 U.S. dollars (Parry et al. 2014).

4. Conclusion

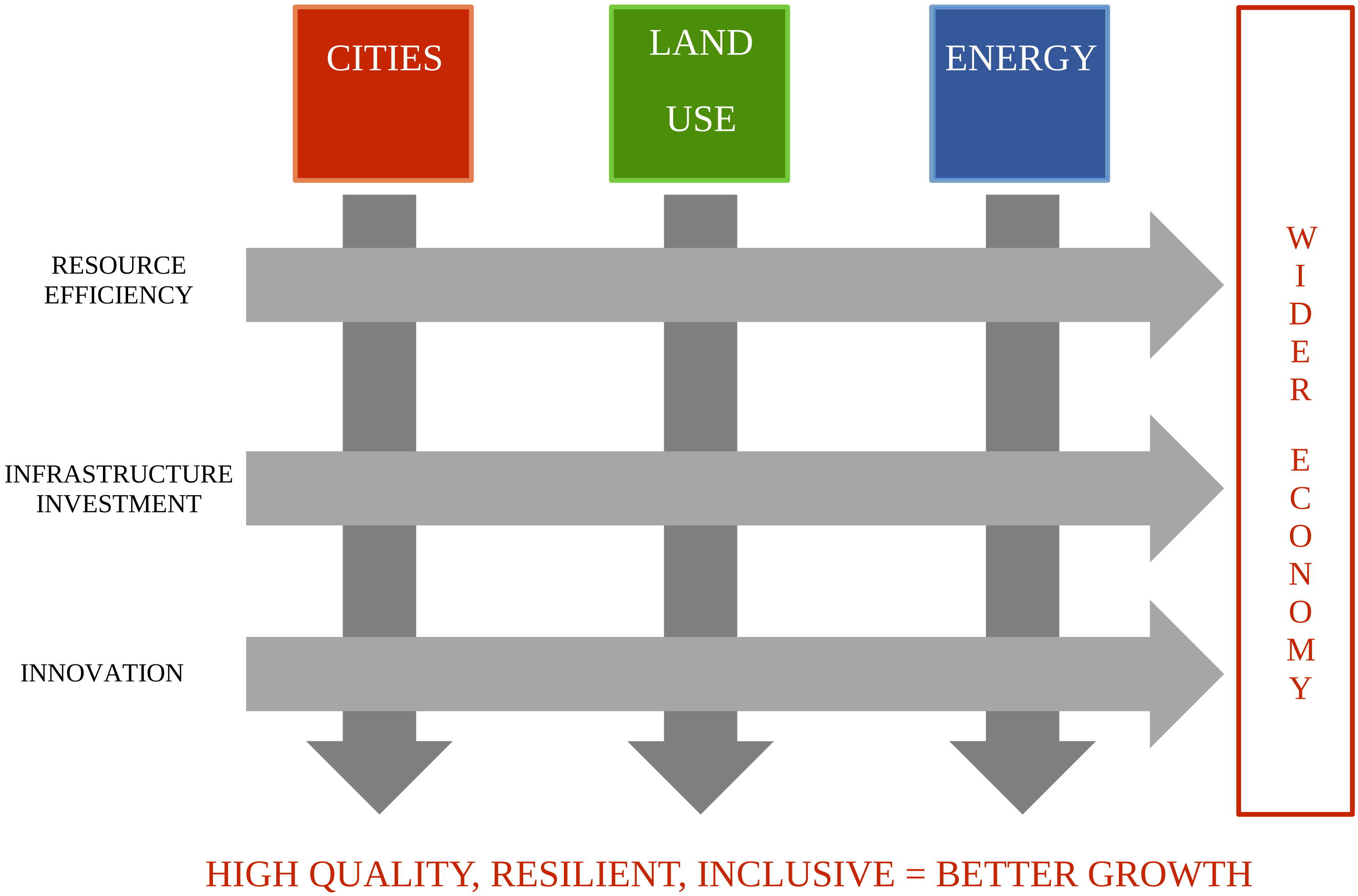
Over the last three and a half decades, China has undertaken major structural reforms that have laid the foundation for subsequent long periods of strong growth. China's reform and opening up in the late 1970s produced the rapid growth of the 1980s. The fiscal reforms of 1993/94 laid the foundations for high levels of government investment and continued strong growth throughout the '90s and 2000s, and provided a strong basis for China to weather the Asian and global financial crises in the latter parts of these decades, respectively (Ahmad et al. 2013). Often written off by the international community, China's ability to identify, chart and implement the next round of reforms has seen the country take the world by surprise, time and time again.

A central part of China's next strategic transition will be to achieve growth and development that is not only strong, but high quality and sustainable, both locally and in regard to the global climate. This transition is eminently achievable. But it will require China to set its sights high and demonstrate once again is ability to identify and make bold reforms.

This paper has outlined a framework for achieving this model of development, focusing on three key drivers of change needed for low-carbon and climate-resilient development: resource productivity; infrastructure; and innovation. Policies and investments targeting each of these drivers of change within the energy sector were discussed as a way of illustrating the application of this framework. The paper then examined four areas of domestic reform, and associated international cooperation, that will be especially important in China's transition to sustainable growth: cities; clean energy innovation; finance and the cost of capital for infrastructure; and carbon pricing, especially taxing coal.

This is a critical decade for China and the world. The actions taken in this period, we have argued, will profoundly shape China's growth pattern for many decades and, directly and indirectly, global climatic conditions for centuries. The next year, as China prepares its 13th Five Year Plan and engages with the world in the lead-up to the Paris 2015 climate conference, will be decisive in determining the actions that follow. China has the creativity, the ability to decide and deliver, and the scale to show the world what the future can be.

Appendix: Key Drivers of Growth and Climate Performance



Source: GCEC (2014)

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