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CAN AFRICA BUILD GREENER INFRASTRUCTURE WHILE SPEEDING UP ITS DEVELOPMENT? LESSONS FROM CHINA

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Cover image: A high-speed train traveling on the railway in Anshun, southwest China's Guizhou province © STR/AFP/Getty Images

ABSTRACT

In 2013 China launched a global connectivity project known as the Belt and Road Initiative. Under its flagship agenda, China seeks to mitigate slowing growth at home while supporting growth abroad, especially in other developing countries. Global environmental pressures, combined with the recognition that China's own development is energy and pollution intensive, mean that the race is on to both learn from China's mistakes and identify new ideas for sustainable development that can replicate its development successes. China is the largest external investor in African infrastructure. This paper shows how Africa can draw lessons from China's own experience of development. These include how China made the most of its demographic dividend through the heavy use of low-cost labour at the early stages of its development. The paper uses examples of how China managed to improve initially polluting infrastructure to help Africa leapfrog directly into cleaner solutions. This includes adopting environmentally responsible transportation infrastructure, such as long-distance rail transport around larger economic centres, greener port infrastructure, and the pre-emptive development of mass transit in urban areas before private vehicles become dominant. By engaging proactively with China's experience of development, Africa can make its own development process more efficient and less environmentally damaging.

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ABBREVIATIONS AND ACRONYMS

ASI	‘Avoid–Shift–Improve’
AfDB	African Development Bank
BRI	Belt and Road Initiative
BRT	bus rapid transit
DECA	Domestic Emission Control Area
FOCAC	Forum on China–Africa Cooperation
GHG	greenhouse gas
HSR	high-speed rail
LNG	liquefied natural gas
MTR	Mass Transit Railway
R+P	‘Rail plus Property’
SIDCA	State International Development Cooperation Agency
US	United States

INTRODUCTION

Infrastructure plays a well-documented role in economic development.[1] The economic performance lag between Africa and other developing regions has been attributed to poor infrastructure. Improved infrastructure alone could add at least 1.2% annually to the region's growth rate.[2]

China is the largest external investor in African infrastructure. It is the dominant player in the sector across many countries, including Ethiopia and Kenya.[3] China's interest is driven by both push and pull factors. Push factors are rooted in contemporary challenges in China's own economy. Pull factors are more nuanced and include China's track record of using infrastructure as a key driver of economic growth, and its stated aim to make a positive contribution to global development – even in the face of developed countries' withdrawing from certain multilateral efforts, most notably the US' intention to leave the Paris Accord on Climate Change.

Bringing these domestic (push) and international (pull) factors together is China's flagship Belt and Road Initiative (BRI). There is a risk that China's structural upgrade will simply shift dirty industries abroad, just as high-income countries moved some of their polluting industries to China in the past. Cases of new plastic recycling industries emerging in India, Turkey and possibly East Africa following China's 2018 import ban on plastic waste, prove this point.[4] Yet, there is also the potential for positive change. The outward expansion gives China the opportunity to bring its recent experience to bear on upgrading standards for cleaner development that are also suited to developing countries.

China's extensive and generally rising foreign aid to and investment interests in African economies are an exception to the relative lack of foreign investor interest in recent decades. It builds on two decades of (on average) more stable macroeconomics in the

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1 For example, Aschauer DA, 'Is public expenditure productive?', *Journal of Monetary Economics*, 23, 2, 1989, pp. 177–200; Munnell AH & LM Cook, 'How does public infrastructure affect regional economic performance?', *New England Economic Review*, September 1990, pp. 11–33; Sahoo P & RK Dash, 'Infrastructure development and economic growth in India', *Journal of the Asia Pacific Economy*, 14, 4, 2009, pp. 351–365.

2 World Bank, Africa's Pulse, 15, April 2017a, https://openknowledge.worldbank.org/handle/10986/26485, accessed 26 November 2018.

3 Geda A, 'Scoping Study on the Chinese Relation with Sub Saharan Africa: The case of Ethiopia', AERC (African Economic Research Consortium) Scoping Study, March 2008, https://www.researchgate.net/publication/267782036_Scoping_Study_on_the_Chinese_Relation_with_Sub_Saharan_Africa_The_Case_of_Ethiopia_AERC_Scoping_Study_Scoping_Study_on_the_Chinese_Relation_with_Sub_Saharan_Africa_The_Case_of_Ethiopia, accessed 26 November 2018; Onjala J, 'China's development loans and the threat of debt crisis in Kenya', *Development Policy Review*, 2017.

4 Reuters, 'East African plastic manufacturers step-up recycling after China ban', *Africanews.com*, 18 September 2018, http://www.africanews.com/2018/09/18/east-african-plastic-manufact urers-step-up-recycling-after-china-ban/, accessed 2 October 2018.

A project can have both positive and negative effects on different aspects of sustainable development. To gauge whether a project will ultimately be beneficial for a country or region, one has to take into account the interaction of politics, economics, science and engineering over time

region.[5] However, optimising China's interests for Africa's citizenry, economy and environment will require foresight, determination and accurate information.

This paper introduces the economic context underlying the BRI. It focuses on explaining the factors driving China's particular interest in infrastructure and its importance to the BRI. It then elucidates China's own experience of infrastructure development, with a focus on the policy environment and case studies from China's own infrastructure experience and discourse. This and ensuing policy suggestions contribute to contemporary debates between African and Chinese policymakers emanating from the 2018 Forum on China–Africa Cooperation (FOCAC) held in Beijing in early September 2018.

Finally, this paper is written with the recognition that sustainability impacts and benefits related to development (in this case, infrastructure development specifically) are myriad and complex. A project can have both positive and negative effects on different aspects of sustainable development. To gauge whether a project will ultimately be beneficial for a country or region, one has to take into account the interaction of politics, economics, science and engineering over time. To achieve the Sustainable Development Goals as defined by the UN, projects must undergo a thorough environmental, social and economic assessment. Making that process cost-effective, timely and scientific is key to its success. Against this background, this paper focuses on understanding first why China is currently interested in investing in African infrastructure under the BRI, and laying out some of its successes and failures in trying to make infrastructure more ecologically sustainable, before offering recommendations for African countries based on lessons from China's own infrastructure experience, particularly in the area of air pollution and greenhouse gas (GHG) emissions.

WHY NOW? TRACING THE PATH TO THE BELT AND ROAD INITIATIVE

In 2018 China celebrated the 40th anniversary of the 'reform and opening' era, initiated by Deng Xiaoping, that enabled millions to climb out of poverty. These efforts collectively catapulted China to the centre of the world economy. Since 2009 China has been Africa's largest trade partner, and it is an increasingly important investor and financier. China has also sought Africa's support in its flagship BRI, announced in 2013. There is some uncertainty in Africa (and beyond) about the logic underpinning China's BRI outreach. This section elucidates the economic logic that decided the timing of the BRI rollout, through an overview of contemporary issues in China's economy and development.

The rise of China's demographic dividend

The official launch of the 'reform and opening' agenda in December 1978 by Deng was in service of China's so-called Four Modernisations: agriculture, industry, national defence, and science and technology. To achieve these as fast as possible, and to complement the

5 Arbache JS & J Page, *Patterns of Long Term Growth in Sub-Saharan Africa*. Washington DC: World Bank, 2007.

planned economic transformation, the 'One Child' policy was implemented, officially from 1980. This guaranteed that China would undergo a rapid demographic transition from high fertility and mortality to a much lower birth and death rate. In turn, this transition gradually opened a productive demographic dividend window: a temporary peak in the economically productive population as a proportion of the entire population. In other words, the country saw an increase in its support ratio (the ratio of the number of 15–64-year-olds per each individual 65 and older) – a ratio that reveals on how much support the aging proportion of a population can draw from their working-age compatriots. China's support ratio increased from 1971 until around 2013 (by which stage rapid population ageing, the later tail of a demographic dividend window, had begun). Calculations have shown that the 42-year-long demographic dividend interlude added about 1.5% to growth each year.[6]

At the start of the 'reform and opening' agenda in 1980, China was home to a youthful, poor and mostly agrarian population. This demographic makeup was very similar to Africa's today. China's policymakers viewed this youthful army of workers as its hope to achieve the Four Modernisations. In this pursuit, they planned how to put them to work in an optimal manner. Tax incentives were offered to foreign investors to bolster labour-intensive manufacturing, especially where the output was also intended for foreign exchange-earning export.

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Economic theory explains China's drive to use its demographic dividend period for optimum development. Where demographic transition meets a gradual process of labour transfer from the informal rural sector to the formal industrial sector, the ensuing productivity gains provide a window for relatively rapid industrialisation. In other words, a steady flow of former farm labourers to factories is fuelled by gradually improving incomes that in turn attract new waves of migrant workers into the industrial sector. This results in intensive productivity gains that kick off rapid industrialisation and boost living standards, in the absence of wage inflation. The process is self-supporting – until the supply of informal farm labour dries up.

China began feeling such labour-related pressures around 2003, when the number of informal labourers moving from rural areas into the industrial sector began to decline.[7] At that point, labourers had to be enticed with higher wages, and low-cost labour advantages started to fade. China quickly realised that it needed new industries and fresh sources of comparative advantage.[8]

6 Mason A *et al*., *Support Ratios and Demographic Dividends: Estimates for the World*. New York: UN Population Division, 2017.

7 Johnston LA, 'Harvesting from "poor old" China to harness "poor young": Africa's demographic dividend', *Bridges Africa*, 7, 5, 2018.

8 The demographic dividend era of China's reform and development is summarised in Song L *et al*., 'Introduction: A review of China's reform and transition to a market economy', in Song L *et al*. (eds.), *China's Forty Years of Reform and Development, 1978–2018*. Canberra: ANU Press, 2018.

The double challenge of the end of China's demographic dividend

China's pool of informal rural labour was exhausted roughly at the same time as its demographic transition matured; in other words, when its population started aging. Late demographic transition is empirically identified by three thresholds:

- more than 7% of the population is older than 65;
- less than 30% of the population is younger than 14; and
- the ratio of old to young (as defined by the two previous points) exceeds 0.3.[9]

China's population passed these thresholds in 2002, 1987 and 2002 respectively.[10] Some 130 million Chinese (about 10% of the population) are now aged 65 and over. The share of the working-age population is shrinking and hence the support ratio has begun a long decline. The combination of the end of mass low-cost rural–urban migration and the onset of rapid population ageing marks a major turning point for China's economy.

These demographic trends alone will dampen China's growth by as much as 1.2% per year. This will in turn affect global growth, given China's size and contribution to the world economy.[11] Moreover, these changes also coincided with the global financial crisis: for a decade China has faced much tighter domestic and international growth conditions. Although several Chinese provinces have per capita incomes in the high-income group, China as a nation remains outside the global club of high-income nations. Chinese policymakers face an uphill struggle to keep increasing the prosperity of China's 1.3 billion citizens through the efforts of a shrinking working-age population while supporting millions of older people. The low-hanging growth and development fruit of the low-cost labour boom are gone.

Chinese policymakers are responding by pursuing new economic advantages in advanced manufacturing and the services sector in the country's more developed coastal provinces, and by selectively relocating less advanced industries to inland provinces. It is also expanding its investment portfolio abroad, especially in industries that are now less competitive domestically or for which there is less demand at home. Given China's accumulated expertise in low-wage manufacturing and heavy industry, the focus of such investing will be countries that are, as China was a few decades ago, emerging low-wage demographic dividend frontiers (countries shaded green in Figure 1).

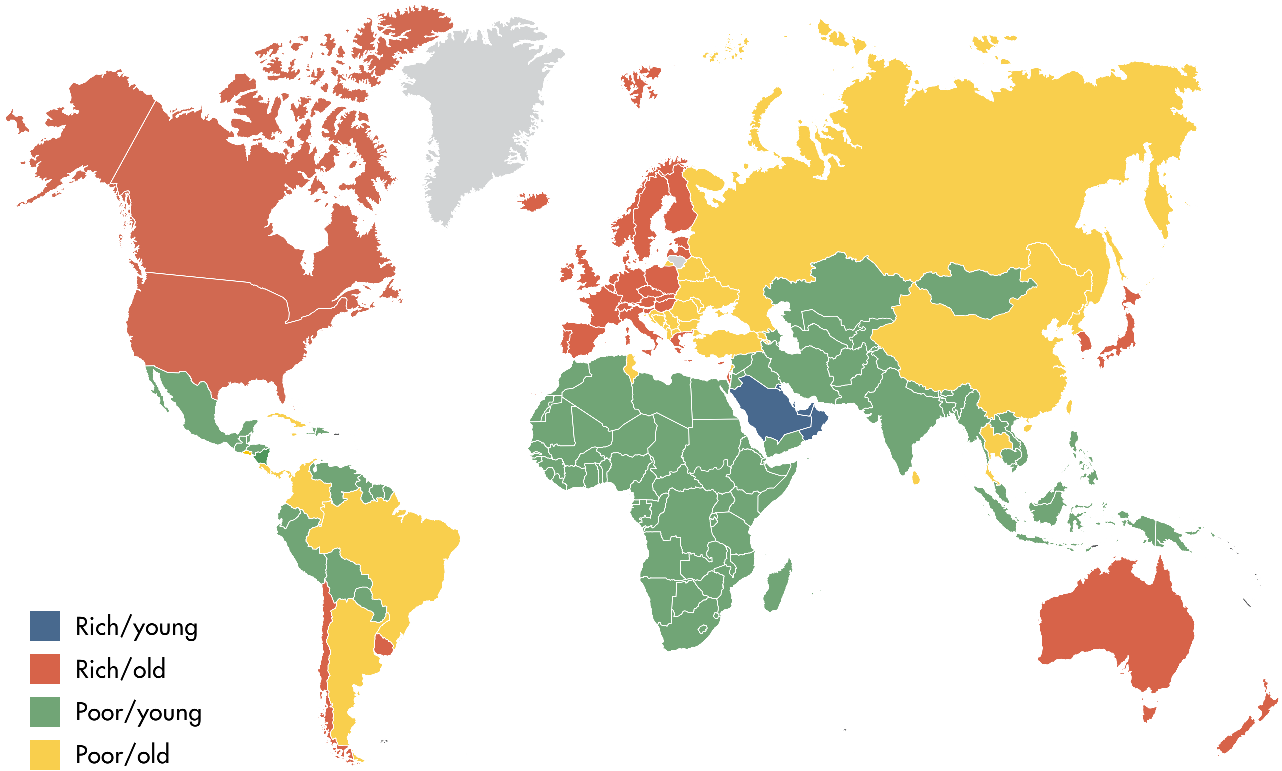
Countries are classified according to four typologies: 'rich and young', 'rich and old', 'poor and young' and 'poor and old'; where 'rich' countries are those with an annual per capita income of $12,476 and over in 2016, and 'old' countries are those where 7% or more of the population are aged 65 or over.

9 Siegel JS, 'On the demography of ageing', *Demography*, 17, 4, 1980, pp. 345–364.

10 World Bank, *World Development Indicators*, 2017b, http://datatopics.worldbank.org/world-development-indicators/, accessed 26 November 2018.

11 Mason A *et al*., *op. cit*.

FIGURE 1 WORLD MAP BY ECONOMIC DEMOGRAPHY MATRIX CATEGORY, 2016



Source: Johnston LA, 'Harvesting from "poor old" China to harness "poor young": Africa's demographic dividend', *Bridges Africa*, 7, 5, 2018

African countries are listed according to their demographic transition stage in Appendix 1 (see page 31). The most important division is between countries that are pre-demographic dividend and those where this dividend is emerging. For such countries, China's post-demographic dividend era of growth is a remarkable opportunity to become the new intensive low-cost labour frontier. To enable them to grasp this opportunity, it is crucial to understand what China did to effectively capture its demographic dividend. It is also the right time to think about how China and African countries can build a partnership for mutual growth that maximises the development and interests of both. The BRI can be a way for China to transform its economy beyond the demographic dividend era while supporting growth in today's 'poor and young' countries, many of which are in Africa (Figure 1).

The Belt and Road Initiative: A new era of outbound Chinese capital

China's outbound investment exceeded inbound investment for the first time in 2015. This reflects both a wide-ranging structural change and the fact that in China savings currently exceed investment, as in most high-income countries. This in turn supports the lowest market-based long-term interest rates on record.[12] When the BRI was launched in 2013, China held foreign exchange reserves of $4 trillion that were earning less than 1% interest per year.[13] When accounting for the expected appreciation of the renminbi against the US dollar, the return on those savings was in fact negative.

This reality was a key factor driving a series of reforms aimed at aiding China's own development via the sparking of development in other regions, such as Africa. Speaking at the AU in 2014, shortly after the launch of the BRI, Chinese Premier Li Keqiang called for an era of 'innovative and pragmatic cooperation' between China and African countries.[14] This was followed in 2017 by a call from President Xi Jinping for China to 'optimise the strategic layout' of its foreign aid.[15] In March 2018 China launched a new government agency dedicated to this task, the State International Development Cooperation Agency (SIDCA). SIDCA is tasked with enhancing the strategic planning and coordination of China's foreign aid, including the integration of aid with the BRI. Xiaotao Wang, a former vice-minister of the National Development and Reform Commission and an official with considerable experience of China's inbound and outbound investment, is SIDCA's inaugural head.

These reforms did not emerge out of the blue. Already in 2012, China EXIM Bank Vice-President Zhu Hongjie called for an expansion in foreign aid, including concessional lending. He argued that this would improve the efficiency with which Chinese aid could promote Chinese exports, while helping reputable Chinese enterprises to boost the development capacity of poorer countries.[16] In other words, China's foreign aid is being used to achieve win–win growth and development objectives in both China and other developing countries.

To that end, China has inaugurated a dizzying array of development finance initiatives. These include the Shanghai-based BRICS-led New Development Bank, which in August 2017 opened an inaugural branch in Johannesburg, the $40 billion Silk Road Fund,

12 Garnaut R *et al*., 'China's new sources of economic growth: A supply-side perspective', in Song L *et al* (eds.) *China's New Sources of Economic Growth: Reform, Resources and Climate Change*. Canberra: ANU Press, 2016.

13 Wei SJ, 'The economic case for China's Belt and Road Initiative', *Project Syndicate*, 13 October 2017, https://www.project-syndicate.org/commentary/china-belt-and-road-economic-case-by-shang-jin-wei-2017-10?barrier=accesspaylog, accessed 16 August 2018.

14 Johnston L, 'Premier Li calls for "innovative and pragmatic" cooperation in Africa', *East Asia Forum*, 11 June 2014, http://www.eastasiaforum.org/2014/06/11/premier-li-calls-for-innovative-and-pragmatic-cooperation-in-africa/, accessed 16 August 2018.

15 *South China Morning Post*, '"We're still figuring out China's Belt and Road": European diplomats confess they don't know much about Xi's trade plan', 12 May 2017, http://www.scmp.com/news/china/diplomacy-defence/article/2093859/were-still-figuring-out-chinas-belt-and-road-european, accessed 16 August 2018.

16 China Economic Net, 'Zhu Hongjie: Expand foreign aid, grasp new opportunities of overseas investment', *Sina Online*, 23 February 2012, finance.sina.com.cn/roll/20120323/100411662171.shtml, accessed 18 August 2018.

established in 2014, and the $3 billion South–South Climate Cooperation Fund, set up in 2015. China is also increasing its investment in existing concessional lending institutions. In August 2016 China EXIM Bank agreed on a $1 billion industrialisation programme with the African Export–Import Bank, with funds allocated to the construction of industrial parks and special economic zones in Africa. These would concentrate on light manufacturing and the processing of raw materials. Multiple industrial cooperation funds have also been inaugurated, typically focusing on specific regions.[17]

The timing is opportune for Africa. African Development Bank (AfDB) President Akinwumi Adesina noted in 2016 that Africa 'needs more, not less' financing:[18]

> I believe that Africa deserves significant support, even in the midst of these challenges. We must not forget that the reason several thousands of Africans have been (illegally) migrating to Europe, is because of lack of jobs and shrinking economic opportunities back at home. Our result must not be to reduce support, but to increase support to help Africa, to build greater resilience, boost its economies, address its structural challenges, such as the closing of its huge infrastructure gap, strengthening intra-regional trade and creating jobs for its teeming youths.

It is not a coincidence that closing the infrastructure gap was Adesina's first noted structural challenge.

China has both a willingness to invest in high-risk developing country environments and excess technical and financial capacity in the area of infrastructure. African countries need both. These priorities align so well that former World Bank chief economist and Peking University Prof. Justin Lin suggested the BRI could become 'One Belt, One Road, and One Continent'.[19]

China has both a willingness to invest in high-risk developing country environments and excess technical and financial capacity in the area of infrastructure. African countries need both

Africa and infrastructure

While global demographic trends are shifting in Africa's favour, similar changes are also emerging in South and Central Asia (see Figure 1). Even in Africa's non-resource-rich economies, labour has mostly been slow to move from low- to high-productivity sectors.[20]

17 Kevin Gallagher *et al*. elaborate on China's emerging development finance with reference to the energy sector and sustainability: Gallagher KP *et al*., 'Energizing development finance? The benefits and risks of China's development finance in the global energy sector', *Energy Policy*, 122, November 2018, pp. 313–321.

18 AfDB (African Development Bank), '"Africa deserves more, not less": Speech delivered by President Akinwumi Adesina at the Final Pledging Session for the African Development Fund 14th Replenishment, November 28, 2016, Luxembourg', https://www.afdb.org/en/news-and-events/africa-deserves-more-not-less-16468/, accessed 26 November 2018.

19 Lin YJ, 'Industry transfer to Africa good for all', *China Daily*, 20 January 2015, http://usa.chinadaily.com.cn/epaper/2015-01/20/content_19357725.htm, accessed 26 November 2018.

20 AfDB, *African Economic Outlook 2018*, 2018, https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African_Economic_Outlook_2018_-_EN.pdf, accessed 5 April 2018.

While global demographic trends are shifting in Africa's favour, similar changes are also emerging in South and Central Asia. Even in Africa's non-resource-rich economies, labour has mostly been slow to move from low- to high-productivity sectors. Inadequate infrastructure is one reason

Inadequate infrastructure is one reason.[21] High transportation costs in sub-Saharan Africa, compounded by the continent's unusual geography (particularly its high number of landlocked countries), account for much of the region's poor economic performance.[22] The infrastructure gap specifically is estimated to slow the region's growth by at least 1.2% per year.[23] Improving the quality of existing infrastructure would add 0.5% to growth.[24]

The AfDB estimates the infrastructure financing gap to be in the range of $130–170 billion annually.[25] The continent's major infrastructure investments can be seen as a response to this pressure. For example, two of China's more prominent recent infrastructural investments in Africa – the Standard Gauge Railway (SGR) in Kenya and the railway connecting landlocked Ethiopia with the port of Djibouti – focus on overcoming geographic hurdles to facilitate trade.

Infrastructure can generate a large economic return and is key to capturing the gains from both trade and globalisation.[26] Between 1950 and 1998, faster air and sea transportation had the same impact on global trade flows as reducing tariffs on manufactured goods from 32% to 9%.[27] Lowering trade costs by 10% through infrastructure investment could increase exports by more than 20%. In the case of China and India, falling trade costs account for three-quarters of trade expansion since the early 1990s.[28]

That said, these gains do not automatically flow from infrastructure investments. They require appropriate institutional, cross-regional (domestic and/or international) and financial arrangements. Such arrangements lie at the heart of the BRI, and China's own experience will influence how the BRI evolves. BRI stakeholders must both take positive lessons from China's 40 years of 'reform and opening' and avoid the pitfalls, including environmental damage and lending risks. The following section takes brief stock of China's infrastructure experience. It then explores a few case studies that provide particular lessons from China's infrastructural experience. The aim is not to offer a comprehensive summary of that experience but to start a conversation about what should and should not be repeated in Chinese infrastructure investment in Africa. In particular, this paper aims

21 World Bank, 2017b, *op. cit*.
22 Limao N & AJ Venables, 'Infrastructure, geographical disadvantage, transport costs, and trade', *The World Bank Economic Review*, 15, 3, September 2001, pp. 451–479.
23 World Bank, 2017a, *op. cit*.
24 *Ibid*.
25 AfDB, 2018, *op. cit*.
26 Henckel T & WJ McKibbin, 'The economics of infrastructure in a globalized world: Issues, lessons and future challenges', *Journal of Infrastructure, Policy and Development*, 1, 2, 2017, pp. 254–272.
27 Hummels D, 'Transportation costs and international trade in the second era of globalization', *Journal of Economic Perspectives*, 21, 3, 2007, pp. 131–154.
28 Brooks DH & B Ferrarini, 'Changing Trade Costs between People's Republic of China and India', ADB (Asian Development Bank) Working Paper, 203, May 2010, https://www.think-asia.org/bitstream/handle/11540/1544/economics-wp203.pdf?sequence=1, accessed 14 September 2018.

to identify ways in which Africa can use Chinese support for green transport infrastructure to leapfrog into sustainable development.

Any discussion about the lessons Africa can take from China in relation to green development has to take into account the fact that China's recent sustainability record in Africa has been mixed. While this paper lacks the space to deal with this issue in detail, it can cite a few examples of recent controversies. Particular attention has been paid to an intended Chinese-led $2 billion, 975-acre coal-fired electricity plant investment in Lamu.[29] The plant will be Kenya's first coal-fired power station, and will help meet the country's burgeoning energy demand. Critics claim it is unnecessary, will damage the local marine environment and create unnecessary carbon pollution. Also in Kenya, the BRI-flagship SGR came in for criticism for running through Nairobi National Park, and alongside the earlier British-built railway through Tsavo East National Park and Tsavo West National Park.[30] In response to this criticism, the SGR was strategically elevated to allow wildlife to pass underneath it.

Such environmental concerns cannot be easily separated from controversies around the cost of these projects, their impact on job creation, and so on. The implicit trade-off between debt, development speed and environmental sustainability creates incentives for concessional and grant financing to be extended to include infrastructure, not least since African countries' preserving the region's forests and wildlife is an investment in a global public good.

> It is important for African countries to ascertain which of those impacts could have been avoided and how to use technological gains to make Chinese investment in African infrastructure environmentally sustainable

CHINA'S INFRASTRUCTURE EXPERIENCE AND POLICY DIALOGUE

China's infrastructure stock has grown astronomically since the 1980s. The Chinese government planned for the country to have 150 000km of railway lines, 5 million km of roads, 260 airports and 2 527 berths for vessels of over 10 000 tonnes by 2020.[31] This ongoing explosion in infrastructure has undoubtedly affected the natural and human environment. It is important for African countries, as they look to build up their own infrastructure stock, to ascertain which of those impacts could have been avoided at little additional cost, and how to use technological gains to make Chinese investment in African infrastructure environmentally sustainable.

29 Sengupta S, 'Why build Kenya's first coal plant? Hint: Think China', *New York Times*, 27 February 2018, https://www.nytimes.com/2018/02/27/climate/coal-kenya-china-power.html, accessed 1 October 2018.

30 Kegoro G, 'SGR project likely to irreparably damage Nairobi National Park', *Daily Nation*, 10 March 2018, https://www.nation.co.ke/oped/opinion/SGR-to-irreparably-damage-Nairobi-national-park/440808-4336360-r7w1d5z/index.html, accessed 1 October 2018.

31 *China Daily*, 'China issues five-year plan to expand transport network', 28 February 2017, http://www.chinadaily.com.cn/china/2017-02/28/content_28382359.htm, accessed 27 August 2018.

The basics of infrastructure in China

Infrastructure has been an important part of the growth and development that lifted more than half a billion Chinese people out of poverty over 40 years. Early in the 'reform and opening' process China had scarce financial resources per capita and was a closed and socialist-oriented economy. Early infrastructure investment was focused on rural feeder roads to transport increased agricultural produce to consumers, as well as on a handful of developments along China's coast expected to enable trade and earn foreign exchange.[32] A State Council directive of July 1979 authorised two coastal provinces, Guangdong and Fujian, to take measures to develop tourism, foreign trade and investment. These provinces were selected not only because they were close to ports that could be used to facilitate trade but also because of their proximity to potential investors in high-income Hong Kong and Taiwan. From the 1990s China's investment in infrastructure increased rapidly as a share of its gross domestic product, as well as in comparison with other major economies.[33]

Several factors influenced this focus on infrastructure. These included the need to take advantage of the demographic dividend era to ensure labour-intensive infrastructure was in place ahead of rising wages.[34] In addition, older Chinese workers' lack of English language skills was a reason for emphasising an export economy – rather than the services sector – as a way for China to accumulate the foreign exchange with which it could continuously upgrade its economy.

An additional explanation lies in the nature of infrastructure finance in China, which underwent changes during the reform era.[35] To summarise, most infrastructure financing in China was domestic, public, and came from three broad channels: direct budget investment from fiscal resources; borrowing; and market-based financing. In China most of the direct budget expenditure on infrastructure happen at the local government (sub-provincial) level. Funding available at this level of government includes 'off-budget fees'.

In China, off-budget fees are typically arbitrarily levied on construction permits and various forms of authorisation for domestic and international business operations. Their impact is important in understanding China's construction boom, because they provided a source of unrestricted local income. Any remaining financing gaps, especially those created by a decline in direct budgetary spending, were filled by borrowing and market-based financing. Since most of the banks were state-owned, their infrastructure lending was encouraged by national policy. Simultaneously, meeting high growth targets facilitated the career advance of officials. Today's domestic debt accumulation fears can be seen as

32 Stoltenberg CD, 'China's special economic zones: Their development and prospects', *Asian Survey*, 24, 6, 1984, pp. 637–54.

33 Wang D *et al*., 'Urban infrastructure financing in reform-era China', *Urban Studies*, 48, 14, 2011, pp. 2975–2998 (Figure 7).

34 Lin S, 'Public infrastructure development in China', *Comparative Economic Studies*, 43, 2, 2001, pp. 83–109.

35 Wang D *et al*., *op. cit*. summarise this in Table 1, p. 29.

a consequence of these dynamics.[36] Indeed, a recent change in China's public service accountability rules means officials will be held accountable for lending happening under their watch across the length of their career.[37]

There is a debate in the literature as to the role played by infrastructure in China's reform and opening era, with one research paper going so far as to argue that[38]

> [t]here is [a] 'China myth' – that the country grew thanks largely to its heavy investment in infrastructure. This is a fundamentally flawed reading of its growth story. In the mid 1980s, China had poor infrastructure but turned in a superb economic performance. China built its infrastructure after – rather than before – many years of economic growth and accumulation of financial resources. The 'China miracle' happened not because it had glittering skyscrapers and modern highways but because bold economic liberalization and institutional reforms – especially agricultural reforms in the 1980s – created competition and nurtured private entrepreneurship.

For those considering ways in which to take advantage of new BRI financing opportunities, finding the right balance of priorities in each African case is critical. Not only did infrastructure in isolation not produce China's growth miracle but the process itself, although on average constructive, was also experimental, and hence subject to trial and error. The latter is especially true for environmental sustainability, the focus of the next section.

Finding the right balance of priorities in each African case is critical. Not only did infrastructure in isolation not produce China's growth miracle but the process itself, although on average constructive, was also experimental, and hence subject to trial and error. The latter is especially true for environmental sustainability

China's infrastructure and sustainability

China has vast resource scarcities. Per capita it is one of the most water- and arable land-stressed countries in the world. Despite these pressures and the presence of environmental protection policies, environmental protection was not a priority in China's infrastructure programme for most of the 40-year reform and opening era. In other words, even where policies were in place they were often not enforced.

China began paying more attention to the environment in policymaking around the turn of the millennium. Beijing tried to balance economic growth and environmental concerns through the concept of sustainable development. The Tenth Five-Year Plan (2001–2005) for Environmental Protection, including the '33211 project', was aimed at preventing pollution, and the plan's foregrounding of the 'recycling economy' provided the foundation of environmental policy in the country. Upgrading the State Environmental Protection Administration (SEPA) to a full ministry in 2008 was another step in this direction, in time for the Beijing 2008 Olympics. However, it was not until December 2012, when a

36 See Tsui KY, 'China's infrastructure investment boom and local debt crisis', *Eurasian Geography and Economics*, 52, 5, 2011, pp. 686–711.

37 Donaldson D, 'Railroads of the Raj: Estimating the impact of transportation infrastructure', *American Economic Review*, 108, 4-5, 2018, pp. 899–934.

38 Ansar A *et al*., 'Does infrastructure investment lead to economic growth or economic fragility? Evidence from China', *Oxford Review of Economic Policy*, 32, 3, 2016, pp. 360–390.

thick haze of coal and diesel smoke descended on northern China, including Beijing, that public criticism of environmental management mounted and the government enacted more comprehensive pollution reduction measures.

The so-called 'airpocalypse' of 2012 resulted in a directive from the National People's Congress for the development of regional plans to combat multiple pollutants. In September 2013 the State Council issued a Pollution Action Plan – the rare occasion when a plan was announced outside of China's five-year planning cycle.[39] In 2018, after a major government reform, the Ministry of Environmental Protection was upgraded again to become the Ministry of Ecology and Environment, covering a vast policy area, including water, oceans, soil, air and climate. The ministry both enforces environmental laws and policies and draws up future protection measures. As a result, nearly every segment of the Chinese economy, including transportation infrastructure, is now expected to consider its environmental impact.

The following section broadly outlines this dialogue to shed light on some of China's current policy priorities for infrastructure development. Taking cognizance of these issues will help African policymakers both to avoid the environmental costs of China's development path and to work environmental priorities into their development process early on.

The policy dialogue around China's transportation sustainability

The conventional approach to resolving transportation bottlenecks has been to provide more transportation infrastructure, with longer, wider roads both within and between cities. However, regions where transportation is relatively developed have found the demand for roads and private vehicles to be insatiable. Road transportation is subject to the 'induced demand' or 'build it and they will come' principle, meaning that roads that are congested today will still be congested next year despite massive investments to widen them.[40] This is because providing more road infrastructure encourages people to buy more cars. Conversely, experiments in cities such as San Francisco, Seoul and Portland have shown that denying private vehicles access to certain roads has resulted in less demand rather than greater congestion.[41] While developing countries need an overall increase in the mobility of their goods and people, examples from the developed world suggest these countries should avoid the wholesale conversion of their societies to road-based private transport. China has much to teach African countries in this respect.

39 Turner J, 'Foreword', in *China Environment Series: Special Water and Energy Issue*, Wilson Center China Environment Forum, 2012/2013, https://www.wilsoncenter.org/sites/default/files/China Environment Series 12 Small_0.pdf, accessed 26 November 2018.

40 Duranton G & MA Turner, 'The fundamental law of road congestion: Evidence from US cities', *American Economic Review*, 101, October 2011, pp. 2616–2652.

41 Walker A, 'Six freeway removals that changed their cities forever', *Gizmodo*, 25 May 2016, https://gizmodo.com/6-freeway-removals-that-changed-their-cities-forever-1548314937, accessed 26 November 2018.

China's current dialogue on sustainable transportation is led by the Ministry of Transport. It focuses on the so-called 'Avoid–Shift–Improve' (ASI) framework, where the order of the terms signal their priority, similar to the Reduce–Reuse–Recycle mantra of resource conservation.

'Avoid' strategies for transportation consist of those that reduce the total demand for transportation. These include improved telecommunications infrastructure, enabling individuals to work remotely, and urban and industrial planning, allowing goods to travel shorter distances during production and consumption. Telecommunications allow remote populations to participate in service industries that deliver higher value but require less transportation. In some places, industrial parks or clusters dedicated to specific value chains are also examples of 'avoid' strategies.

'Shift' strategies focus on the different environmental impacts of various forms of transportation and transportation infrastructure. This includes comparing road or rail construction practices in terms of their social and environmental impacts, in addition to their financial cost. For example, bus rapid transit (BRT) systems require significantly fewer resources to develop and less energy to operate than road systems for private vehicles. Using railways and inland waterways to transport goods is much more energy efficient than road freight. 'Shift' strategies aim at providing similar or better levels of mobility, with significantly lower environmental and fiscal impacts than private individual transportation systems.

'Improve' strategies involve reducing the direct environmental and social impacts of specific modes of transport. This is most often seen in the use of standards and policies to enforce the upgrading of automotive technologies. These strategies include emission standards and fuel economy standards.

The following section applies elements of this sustainability approach to three infrastructure case studies in China: long-distance railways; the Shanghai port; and urban railway infrastructure.

TRANSPORT INFRASTRUCTURE IN CHINA: THREE EXAMPLES

China provides numerous examples of transportation infrastructure development. The following three give a window into China's own dialogue around (and policy on) greener transportation infrastructure. Specifically, this section looks at three cases where infrastructure interventions were aimed at providing better economic and personal connectivity. The section attempts to draw lessons from these experiences.

Long-distance railways

China developed its railway system recently and at an astonishing speed. This made it an icon of development for middle-income economies. Its rail development is generally seen as having followed three phases. During the initial pre-centralisation period (1876–1949), the railway was generally considered a foreign trifle. This changed during the centralisation period (1949–1978), when 20 000km of railway lines was constructed, largely to transport coal. During the reform period (1978–present), rail expanded into a massive national enterprise, with 127 000km of rail by 2017.[42] This includes 25 000km of high-speed rail (HSR), the largest such network in the world. Not only is the Chinese railway huge, it is also very busy. In 2017, 3.04 billion passenger trips were made – nearly three trips for every person in China, up by 9.6% from 2016. Today, personal railway travel, whether HSR or conventional, has become a central part of Chinese travel culture. Rail travel is often viewed as more convenient, more comfortable and cheaper than air travel.

Put in the terms of the ASI framework described above, railway development is a type of 'shift' strategy towards sustainable transportation. Over the long term, railway transport is clearly more ecologically sustainable than air transport, owing to its low-friction steel-on-steel rolling wheels and access to electrified (and potentially renewable energy-powered) traction, among other reasons.[43] By 2025 HSR transportation will emit 20.6g of CO2 per passenger-kilometre, compared to the 117.2g of CO2 emitted by short-haul aircraft.[44] The International Energy Agency estimated in 2015 that China's HSR emitted just below 25g of CO2 per passenger-kilometre.[45] It is clear that China's high stakes bet on HSR is delivering increased mobility at a much lower cost to the climate than aviation, while serving billions of passengers per year.

The Chinese government has also noted the benefits of HSR for both passengers and freight. The 12th five-year (2016–2020) plan for rail allocates RMB[46] 2.8 trillion (roughly $407 billion) by 2020 to expand the HSR rail network to 30 000km (the aim is that 65% of all passenger trips should be via HSR), expand the total rail network to 150 000km, strengthen online ticketing services, hasten the development of HSR in lower-income regions of China, and extend HSR networks beyond China's borders (for example to Myanmar, Vietnam, Thailand and Malaysia). China is also investigating the possibility of connecting its railway system with that of Pakistan, Kyrgyzstan and Uzbekistan. The last two are landlocked and would benefit greatly from improved regional infrastructure.[47]

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42 People's Republic of China, National Railway Administration, *2017 Railway Statistical Report*, 2018, http://www.nra.gov.cn/xwzx/zlzx/hytj/201804/t20180412_55248.shtml, accessed 26 November 2018.

43 Railroad construction may involve larger initial environmental disruption, but its operations are significantly cleaner than other modes of transport.

44 Kageson P, 'Environmental Aspects of Inter-city Transport', OECD Joint Transport Research Centre Discussion Paper, 2009-28, December 2009, https://www.itf-oecd.org/sites/default/files/docs/dp200928.pdf, accessed 26 November 2018.

45 IEA (International Energy Agency) & UIC (International Union of Railways), *Railway Handbook 2017*, https://uic.org/IMG/pdf/handbook_iea-uic_2017_web3.pdf, accessed 26 November 2018.

46 Currency code for the Chinese renminbi.

47 People's Republic of China, National Development and Reform Commission, 附件： 铁路“十三五”发展规划 (translation: 'Annex: Railway 13th Five Year Development Plan'), http://www.ndrc. gov.cn/zcfb/zcfbghwb/201711/W020171124600458022320.pdf, accessed 26 November 2018.

The cost of Chinese HSR development has proven relatively inexpensive compared to that in other countries. Chinese HSR costs $1–21 million/km, as opposed to $25–39 million/km in Europe or $56 million/km in the US.[48] There are several major reasons for this:

- the relatively low cost of labour in China;
- the low cost of residential relocation in China;
- large-scale planning;
- standardisation of many design elements of rail construction; and
- financial creativity allowed by long time horizons on projects.

However, these are not the only reasons for the relative success of HSR expansion in China. The system is also used intensively. In fact, travel by rail has become a top means of travel for Chinese people. While the trains are often full even at regular times, the system runs at maximum capacity during the Chinese Spring Festival, when people often return to their hometowns to celebrate the new year. Spring Festival 2018 was expected to prompt 390 million passenger trips. In 2018, the Beijing–Shanghai HSR line increased its speed to 350km/h, and although it is still slightly slower than a flight, passengers are attracted by more comfortable seating and less onerous security protocols on trains.[49]

China's HSR is not perfect, and there are lessons that can be learned. In 2011, shortly after fully opening to the public, a signalling failure caused one HSR train on the Beijing–Shanghai line to crash into another, killing more than 40 people and injuring hundreds. After the incident, 10% of passengers stopped using the HSR in favour of air travel, and 7% in favour of conventional rail.[50] Yet, with the HSR system expanding to 30 000km in length by 2020, reaching more remote and economically disadvantaged places, it is sure to grow in popularity. It will also provide a significant GHG emission benefit over other forms of transportation in China. This is especially true given that operation of the HSR in China was responsible for 86% of HSR-related GHG emissions in 2012, compared to 11% from infrastructure construction and 3% for vehicle manufacture, maintenance and decommissioning.[51] What this means is that, as renewable energy becomes a larger component of the power driving HSR systems, emissions could be driven down quickly. Ideally, in developing countries along the BRI route, renewable energy would make up a larger component of grid power in the early stages of development, making electric-powered train transport a clean and low-carbon means of travel.

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48 World Bank, 'Cost of high speed rail in China one third lower than in other countries', Press Release, 10 July 2014, http://www.worldbank.org/en/news/press-release/2014/07/10/cost-of-high-speed-rail-in-china-one-third-lower-than-in-other-countries, accessed 12 August 2018.

49 Grey E, 'Faster than flying: The high-speed rail routes taking on the air industry', *Railway Technology*, 19 February 2018, https://www.railway-technology.com/features/faster-flying-high-speed-rail-routes-taking-air-industry, accessed 12 August 2018.

50 Clewlow RL, 'The Climate Impacts of High-Speed Rail and Air Transportation: A Global Comparative Analysis,' unpublished PhD dissertation, Massachusetts Institute of Technology, 2012.

51 Ye Y *et al.*, 'Life cycle assessment of high speed rail in China', *Transportation Research Part D*, 41, 2015, pp. 367–376.

Another lesson learned is that, since HSR is driven by electric power, it is possible to replace fossil fuel-generated electricity with renewable power, which will significantly and permanently reduce the GHG emission impact of HSR in the future, particularly if China's goals for renewable energy implementation are achieved by 2030. By increasing the speed and frequency of trains, China will be able to increase clean energy mobility, connecting more and more communities to the national economy while reducing high emissions from air travel by up to 80%.

While many African countries may not be able to implement HSR at the same level as China, the Chinese experience may nonetheless prove relevant to others.

- HSR, while often bringing to mind images of China's 300+ km/h railway, can actually mean any new railway built to support speeds of over 250 km/h, which can involve less intensive, lower-cost engineering; or an upgraded railway with speeds of up to 200 km/h.[52]
- China's fast roll-out of HSR proves that standardising and pre-fabricating railway components can reduce costs by as much as half compared to Europe, and 80% compared to US estimates. African regions can take advantage of these savings and low labour costs to 'lock in' this sustainable transportation system instead of road networks.
- Although China used public financing to build its HSR system, this may not be suitable for countries wary of high debt levels. Japan has successfully financed HSR systems by offering rail companies the opportunity to construct profitable real estate developments above and around stations and rail lines – a model called the Kobayashi Ichizo model. This model uses railway construction to attract urban dwellers to new communities, thus increasing both usage of the railway and the value of nearby land – to the railway's profit. Much of the Japanese rail system has been built using this model, resulting in low public debt and a healthy, profitable railway.[53] The experience offered by Hong Kong in the 'Rail plus Property' (R+P) model is also relevant (see below).[54]
- By combining some of these innovations African countries could leapfrog over a dependence on highways and airlines towards more sustainable travel.

Shanghai Port: Aiming to be the world's preeminent port

Shanghai Port is a sprawling complex serving China's Yangtze River Delta. It aspires to become the largest freight hub in the world, integrating shipping, aviation and rail freight,

52 UIC, 'High speed', https://uic.org/highspeed#General-definitions-of-highspeed, accessed 26 November 2018.

53 Kurosaki F, 'Urban Railway System Development in Japan: Contribution of the Private Sector', Training presentation, UN Center for Regional Development, Regional EST Training Course on Railways, Tokyo, 27 February 2018, http://www.uncrd.or.jp/content/documents/5965Lecture 5 Dr. Kurosaki_For WEB & HANDOUT.pdf, accessed 12 August 2018.

54 Leong L, 'The 'Rail plus Property' model: Hong Kong's successful self-financing formula', McKinsey & Company, Briefing, June 2016, https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-rail-plus-property-model, accessed 12 August 2018.

capable of handling 45 million 20-foot equivalent units (TEU) of freight by 2040. Even by the end of 2017, Shanghai Port reported that it had set a new world record by handling 40 million TEUs in one year, putting it on track to achieve its 2040 goal.[55]

Shanghai Port is operated by Shanghai International Port Group, which is a joint venture with major shareholders, including the Shanghai Municipal Government, China Merchants International Terminals and Shanghai Tongsheng Investment Group Corporation, coordinating activities across various areas of the port.[56] In addition to its aviation and rail components, the port comprises three major parts: the Wusongkou area (the oldest port area in Shanghai, now serving as a cruise ship terminal), the Waigaoqiao area (construction starting in 1991, handling containerised traffic) and the Yangshan Deep Water Port, the newest and most advanced addition to the port complex.

The Yangshan Deep Water Port was built on reclaimed land and islands in deep water between 2001 and 2015. It is served by a 30km sea bridge, facilitating the loading and unloading of over 15 million TEU shipping units in 2015. Operated by Shanghai Shengdong International Container Terminal Company, the port has 34 container quay cranes and 120 gantry cranes. The Phase I terminal, which opened in December 2005, operates at a water depth of 16m and has five berths. In the first year of its operation, the terminal handled 3.1 million TEU. Phase II opened for operation in December 2006, adding four more berths and an additional capacity of 2.1 million TEU, while Phase III, comprising seven additional berths, was completed in 2010. The fourth and final phase of development, which began pilot operations in late 2017, saw the installation of seven berths with a handling capacity of between 4 million and 6.3 million TEU. Significantly, Phase IV is a completely automated container handling facility, meaning that there will be no staff on site. While gantry cranes will be operated remotely by people, the almost complete automation means that the operational costs of Phase IV will be lower than that of other ports, and the danger of worker injury or death will be significantly reduced.[57]

Green technology and a green integrated port

In addition to being a leader in overall capacity, Shanghai Port has prioritised the minimisation of port operations' environmental impact on urban Shanghai. Several technological and organisational decisions reduce air pollution and energy consumption in Shanghai by improving the efficiency of the port. These interventions reduce both the environmental impact of the products being shipped and the costs.

55 The Maritime Executive, 'Shanghai port sets new world record', 1 January 2018, https://www.maritime-executive.com/article/shanghai-port-sets-new-world-record#gs.hYeN4Qo, accessed 26 November 2018.

56 Ship Technology, 'Port of Shanghai', https://www.ship-technology.com/ projects/portofshnaghai/, accessed 26 November 2018.

57 Xu W, 'Shanghai Yangshan Port kicks off project to become world's largest automatic deep-water container terminal', *Yicai Global*, 11 December 2017, https://www.yicaiglobal.com/news/shanghai-yangshan-port-kicks-project-become-world's-largest-automatic-deep-water-contain, accessed 26 November 2018.

FIGURE 2 THE YANGTZE RIVER DELTA DOMESTIC EMISSION CONTROL AREA

Note: Based on ICCT (International Council on Clean Transportation), 'Policy Update: Action Plan for Establishing Ship Emission Control Zones in China', May 2016, https://www.theicct.org/sites/default/files/publications/China ECZ Policy Update vF.pdf, accessed 26 November 2018

Source: Author

Most air pollutants at seaports come from just a few sources. The first source is ships coming to port to be loaded and unloaded. From tens of kilometres offshore, the particulate matter and sulphur dioxide emissions from ships can affect Shanghai's air quality. This worsens at port, when the ships are loaded and unloaded, because they burn heavy bunker oil to run on-ship operations. The second source of pollution is the service boats that guide ships into the port. The third is the gantry cranes that lift containers to and from ships, which often run on diesel. The final source is trucks and other ground handling equipment. These are also powered by diesel and frequently are the oldest vehicles in a national fleet because of their tendency to get damaged while being loaded or unloaded.

In response to these risks, the Chinese Ministry of Transport and Shanghai Port focused on greener technologies and port planning to reduce emissions and improve the efficiency and competitiveness of the port. Several specific initiatives have been put in place.

- **Domestic Emission Control Areas (DECAs):** The Ministry of Transport issued a notice in 2015 creating DECAs – designated areas for ships burning fuel that contain less than 5 000ppm (0.5%) sulphur, compared to traditional bunker fuels that contain more than 30 000ppm sulphur.[58] DECAs were implemented in three major coastal regions: the Pearl River Delta, Yangtze River Delta (of which Shanghai Port is a major component) and the Bohai Sea area. This policy will significantly reduce particulate matter emissions, which cause air pollution and lung and heart diseases in humans, and SO2 emissions, which cause acid rain. The Ministry of Transport has stated that it may consider requiring the use of 1 000ppm sulphur fuels in 2020, and expanding the geographical size of the DECAs.[59]
- **Offering shore power to ships at port:** Traditionally, when ships are at port, they run either their main engines or auxiliary engines to produce electricity for on-board operations. While cruise ships are particularly polluting because they burn bunker fuel to produce on-board electricity while at port, bulk cargo ships also contribute to emissions while being loaded and unloaded. Since 2010 the Ministry of Transport has focused on installing infrastructure at ports connecting ships to electricity sources on land. This allows them to shut down their engines. By 2018 Shanghai Port had installed 20 sets of shore power facilities covering 26 berths: seven container ship berths, two cruise ship berths, four power plant bulk commodity ship berths, six maintenance berths, six general purpose berths, and one project berth (of a total of 1 195[60]).[61] Installing this equipment is expensive, with each set costing CNY[62] 25 million (roughly $3.6 million) for container ship berths and CNY 50 million ($7.2 million) for cruise

58 People's Republic of China, Ministry of Transport, 交通运输部关于印发珠三角，长三角，环渤海（京津冀）水域船舶排放控制区实施方案的通知 ('Ministry of Transport Notice on Emission Control Area Implementation in the Pearl River Delta, Yangtze River Delta and Bohai Sea [Beijing-Tianjin-Hebei] Water Areas'), 4 December 2015, http://www.mot.gov.cn/2016wangshangzhibo/2016zhuanti2/xiangguanlianjie/201602/t20160201_1984227.html, accessed 26 November 2018.

59 Su S, 'A Clean air challenge for China's ports: Cutting maritime emissions', WRI (World Resources Institute), Blog Post, 24 October 2017, http://www.wri.org/blog/2017/10/clean-air-challenge-chinas-ports-cutting-maritime-emissions, accessed 26 November 2018.

60 Government of Shanghai, 二)港口、航道 ('Ports and routes'), 17 May 2018, http://www.shanghai.gov.cn/ nw2/nw2314/nw24651/nw43437/nw43454/u21aw1311590.html, accessed 26 November 2018.

61 Chen C & Z Xuan (eds.), 上海港打造"绿色航运"岸电方式值得推广 ('Shanghai creating "green shipping" shore power worth promoting'), People.cn, 6 June 2018, http://sh.people.com.cn/n2/2018/0606/c134768-31671199.html, accessed 26 November 2018.

62 Currency code for the Chinese yuan renminbi.

ship berths, and the Ministry of Transport is heavily subsidising this investment – up to 50% of the cost.[63] Shanghai has also committed to installing six additional power generators near Shanghai Port to serve this demand.[64]

However, using this service also requires ships to upgrade their systems – at significant cost – and electricity is provided to ships at normal commercial rates, which could be a financial burden on ships.[65] A subsidy supporting ships' using shore power may help defray these costs in the short term, but if this technology cannot survive without subsidies, it will not be successful.[66] Nonetheless, according to the Shanghai Clean Air Action Plan (2018–2020), 50% or more of berths for container ships, cruise ships of over 3 000 tonnes, and bulk freight ships of over 50 000 tonnes will be covered by this technology by 2020.[67]

- **Switching ships and shore vehicles to cleaner fuels:** Liquefied natural gas (LNG) is becoming an increasingly popular fuel for vehicles and ships that cannot use electric batteries. The Shanghai Clean Air Action Plan (2018–2020) notes that, by 2020, 90% of trucks in the Shanghai Port area will be converted to LNG.[68] In fact, Shanghai Port bought 194 LNG terminal tractors in 2017, and the conversion seems to be speeding up.[69] Shanghai International Port Group has established an LNG bunkering joint venture to provide LNG bunkering stations at Yangshan Deep Water Port and Waigaoqiao Port,[70] and was reported to have acquired 135 LNG-powered inland waterway vessels by 2017 to reduce emissions from the shipping sector along the Huangpu River.[71] Furthermore, gantry cranes at Shanghai port will likely be converted

63 People's Republic of China, Ministry of Transport, 关于靠港船舶使用岸电2016–2018年度奖励资金申请项目（第一批）的公示 ('Notice on the Application Period for Subsidy for the Use of Shore Power for Berthing Ships [2016–2018] First Batch)', 5 May 2017, http://zizhan.mot.gov.cn/zfxxgk/bnssj/zhghs/201705/t20170515_2204298.html, accessed 26 November 2018.

64 *Ship and Bunker*, 'Shanghai plans six more shore power generators for cruise terminals', 25 February 2016, https://shipandbunker.com/news/apac/922879-shanghai-plans-six-more-shore-power-generators-for-cruise-terminals, accessed 26 November 2018.

65 Chen C & Z Xuan (eds.), *op. cit*.

66 *Ship and Bunker*, *op. cit*.

67 Shanghai People's Government Office, 上海市清洁空气行动计划2018-2022年) ('Shanghai Clean Air Action Plan' [2018–2022]), 3 July 2018, http://www.shanghai.gov.cn/nw2/nw2314/nw2319/nw12344/u26aw56434.html, accessed 26 November 2018.

68 *Ibid.*

69 *NGV Global News*, 'Shanghai Port buys 194 LNG terminal tractors', 6 January 2017, https://www.ngvglobal.com/blog/ shanghai-port-buys-194-lng-terminal-tractors-0106, accessed 26 November 2018.

70 Jiang J, 'SIPG establishes LNG bunkering joint venture', *Splash247.com*, 22 July 2015, https://splash247.com/sipg-establishes-lng-bunkering-joint-venture/, accessed 26 November 2018.

71 Liang LH, 'Shanghai to see 135 LNG-fuelled inland vessels by 2017', *Seatrade Maritime News*, 22 September 2015, http://www.seatrade-maritime.com/news/asia/shanghai-to-see-135-lng-fueled-inland-vessels-by-2017.html, accessed 26 November 2018.

either completely to electricity or to diesel-electric hybrid motors that do not idle when they are not actively lifting containers. The 21 gantry cranes operating with hybrid technology will eliminate 5 300 metric tonnes of CO2 per year, equal to removing 1 143 cars from the road.[72]

- **Encouraging rail and inland waterway linkages at container ports:** Historically, Chinese ports have not made allowance for trains to be directly loaded at container ports. Instead trucks were used for port-to-customer service. Until recently the Chinese rail system was primarily oriented towards passenger service and bulk freight such as coal or grain.[73] Yet rail transport for container traffic is very energy efficient and inexpensive compared to truck freight. Shanghai Port made a start in 2007 with the construction of an intermodal transfer station at Luchaogang in Anhui province, located near the Yangshan Deep Water Port.[74] At that time, China planned to build 18 rail container terminals to shuttle goods across the country by train.

  However, until recent years this transformation has been relatively slow. Despite the national government's goal to move 10% of containers by rail by 2011, it had only achieved 1% by 2012.[75] The Shanghai Clean Air Action Plan (2018–2020) supports the further expansion of containerised rail freight from the port, and aims to have half of these containers delivered to the port via inland waterway – also a much more efficient mode of transport than trucks. In addition, the measure allows the expanded use of cleaner, LNG-powered transport as more inland waterway vessels are converted to LNG.[76]

Shanghai is moving towards both operating the world's largest port complex and making it increasingly efficient and environmentally responsible. By using automation, emission control areas, fuel switching and on-shore power for ships, and improving transport systems to support on-shore container transport, the region could increase its competitiveness for the foreseeable future.

However, competition is increasing dramatically between ports in China as the country's industry moves further west, and as containerised traffic decreases as China moves away from a manufacturing economy. There is also overcapacity in the port services sector. Shanghai Port, like others in the region, will have to demonstrate the benefits of green port infrastructure and continuously upgrade to keep attracting clients.

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72 The Maritime Executive, 'Port of Shanghai installs hybrid gantry cranes', 12 January 2016, https://www.maritime-executive.com/corporate/hybrid-rubber-tired-gantry-cranes-to-be-installed-in-port-of-shanghai#gs.QdcxRwU, accessed 26 November 2018.

73 Miller M, 'Port competition in southern China heats up', *American Journal of Transportation*, 631, 8 August 2016, https://www.ajot.com/premium/ajot-port-competition-in-southern-china-heats-up, accessed 26 November 2018.

74 Miao Q, 'Shanghai leads the way in shipping-railway transport', *China Daily*, 2 June 1997, p. 4.

75 Miller M, *op. cit*.

76 Shanghai People's Government Office, *op. cit*.

Urban rail systems in China

Urban rail has been hailed around the world as the optimum mode of urban public transport, providing clean, electric-powered, efficient transport above and below ground, and responding as urban populations grow and demand for mobility increases. The most famous urban rail systems in the world – the underground metros of London, Paris, New York, Hong Kong and Tokyo – have been expanded for decades, and their value has been proven through higher urban density, lower dependency on automobiles and less congestion in cities.

China's metro rail systems had a relatively late and slow start compared to these countries. Its first subway system debuted in Beijing in 1969, in the form of a single east–west line along the axis of the city. This was followed by a ring line around the city centre in 1971. Beijing's subway system added more lines only in 2002, when the city started its rapid expansion. Today, Beijing's subway system is the world's busiest, averaging nearly 10 million trips per day.[77] Shanghai's metro only started operations in 1993, and expanded quickly to become the longest metro system in the world at 666km as of March 2018, with plans to increase to 830km by 2020.[78]

After decades of slow growth, Chinese urban rail has grown dramatically over the last 15 years. By the end of December 2017, 34 cities were operating urban rail systems, including underground metros, light rail and tram systems and monorail systems (among other niche technologies), with a total track length of 5 021.7km – 868.9km longer than in late 2016. At the end of 2017 underground metro accounted for 77.3% of urban rail lines in China, with 3 881.8km in operation. There are also 476.8km of light rail and tramway (9.4% of the total), 98.5km of monorail (2%) and 58.8km of maglev lines (1.2%).[79]

The cost of these metro systems is high. Estimates of the metro rail development in Shanghai's cost per kilometre ranged from CNY 500 million (roughly $73 million) to CNY 700 million ($102 million) per kilometre in suburban areas, and up to CNY 1.3 billion ($190 million) per kilometre downtown. Costs increase in tandem with the cost of labour in mainland Chinese cities. This means that investment requirements are starting to take a toll on the ability of Chinese cities to develop urban rail.[80] High costs are putting some rail developments at risk, particularly in cities that cannot take on the debt required to finance

77 Ji X (ed.), 北京地铁全网客流再创历史纪录逼近1270万 ('Beijing subway total network ridership sets new record – nearly 12.70 million'), Chinanews.com, 1 May 2016, http://www.chinanews.com/cj/2016/05-01/7854979.shtml, accessed 26 November 2018.

78 *Bendibao.com*, 上海地铁2020年底运营里程将达830公里 最新地铁规划图公布 ('Shanghai subway operating length to reach 830 km by 2020 – newest subway plan map released'), 12 March 2018, http://sh.bendibao.com/traffic/ 2018312/191092.shtm, accessed 26 November 2018.

79 Barrow K, 'Chinese urban rail reaches 5 000km', *International Railway Journal*, 22 January 2018, http://www.railjournal.com/index.php/asia/chinese-urban-rail-reaches-5000km.html, accessed 26 November 2018.

80 Aldama Z, 'Shanghai metro: Keeping world's longest mass-transit rail system on track', *South China Morning Post*, 12 August 2017, https://www.scmp.com/magazines/post-magazine/

their construction. Operating these metro systems can also be a significant challenge for some cities. China's busiest metro system, in Beijing, is reported to have suffered a loss of \$558 million in 2013 through ticket price subsidies.[81]

Bloomberg reports that fixed-asset investment in rail transportation slowed to almost a standstill in 2017, increasing just 0.4% between January and October compared to a year earlier, and that rail projects in Baotou and Hohhot, inner Mongolia (projects worth CNY 30 billion [\$4.3 billion] and CNY 27 billion [\$3.9 billion] respectively) have been put on hold by the National Development and Reform Commission.[82]

While mainland metro rail projects struggle with debt and increasing costs, one rail network in China is one of the few in the world to support itself without government subsidies. The Mass Transit Railway (MTR) in Hong Kong is unique in that it owns the land development rights above its stations. As a result, when property values increase after railway construction, the MTR can profit and fund its own expansion and operation. In 2014 the MTR made a profit of HKD[83] 1.5 billion (about \$193 million in 2014) on this R+P model, while charging ticket prices that were much lower than in Tokyo, New York or Stockholm.[84] Once an agreement to build a station is made with the Hong Kong government, MTR pays for the land development rights and partners with private sector real estate developers to take advantage of the increased development density resulting from a new subway station. Revenues from R+P developments above stations along MTR's Tseung Kwan O line, for example, financed the extension of that line to serve a new town whose population has since grown to 380 000.

Collaboration with MTR is a possibility around the world. While Hong Kong's ultra-dense and public transit-oriented population makes this R+P model particularly successful, the company serves as many passengers outside Hong Kong as it does inside, through joint venture initiatives in China, Europe and Australia.[85]

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long-reads/article/2106229/shanghai-metro-keeping-worlds-longest-mass, accessed 26 November 2018.

81 Qi L, 'Fast, cheap and in the red: Beijing's subway system bled \$558 million last year', *The Wall Street Journal China Real Time Report*, 15 July 2014, https://blogs.wsj.com/chinarealtime/2014/ 07/15/fast-cheap-and-in-the-red-beijings-subway-system-bled-558-million-last-year/, accessed 26 November 2018.

82 *Bloomberg News*, 'Subways may be the latest casualty of China's crackdown on debt', 19 November 2017, https://www.bloomberg.com/news/articles/2017-11-19/subways-may-be-the-latest-casualty-of-china-s-crackdown-on-debt, accessed 26 November 2018.

83 Currency code for the Hong Kong dollar.

84 Leong L, 'The 'Rail plus Property' model: Hong Kong's successful self-financing formula', McKinsey & Company Briefing, June 2016, https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-rail-plus-property-model, accessed 12 August 2018.

85 Li S, 'Improving Railway Technologies and Efficiencies: The Case of China', Training Presentation, UN Center for Regional Development, Regional EST Training Course on Railways, Tokyo, 27 February 2018, http://www.uncrd.or.jp/content/documents/5929Presentation 2-Ms. Shanshan Li.pdf, accessed 12 August 2018.

The World Resources Institute's CityLab blog has also emphasised that rail systems – especially subway systems – are not the only solution for urban mass transit. The Guangzhou BRT system serves 800 000 users per day and has been credited for preventing 30 000 passenger car trips per day, increasing urban traffic speeds and avoiding the emission of 86 000 tonnes of CO_2 in its first 10 years of operation.[86] The BRT system was constructed at a cost of $4.4 million/km: only 1/10th of the cost of an equivalent subway system.

DISCUSSION AND POLICY SUGGESTIONS

In 2018 China celebrated 40 years of reforms. The success of that project and the efforts of millions taking advantage of new opportunities to become more prosperous, have taken China from economic isolation to the centre of the world economy. While this expansion was driven by official promotion incentives, state-owned infrastructure companies and banks, as well as an ambition to capture the country's demographic dividend, infrastructure was a key element in that success. However, this infrastructure was possibly dirtier than necessary.

Now, as a net outbound investor, China is interested in expanding infrastructure construction and connectivity across the world under the BRI. This focus falls in particular on today's 'poor and young' countries, where the lack of infrastructure is the most serious and a possible demographic dividend growth curve lies ahead. For China, this opens up direct and indirect opportunities for its own infrastructure and logistics services companies, as well as pathways via which it can internationalise its domestic financial sector. Moreover, given rapid population ageing in and lagging export demand from high-income countries, China also seeks to realise new and long-term investor dividends that contribute directly and indirectly (via unlocking new markets) to its future growth. This helps to explain why it wants to invest in infrastructure in Africa and beyond.

This paper attempted to extract lessons from China's own infrastructure experience for African policymakers to consider in their negotiations with Chinese (and other) investors.

- The mix of land value expense in infrastructure construction and land value gain capture from infrastructure investment is unique to each country context, but it has a significant impact on the sustainable financing of infrastructure. This mix should be reflected in African countries' planning for optimal sustainable financing.

- China's rapid expansion of infrastructure was driven by promotion incentives for officials, the availability of state finance and the presence of state-owned infrastructure firms. This infrastructure programme was intensive, but its financing was relatively opaque and hard to unpack. Such an intensive investment programme may not suit all

86 Poon L, 'China's subway boom slows down', *CityLab*, 26 February 2018, https://www.citylab.com/transportation/2018/02/chinas-subway-boom-slows-down/552935/, accessed 12 August 2018.

African economies, and a different institutional environment for financing may also require a different approach.

- China's infrastructure investments were focused initially on a few clusters along its coast that could deliver foreign exchange and attract foreign investment, and were directed at agricultural development and the alleviation of hunger. African infrastructure can follow a similar pattern, or start focusing earlier on intra-regional connectivity. The latter approach echoes a different set of Chinese infrastructure interventions, which focused on facilitating the transfer of goods and services to landlocked provinces via a centralised system based in Beijing. A similar approach could benefit Africa's landlocked countries, albeit not through a federal transfer system. Intra-regional priorities will be different and planning should be adapted accordingly.

China has accumulated immense experience in rail, port and metro rail development. It has proven the potential of metro rail to shape urban development while acting as the primary mode of transportation for millions of urban residents. Yet it has also experienced the financial risks that come with hastily built capital infrastructure projects. China has experienced cases where infrastructure drove up debt, and where revenues did not cover operational costs. African countries can learn from cities such as Hong Kong (and certain Japanese cities such as Tokyo) that offer metro systems development rights above their stations. These incentives have proven effective in leveraging private capital and increased property values to finance rail development and operations. At the same time, China has had other, less capital-intensive mass transit styles – including BRT systems that require minimal investment and could still make use of property development schemes to increase value, or elevated monorail systems that are faster to implement and energy efficient.

African countries can learn from cities such as Hong Kong and Tokyo that offer metro systems development rights above their stations. These incentives have proven effective in leveraging private capital and increased property values to finance rail development and operations

In this paper, three case studies were examined: HSR, the Shanghai Port, and urban rail projects. One obvious lesson to take from these examples is the importance of rail in transport development. Rail is a key technology for transportation, for both people and goods and within and between cities. It is clean, efficient, predictable and comfortable, and should be a transportation priority before personal vehicles, trucks or aviation. Yet railways are expensive to build, and this cost needs to be considered in the context of what a particular country or city can support economically. There are technologies that mimic rail, which can be considered as countries and cities develop. BRT systems provide a fast, efficient transport service at a fraction of the cost of rail systems. Elevated monorail systems are also less capital intensive and quicker to build, and can kick-start urban mass transit.

The private sector can also be an important driver in establishing mass transit systems. Giving transit companies development rights around their stations allows them to attract private investment. These added developments around stations draw more passengers into the transit system, while bringing higher value to public transit companies. Cities around the world are starting to experiment with this business model, perfected in Hong Kong and Japan, to pay for efficient mass-transit systems. It could provide a key means for some African cities to redefine their urban fabric, attract private investment and create healthy, walkable, liveable communities.

Waterborne transport is another key means of reducing emissions from transportation. Shanghai Port has become the largest port in the world by centralising manufacturing and import–export regulatory responsibility along the Yangtze River Delta. By developing infrastructure at the mouth of the Yangtze River, the port became a major driver of economic development up the river. Upstream ports can load goods onto riverboats or barges using efficient waterborne transport and quickly transfer them to ocean-going freighters. The city of Shanghai has also recognised the pollution threat of ships' burning dirty fuel. Perhaps the most significant policy to manage air pollution from port activity has been to put in place the DECAs, to ensure that ships near Shanghai burn clean fuel.

China offers many lessons on the importance of infrastructure in economic development. It also shows how important it is to choose the right transportation infrastructure

China offers many lessons on the importance of infrastructure in economic development. It also shows how important it is to choose the right transportation infrastructure. These lessons can be taken from both its successes and failures. Much can be learned from China's efforts to address mistakes made in the past, or to take advantage of technological advances. China is now interested in contributing to the development of infrastructure in Africa. Africa has an opportunity to take crucial lessons on how China used infrastructure to make the most of its demographic dividend and maximise development. African leaders would be wise to focus on the details of what China did (and did not do) well, and to take advantage of new technological gains. This paper drew a few environmental lessons for Africa from China's development experience. This is only a first step, and much more can be learned from China's experience of financing its infrastructure construction and maintenance programme, and the additional incentives it put in place to make this infrastructure greener. If Africa wants its youth to lead development, these lessons provide a crucial road map. They also facilitate a discussion about more innovative and generous financing strategies for African development, given the important global environmental value of the region's forests and wildlife.

That said, not all of China's experiences can be applied to other contexts. Hence, it is also key that BRI countries, Chinese infrastructure investors and co-financiers such as the World Bank and AfDB collaborate to emphasise experience relevant to the planning and construction of projects and bring forth affordable applications of global best practices.

APPENDIX 1: AFRICAN COUNTRIES BY SHARE OF YOUTH AND SHARE OF OLD, 2016 (%)

Country	Youth share		65+ share	
	1979	2016	1979	2016
Algeria	46.4	29.0	3.5	6.0
Angola	47.4	47.0	2.6	2.3
Benin	44.6	42.9	4.4	3.2
Botswana	46.8	31.6	2.5	3.8
Burkina Faso	45.4	45.4	3.2	2.4
Burundi	44.4	44.9	3.3	2.5
Cabo Verde	47.5	30.7	5.1	4.4
Cameroon	44.5	42.9	3.7	3.2
Central African Republic	42.2	43.5	4.1	3.7
Chad	44.8	47.4	3.5	2.5
Comoros	44.8	40.0	3.2	2.9
Congo, Democratic Republic of	44.6	46.3	2.9	3.0
Congo, Republic of	44.9	42.4	3.8	3.4
Côte d'Ivoire	45.6	42.6	2.5	2.9
Djibouti	47.2	31.6	2.3	4.2
Egypt	41.0	33.5	4.4	5.1
Equatorial Guinea	38.9	37.4	4.3	2.9
Eritrea	44.3	n.a.	2.6	n.a.
Ethiopia	45.0	41.1	3.1	3.5
Gabon	38.9	35.9	6.2	4.5
Gambia, The	44.8	45.5	3.0	2.3
Ghana	45.8	38.7	2.6	3.4
Guinea	41.6	42.5	3.2	3.1
Guinea-Bissau	42.8	41.6	3.6	2.9
Kenya	50.0	40.9	3.1	2.6
Liberia	44.8	42.1	2.6	3.0
Libya	48.1	28.4	2.8	4.4
Lesotho	44.5	35.5	4.1	4.5
Madagascar	46.2	41.3	3.4	2.9
Mali	44.0	47.8	3.2	2.5
Mauritania	45.5	40.1	2.8	3.1
Mauritius	36.0	18.9	3.4	10.4
Malawi	47.2	44.3	2.4	3.0
Morocco	43.8	27.6	3.3	6.6
Mozambique	44.3	45.0	3.0	3.1
Namibia	46.3	36.9	3.5	3.5

Niger	48.2	50.2	1.9	2.5
Nigeria	44.0	44.1	2.8	2.7
Rwanda	47.8	40.5	2.4	2.9
São Tomé and Príncipe	47.6	43.2	4.7	2.9
Senegal	46.2	43.0	2.6	3.0
Seychelles	38.9	22.0	6.5	8.4
Sierra Leone	43.1	42.4	3.1	2.5
Somalia	44.0	46.5	3.1	2.7
South Africa	41.1	29.2	3.6	5.2
South Sudan	44.6	41.9	2.6	3.5
Sudan	47.1	41.2	2.9	3.5
Swaziland	48.7	37.4	2.7	3.1
Tanzania	46.6	45.1	2.6	3.1
Togo	46.3	41.8	2.9	2.8
Tunisia	42.1	23.9	3.9	7.8
Uganda	47.4	48.0	2.6	2.2
Zambia	47.8	45.1	2.7	2.5
Zimbabwe	49.1	41.4	3.0	2.8
Pre-demographic dividend	45.5	44.2	2.9	2.8
Early-demographic dividend	41.3	29.6	3.7	5.5
Late-demographic dividend	35.3	19.0	5.3	10.0
Post-demographic dividend	23.3	16.2	11.6	18.4
China	36.7	17.7	4.6	10.1

Source: World Bank, 'World Development Indicators', 2018, http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators&, accessed 29 November 2018

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