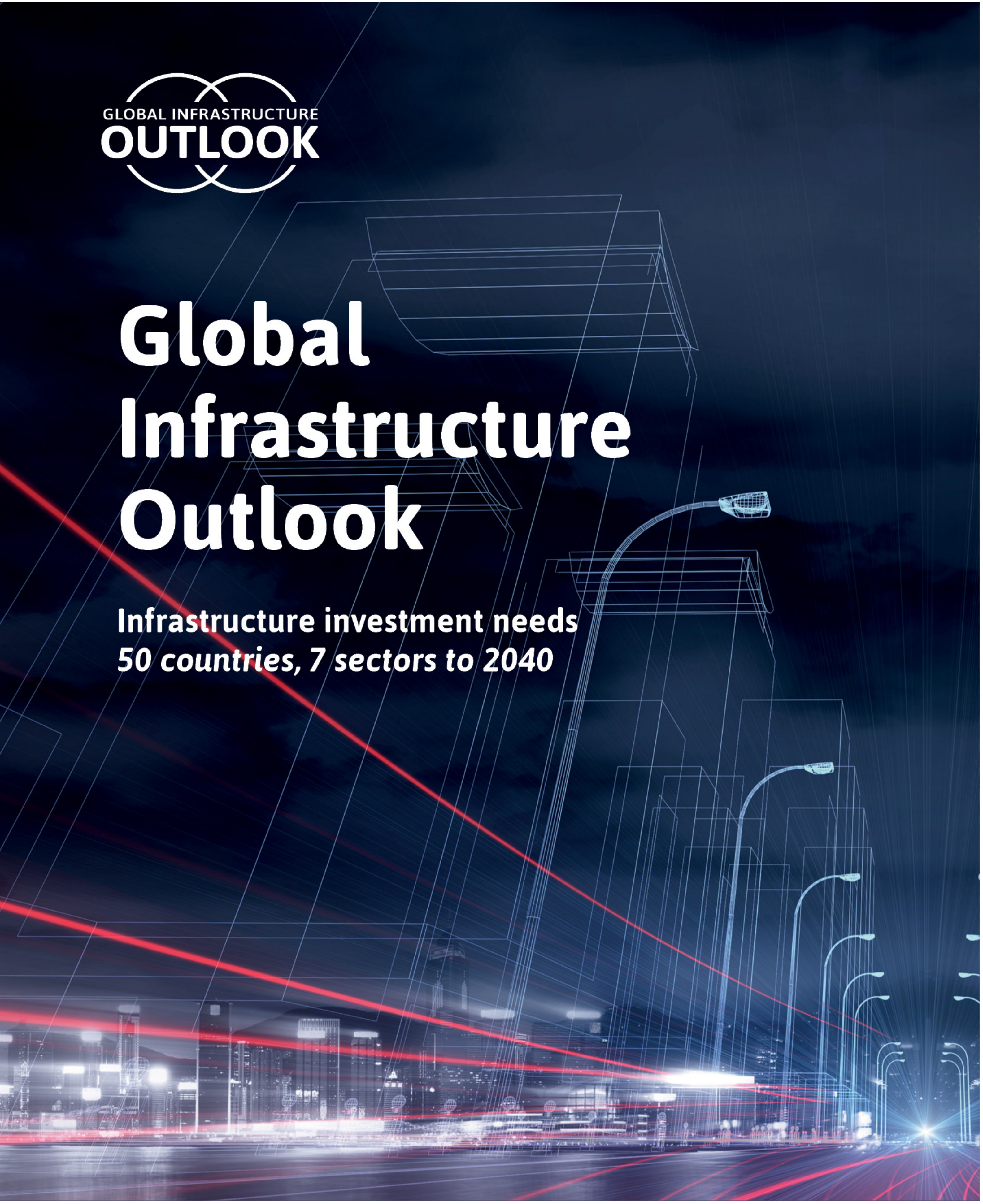

GLOBAL INFRASTRUCTURE OUTLOOK

Global Infrastructure Outlook

Infrastructure investment needs
50 countries, 7 sectors to 2040

OXFORD ECONOMICS

Global Infrastructure Hub
A G20 INITIATIVE

Oxford Economics

Oxford Economics was founded in 1981 as a commercial venture with Oxford University's business college to provide economic forecasting and modelling to UK companies and financial institutions expanding abroad. Since then, we have become one of the world's foremost independent global advisory firms, providing reports, forecasts and analytical tools on 200 countries, 100 industrial sectors and over 3,000 cities. Our best-of-class global economic and industry models and analytical tools give us an unparalleled ability to forecast external market trends and assess their economic, social and business impact.

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July 2017

The modelling and results presented here are based on information provided by third parties, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

Acknowledgements

In undertaking this research Oxford Economics has drawn on insights and knowledge developed through earlier research into infrastructure spending undertaken in conjunction with PwC.[1] We would therefore like to acknowledge PwC's contribution to the underlying intellectual property for this work.

We would like to extend our thanks to the peer reviewers from the following organisations who provided a large number of helpful comments and suggestions: Australian Treasury, The Brattle Group, European Bank for Reconstruction and Development, Inter-American Development Bank, International Monetary Fund, and the University of Cape Town.

[1] PwC and Oxford Economics, Capital project and infrastructure spending outlook: Agile strategies for changing markets (2016).

FOREWORD

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CHRIS HEATHCOTE
CHIEF EXECUTIVE OFFICER
GLOBAL INFRASTRUCTURE HUB

GLOBAL INFRASTRUCTURE OUTLOOK (OUTLOOK) IS A DETAILED REVIEW AND ANALYTICAL TOOL THAT ENABLES GOVERNMENTS, BUSINESSES AND INFRASTRUCTURE ORGANISATIONS TO COMPREHENSIVELY ANALYSE AND PREDICT INFRASTRUCTURE INVESTMENT REQUIREMENTS ACROSS THE GLOBE OVER THE NEXT 25 YEARS.

Globally, the need for infrastructure investment, is forecast to reach $94 trillion by 2040, and a further $3.5 trillion will be required to meet the United Nations' Sustainable Development Goals for electricity and water. Outlook reveals where investment is most likely to fall short, and therefore where the needs are greatest, across 50 countries and seven sectors. It considers what investment is needed and what is likely to occur based on a range of factors, such as a country's historic infrastructure spending levels and how its population and economy is changing, hence identifying investment gaps.

The findings are compelling. For instance, Asia has the largest overall need, requiring just over 50% of global investment in infrastructure, however the region is forecast to have a relatively small investment gap. The picture is very different in other regions where investment gaps are more prominent.

The Americas and Africa, by contrast, are forecast to have proportionally much larger infrastructure investment gaps. In these regions investment gap is 32% and 28% respectively of investment need. Africa's investment gap is forecast to widen further to 43%, if investment need includes SDGs.

Quantifying country-level needs is a powerful and positive step. These insights will help governments identify and respond to infrastructure needs, and guide opportunities for private sector investors.

Many countries are increasingly focussed on the role of infrastructure to improve economic growth and community wellbeing. With the right information, policy leadership and supportive financing environments the investment gaps highlighted in this report can be successfully addressed.

Outlook provides that information to help in identifying and funding the effective infrastructure plans to support stronger economic growth and more prosperous and liveable communities.

IAN MULHEIRN
DIRECTOR OF CONSULTING
OXFORD ECONOMICS

INFRASTRUCTURE IS THE BEDROCK OF ECONOMIC GROWTH AND PRODUCTIVITY BUT A LACK OF CONSISTENT AND DETAILED, HISTORICAL DATA HAS HINDERED INVESTMENT PLANNING.

Responding to this, our study explores how, where and when infrastructure investment will be needed in the coming decades, addressing a major knowledge gap. It represents the culmination of a year-long research project, during which we have worked closely with our partners at the Global Infrastructure Hub.

Our brief was a challenging one: to produce forecasts of infrastructure spending and need for seven sectors across 50 countries. Our study seeks to estimate how much the world needs to spend on infrastructure in the years to 2040, and in which countries and sectors this investment will be required. It identifies the countries that appear to be on the right track, and by contrast, the countries that need to do more. This report explores infrastructure needs from the perspective of different countries and sectors—building roads in Nigeria is a very different task to improving rail in Japan. To our knowledge, no previous study has published estimates and forecasts of infrastructure investment in this level of granularity. We therefore hope the study brings the global infrastructure challenge into sharper relief than ever before.

The findings are the result of a major data collection and econometric analysis exercise, drawing on information from 50 or so separate datasets, alongside the development of bespoke models to produce estimates for countries and sectors where no data could be identified.

The findings are the result of a major data collection and econometric analysis exercise, drawing on information from 50 or so separate datasets, alongside the development of bespoke models to produce estimates for countries and sectors where no data could be identified.

This innovative study will be of interest not just to those within the infrastructure sector, but to policymakers and practitioners the world over who are concerned with how to boost productivity and improve living standards. The report also proves a valuable addition to the growing body of research into global infrastructure needs.

CONTENTS

Executive summary

ACROSS THE GLOBE, A WELL-FUNCTIONING, MODERN INFRASTRUCTURE IS CENTRAL TO ECONOMIC DEVELOPMENT AND TO QUALITY OF LIFE. FROM THE ROADS AND RAILWAYS NEEDED TO TRANSPORT PEOPLE AND GOODS, TO THE POWER PLANTS AND COMMUNICATIONS NETWORKS THAT UNDERPIN ECONOMIC AND HOUSEHOLD ACTIVITY, TO THE BASIC HUMAN NEED FOR CLEAN WATER AND SANITATION, INFRASTRUCTURE MATTERS TO PEOPLE AND BUSINESS EVERYWHERE.

Infrastructure investment is crucially important for the most advanced economies and those at the early stages of development alike. In developing economies, as roads are built, reliable electricity installed and clean water made available to all, infrastructure can have a truly transformative impact on the lives of citizens and the prospects of businesses. In more mature economies too, keeping pace with demand, and building new and upgraded infrastructure, is integral in efforts to sustain economic growth.

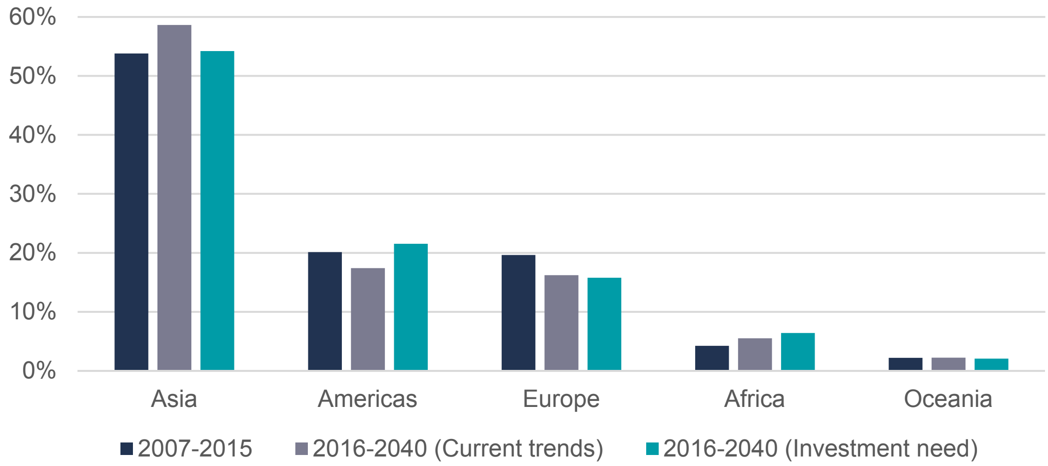
Attempts to track and monitor infrastructure investment, however, and to break this down by sectors and countries, and over time, are limited. This has made it difficult to predict how, where and when investment is most needed. This study addresses this knowledge gap. It explores how much the world needs to invest in infrastructure in the years to 2040, and in which sectors this investment will be needed. It considers the countries that appear to be on the right track, and identifies those that need to do more.

As well as exploring how infrastructure investment will develop based on current trends, this study adopts an innovative approach to assess infrastructure needs based on comparison with countries' best performing peers. The granularity this study provides is unique: it collates data and creates forecasts for seven sectors in 50 countries, over a period of 25 years.

We estimate global infrastructure investment needs to be $94 trillion between 2016 and 2040. This is 19 percent higher than would be delivered under current trends, and is an average of $3.7 trillion per year. To meet this investment need, the world will need to increase the proportion of GDP it dedicates to infrastructure to 3.5 percent, compared to the 3.0 percent expected under current trends.

Asia will dominate the global infrastructure market in the years ahead as it does at present. Asia accounts for some 54 percent of global infrastructure investment needs to 2040, compared to 22 percent for the Americas, the next largest region. Indeed, just four countries account for more than half of global infrastructure investment requirements to 2040: China, the US, India and Japan. China alone is estimated to account for 30 percent of global infrastructure needs.

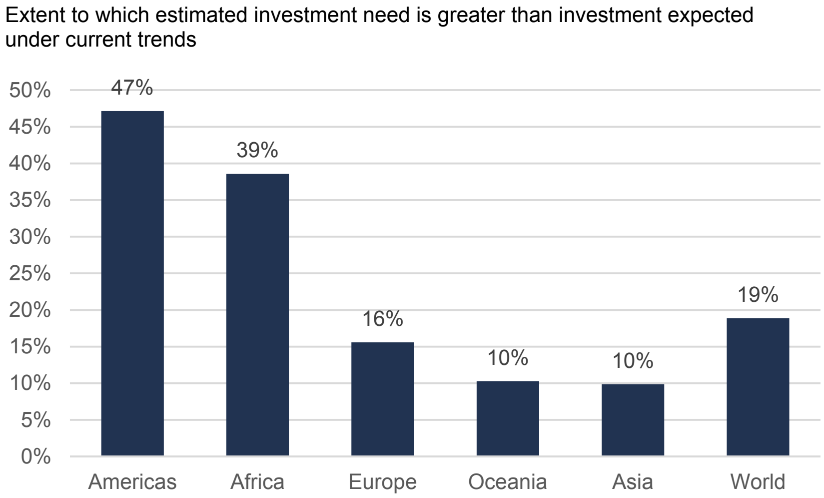
Fig. 1. Regional share of global infrastructure investment, 2007-2040



Source: Oxford Economics

The infrastructure investment gap is proportionately largest for the Americas and Africa. Comparing our forecasts of infrastructure need to what would be delivered under current trends enables us to estimate the infrastructure investment 'gap'. Our analysis suggests that investment needs in the Americas are 47 percent greater than forecast investment under current trends. For Africa the equivalent figure is 39 percent. While the latter offers considerable growth potential, the African infrastructure market remains small in absolute terms: the region accounts for 6 percent of global infrastructure investment need.

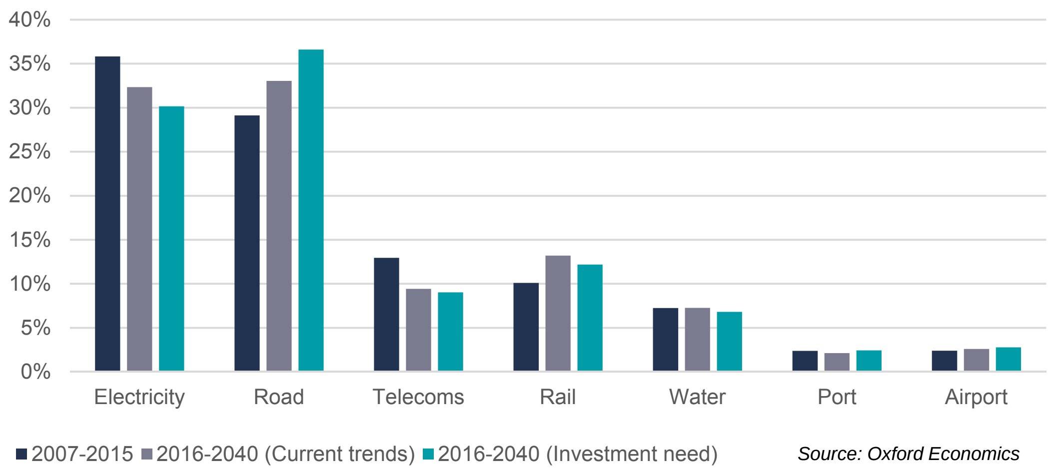
Fig. 2. Infrastructure investment gap by region, 2016-2040



Source: Oxford Economics

Electricity and roads are the two most important sectors—together they account for more than two-thirds of global investment needs. The investment gap between the two scenarios is greatest in the roads sector, where investment needs are 31 percent higher than would be delivered under current trends. The gap is also relatively large for ports and airports, where investment needs are 32 percent and 26 percent greater than our current trends forecast, respectively.

Fig. 3. *Sectoral share of global infrastructure investment, 2007-2040*



Source: Oxford Economics

If GDP growth is higher than forecast, the requirement for infrastructure will be higher still. We also, therefore, explored a scenario under which global GDP growth is assumed to be 0.4 percentage points higher for the duration of the forecast period. Under this scenario, the total global spending requirement for 2016 to 2040 would be some $9-10 trillion, or 11 percent more.

Meeting the UN Sustainable Development Goals for universal access to drinking water, sanitation and electricity by 2030 increases the global infrastructure need by a further $3.5 trillion by 2030. We find that meeting the SDGs for drinking water and sanitation will require investment of $1.9 trillion, while providing universal access to electricity by 2030 will be particularly challenging for the world's poorest countries, requiring some $3.9 trillion of investment. To meet these objectives, the total global infrastructure investment need to 2030 would be some $3.5 trillion higher than in our main scenario, equivalent to an additional 0.3 percent of world GDP.

Countries all over the world need to invest heavily in infrastructure to meet the needs of their citizens and underpin productivity throughout their economies. This study provides a detailed analysis of the countries and sectors where this investment will be needed. It represents a timely and significant addition to the debate.

Table 1: Global investment needs, 2016-2040

% OF GDP	CURRENT TRENDS (CT)	INVESTMENT NEED (IN)	GAP (IN - CT)	SDG (REQUIREMENT OVER AND ABOVE IN)*
ROAD	1.0%	1.3%	0.3%	
ELECTRICITY	1.0%	1.1%	0.1%	0.2%
RAIL	0.4%	0.4%	0.0%	
TELECOMS	0.3%	0.3%	0.0%	
WATER	0.2%	0.2%	0.0%	0.1%
AIRPORTS	0.1%	0.1%	0.0%	
PORTS	0.1%	0.1%	0.0%	
ASIA	4.0%	4.4%	0.4%	0.3%
AMERICAS	1.7%	2.5%	0.8%	0.1%
EUROPE	2.3%	2.6%	0.4%	0.0%
AFRICA	4.3%	5.9%	1.7%	3.4%
OCEANIA	3.5%	3.8%	0.4%	0.0%
WORLD	3.0%	3.5%	0.6%	0.3%

*2016-2030

1. Introduction

1.1 CONTEXT AND RATIONALE FOR THE STUDY

Infrastructure is critical for economic and social development the world over. At the most basic human level, people need access to clean, safe water for drinking and cooking, and power for lighting and heating their homes. Roads and railways allow people to get to work and provide for their families. This transport infrastructure, as well as sea ports and airports, allows firms to reach the markets they need to trade their goods and services, including across international boundaries. In these ways, and many more, infrastructure is vital to quality of life and economic development.

Infrastructure investment is of major importance in both developed and developing economies. For the latter, the impact can be seismic—transforming an economy and the prospects for its citizens as roads are built and utilities put in place. But in more mature economies too, where evidence suggests that returns to investment are more in line with other types of capital investment, keeping pace with infrastructure needs remains integral to sustaining economic growth—whether through new investment or upgrading of existing provision.[2]

Infrastructure affects economic growth in two central ways—by directly boosting activity and by underpinning productivity. In the former, simply constructing and operating new or upgraded infrastructure supports economic activity, boosting demand for goods and services and providing jobs. Much more fundamentally, however, infrastructure underpins productivity throughout an economy. Good quality roads and railways, for example, make it easier, cheaper and faster to transport goods and people, while airports and sea ports connect firms across international boundaries, facilitating trade and investment. Reliable electricity, water and telecoms infrastructures enable firms to function efficiently and without disruption, and support wider goals, such as those related to the environment. All this means that even in the most advanced economies, if infrastructure capacity does not increase in line with economic and demographic growth, it can instead act as a drag on progress.

Yet, there is often a tendency to under-invest in infrastructure, even in developed economies with strong institutions. Several factors are at play that explain this.[3] Firstly, infrastructure typically involves making large up-front investments, while returns may take decades to accrue. Secondly, the risk of uncertain returns can make raising finances challenging. This is the case even in countries with well-functioning capital markets and, particularly, where technologies are changing quickly. Thirdly, the benefit to society of an infrastructure project may often be greater than the private returns generated for the operator (infrastructure creates so-called 'positive externalities'). As a result infrastructure may be under-provided if left to the market. These challenges are often addressed through government regulation, or direct government provision of infrastructure (sometimes with a private sector partner), meaning government policy is

[2] National Infrastructure Commission, *Economic growth and demand for infrastructure services* (London, 2017).

[3] IMF, World Economic Outlook: Legacies, Clouds, Uncertainties (Washington, 2014).

decisive. But, this exposes infrastructure investment decisions to a fourth explanatory factor—that short-term political considerations and government borrowing constraints may hinder consistent long-term planning and investment.

This report sets out to explore the extent of infrastructure investment expected in the coming decades as well as the extent to which provision could be increased if countries raised their game to match their best performing peers. We also present separate estimates of the costs of meeting the UN Sustainable Development Goals for universal access to electricity, water and sanitation.

1.2 STUDY OBJECTIVES

The importance of infrastructure is widely recognised and well researched, but there have been relatively few attempts to track and monitor infrastructure investment across countries. Where studies have assessed global infrastructure needs, the adoption of myriad definitions and approaches has made it difficult to monitor trends over time on a consistent basis.[4] In addition, very few studies provide detailed forecasts for individual countries and sectors.

The lack of consistent and detailed historical data presents problems in forecasting how, where and when infrastructure investment will be needed. This, in turn, means it is hard for investors to identify where there is likely to be strong demand. Consequently, access to funding may be constrained, often in countries and sectors where it is most needed.

This study seeks to address this knowledge gap. It asks how much the world needs to spend on infrastructure in the years to 2040, and in which countries and sectors this investment will be required. It identifies the countries that appear to be on the right track, and by contrast, the countries that may wish to do more.

We assess future infrastructure investment requirements under two main scenarios. Firstly, we examine how investment would develop if **current trends** continue, to understand how much countries are likely to spend in the years ahead.

Secondly, we estimate an '**investment need**' forecast based on the investment that would occur if countries were to match the performance of their best performing peers. This is after controlling for differences in the economic and demographic characteristics of each country, and taking into account the current quality of infrastructure. Peers are identified as other countries within the same income group,

[4] See, for example, PwC and Oxford Economics, Capital project and infrastructure spending outlook: Agile strategies for changing markets (2016); McKinsey Global Institute, Bridging Global Infrastructure Gaps (2016); Asian Development Bank, Meeting Asia's Infrastructure Needs (Manila, 2017); OECD, Strategic transport infrastructure needs to 2030, main findings (Paris: OECD, 2011); Marianne Fay and Tito Yepes, Investment in infrastructure: what is needed from 2000 to 2010? (World Bank Policy Resesarch Working Papers, 2003).

enabling us to benchmark countries' infrastructure needs against the observed performance of other countries at a similar stage of development.[5]

The difference between the two scenarios enables us to estimate the **investment gap** for each country and sector.[6] A full explanation of our methodology and data sources is presented in the technical appendix.

Work in this area is not, however, without challenges. In particular, there is no single, consistent source of data on infrastructure investment by country and sector. To overcome this, we have compiled a new dataset based on around 50 sources, complemented with our own estimations to fill gaps. Our results should therefore be treated with a degree of caution, particularly in areas where data are poorest,[7] and they should not be regarded as a substitute for more detailed country-specific analysis.

We do, nonetheless, hope that the innovation we bring to the subject area will stimulate debate and discussion, and that our approach may be refined and updated as new and better sources of information emerge.

1.3 COVERAGE

We have collected data and produced forecasts for seven infrastructure sectors in 50 countries. The full dataset has been published alongside this paper, enabling governments, investors and other stakeholders to explore the findings and undertake their own analysis.

Our data and forecasts relate to capital expenditure on both new and replacement infrastructure, but exclude ongoing operation and maintenance costs.

Values throughout the report are presented in US dollars at 2015 prices and exchange rates, unless otherwise stated.

[5] While an implicit underlying assumption of our analysis is that 'more is better', we protect against the risk of encouraging inefficient over-investment in two ways. Firstly, we benchmark performance against the 75th percentile of each peer group to avoid linking the forecasts to countries with unusually high rates of investment and, secondly, we take account of current infrastructure quality so that our model does not propose large amounts of additional investment where provision is already good.

[6] A simplifying assumption within our analysis is that a country will need to invest more to close its infrastructure gap. That is, our forecasts implicitly assume that the efficiency of investment remains constant. In reality it may sometimes be possible to increase infrastructure provision by increasing the efficiency, rather than the volume, of investment.

[7] The Technical Appendix provides details of the sources and quality of data available for each country and sector

SECTORS AND COUNTRIES INCLUDED IN THE STUDY

The research covers seven infrastructure sectors as outlined below[8]:

- Roads, including roads and bridges
- Railways—fixed assets which form an integral part of rail networks, such as tracks, signalling and stations, including urban rail networks
- Airports—fixed infrastructure such as terminals, runways, aprons, etc.
- Sea ports—fixed infrastructure for sea ports
- Electricity, including generation, transmission and distribution[9]
- Water, including infrastructure used for the collection, treatment, processing and distribution of water and sewerage
- Telecommunications—physical infrastructure required for the provision of fixed line, mobile and broadband services

Countries were primarily selected to ensure coverage across world regions and income groups. The latter are based on World Bank definitions. In total, the 50 countries included in the study account for more than 85 percent of world GDP.

Throughout this report we report regional totals. Except where otherwise stated, we scale up the findings for the individual countries within a region using GDP data. For example, if our countries account for 50 percent of regional GDP, our estimates are multiplied by a factor of two to estimate the regional total. The world total is calculated as the sum of these scaled regional totals.

Fig. 4. *Countries included in the study by region and income group*

	AFRICA	AMERICAS	ASIA	EUROPE	OCEANIA
LOW AND LOWER MIDDLE INCOME	Egypt Ethiopia Kenya Morocco Nigeria Senegal Tanzania		Bangladesh Cambodia India Indonesia Myanmar Pakistan Philippines Vietnam		
UPPER MIDDLE INCOME	Angola South Africa	Argentina Brazil Colombia Ecuador Mexico Paraguay Peru	Azerbaijan China Jordan Kazakhstan Malaysia Thailand Turkey	Romania Russia	
HIGH INCOME		Canada Chile United States Uruguay	Japan Saudi Arabia Singapore South Korea	Croatia France Germany Italy Poland Spain United Kingdom	Australia New Zealand

[8] Here we present our preferred definition of each sector. However, the precise coverage for each country and sector will vary according to what is captured within the underlying data sources.

[9] We decided to exclude natural gas distribution infrastructure. Experience from earlier research suggests that data can be particularly difficult to obtain for this sector.

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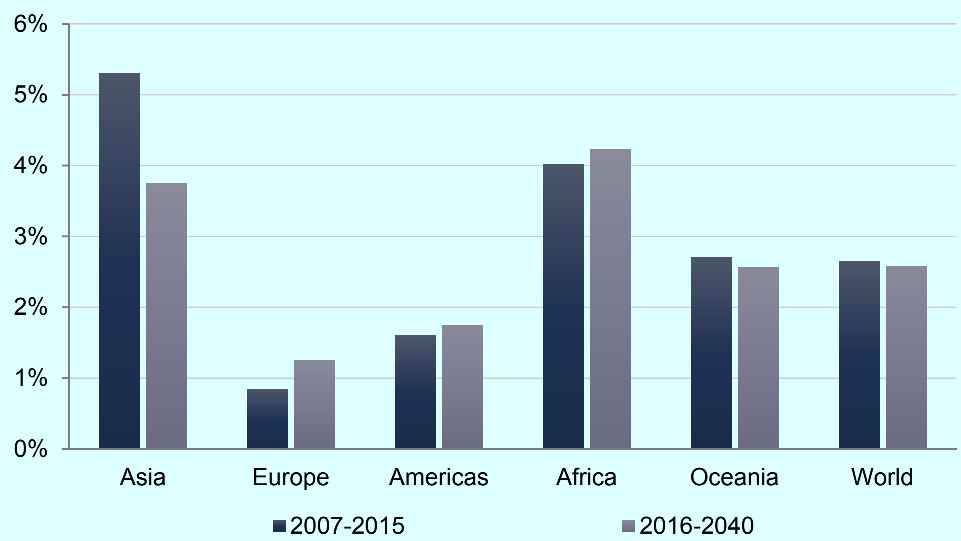
GLOBAL ECONOMIC GROWTH OUTLOOK

Future infrastructure investment need is closely linked to the rate at which an economy grows. As incomes and populations grow, businesses demand more power and water to support their production processes, and have a growing need for transport infrastructure to move people and goods. Similarly, economic growth drives demand for household utilities, and for travel to access work and leisure.

As such, forecasts of economic and demographic variables are crucial in understanding how the requirement for infrastructure will develop over the coming years. A country that faces major population increases over the next 25 years, for example, is likely to need to invest more heavily to provide for that population boost than one in which the population is expected to stagnate.

The analysis in this box provides an overview of the assumptions that underpin the forecasts that are the focus of the study. It gives a sense of the relative economic importance of the five regions we consider and how that is changing over time. Details for each of the individual countries are presented in section 0.

Fig. 5. Average annual GDP growth by world region, 2016-2040

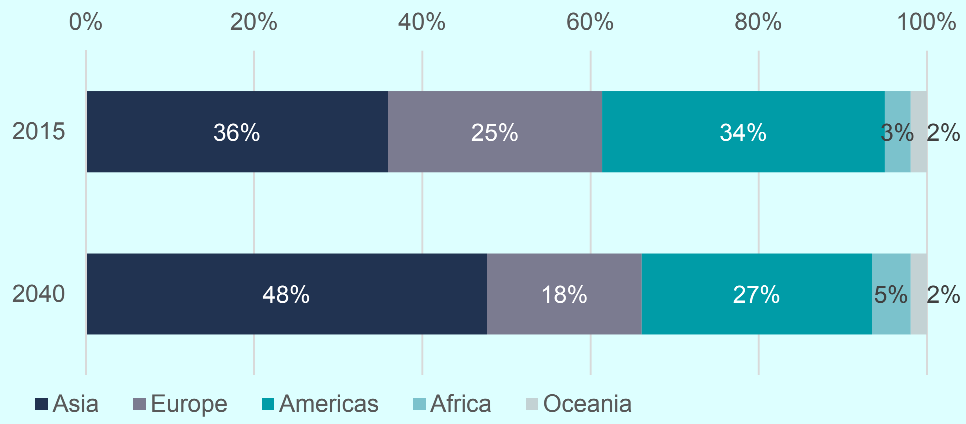


Source: Oxford Economics

The past decade has seen growth rates in Asia outstrip other regions of the world. Forecasts of GDP, taken from Oxford Economics' Global Economic Model, suggest that the rate of growth in Asia is likely to ease a little in the period to 2050, from an average of 5.3 percent over the last decade, to an average of 3.7 percent. Nonetheless, the region is expected to account for almost half of global GDP by 2040, with obvious implications for the need for accompanying infrastructure investment.

Growth in Europe is expected to pick up slightly through to 2040, but to remain weaker than the other regions at around 1.3 percent per year. At 4.2 percent per year, Africa is expected to achieve the fastest average GDP growth rate over the next 25 years, though is still expected to account for only 4.6 percent of the world economy in 2040.

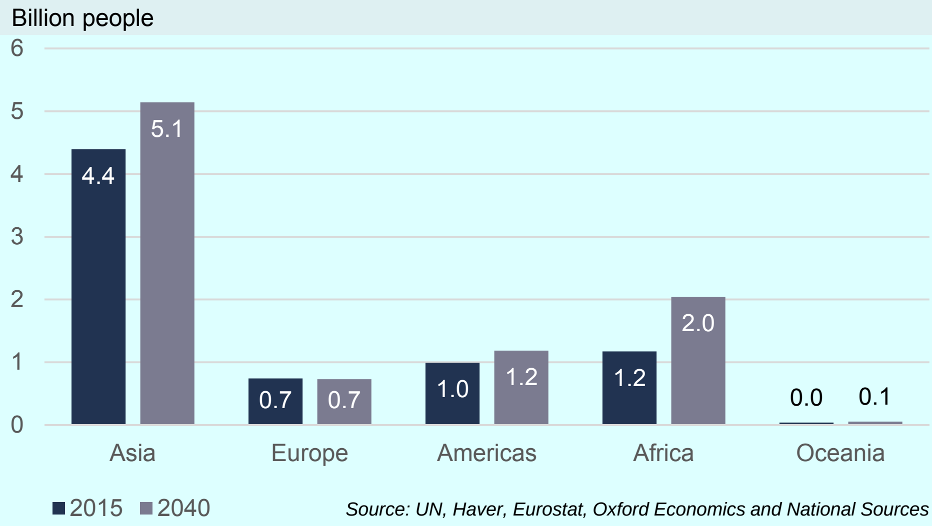
Fig. 6. *Regional shares of world GDP, 2015 and 2040*



Source: Oxford Economics

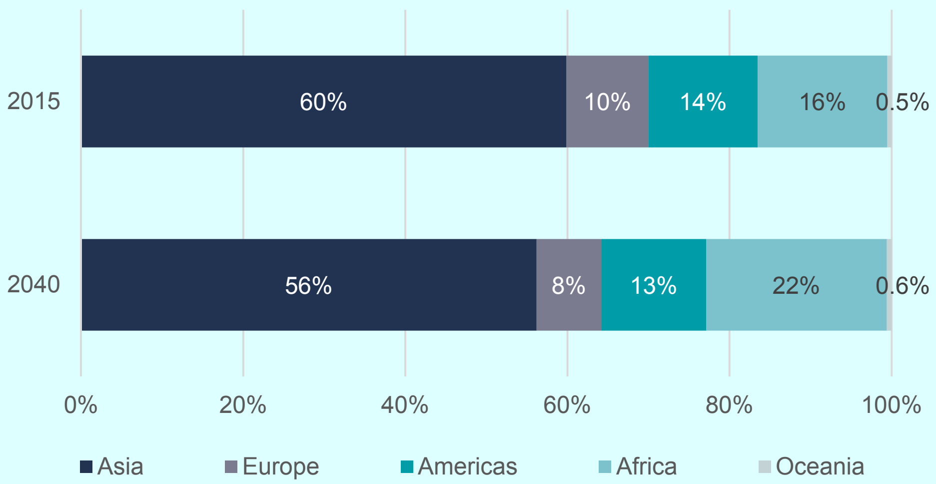
It is not just economic growth that matters. Demographic changes are also central in determining infrastructure demand, and are of course intricately linked with economic growth prospects. For example, Africa's relatively strong rate of economic growth will be supported by very strong population growth: the continent's population is expected to exceed two billion by 2040—an increase of almost 75 percent over the 2015 figure of 1.2 billion people. This will see the continent's share of world population increase from 16 percent to 22 percent by the end of the forecast period. The second strongest rate of population growth is expected in Oceania, where the number of inhabitants is forecast to reach 54 million by 2040, an increase of 40 percent, although in this case the region's share of world population will increase from 0.5 percent to 0.6 percent. In Europe, population growth is expected to stall in the period to 2040, at around 700 million people.

Fig. 7. Population by world region, 2015 and 2040



Source: UN, Haver, Eurostat, Oxford Economics and National Sources

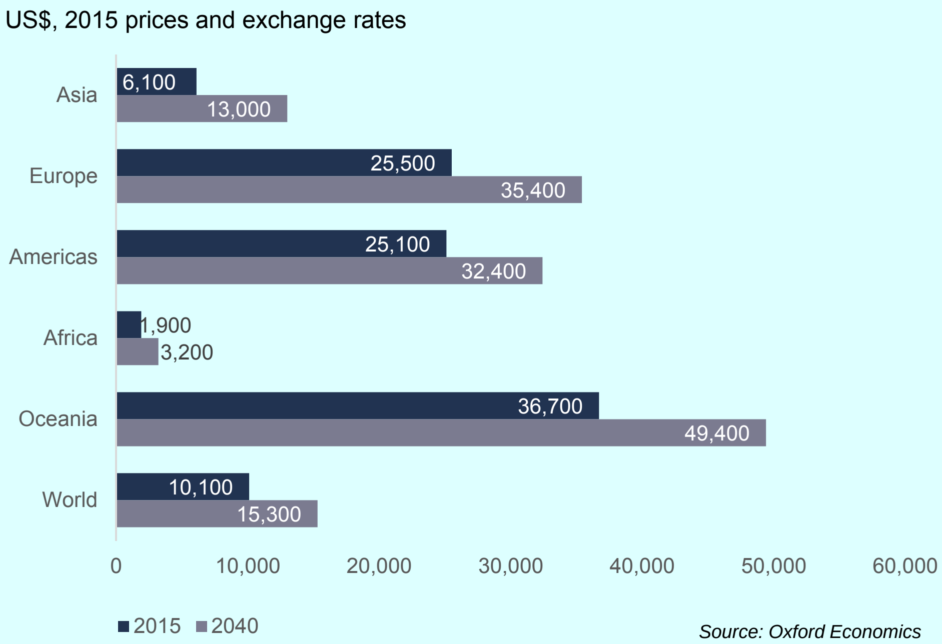
Fig. 8. Share of population by world region



Source: UN, Haver, Eurostat, Oxford Economics and National Sources

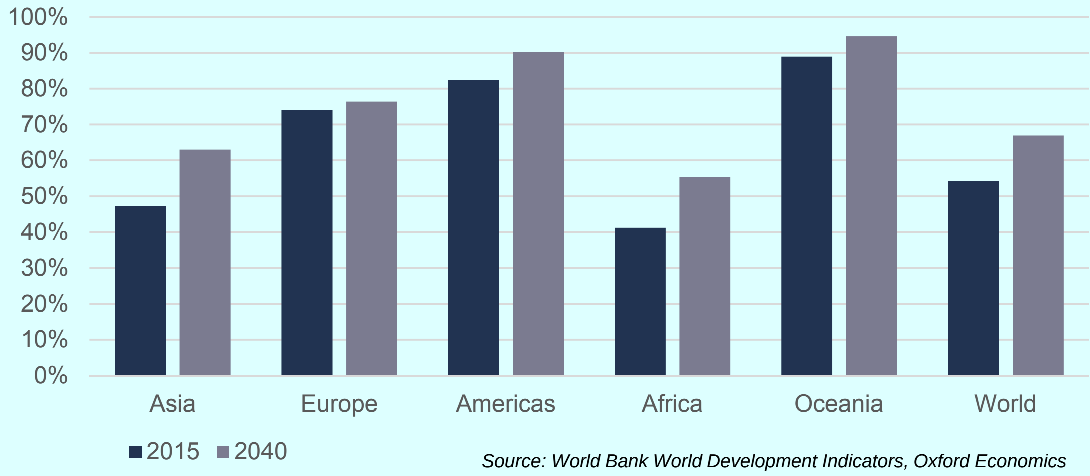
Combining the forecasts for GDP and population enables us to derive forecasts for GDP per head. We can use this measure to understand how average income levels change over time, after allowing for population growth, and to compare income levels across countries of different sizes. On this basis, the strongest rate of growth is expected in Asia, where GDP per head is forecast to double over the next 25 years. Nonetheless, by the end of the forecast the average for Asia will still only be around half of the current level in Europe. Likewise, while our forecasts suggest GDP per head in Africa will increase by almost 70 percent, the 2040 level for Africa will still only be just over half the 2015 average for Asia.

Fig. 9. *GDP per head by world region, 2015 and 2040*



As well as the overall rate of population growth, the *distribution* of a country's residents plays an important role in determining the amount and type of infrastructure needed. As countries become more prosperous, residents tend to gravitate towards urban areas to take advantage of the economic and social opportunities they offer. Urbanisation is projected to continue across all regions, but be strongest in regions where income levels are lower as the proportion of the population living in urban areas increases towards the high urbanisation rates observed in the Americas and Oceania.

Fig. 10. Share of population living in urban areas, 2015 and 2040[10]



Source: World Bank World Development Indicators, Oxford Economics

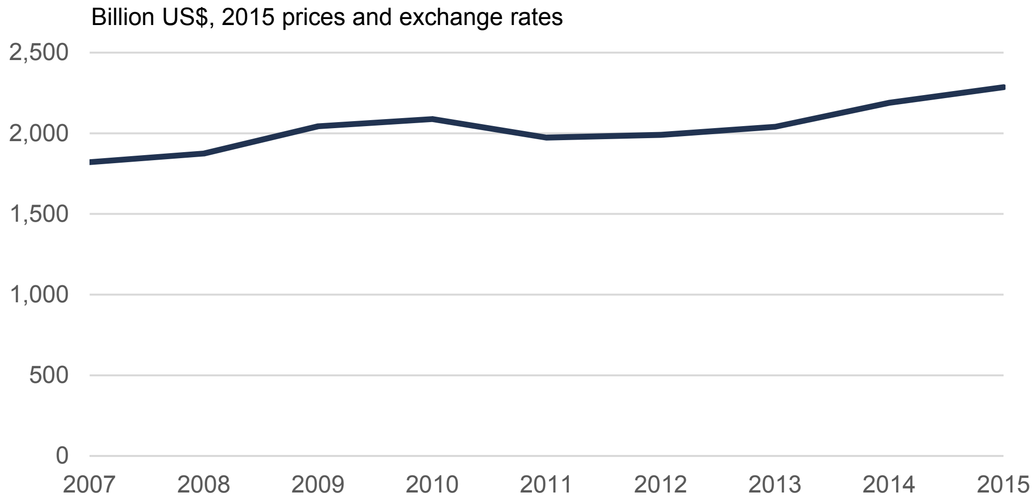
These trends are particularly important for this study because urbanisation is often accompanied by an increase in the proportion of the population able to access utilities. Higher population densities reduce the cost of supplying each household, while city dwellers typically benefit from higher wages and are better able to pay for both access to utilities, and the domestic appliances which rely on a reliable electricity and water supply. Alongside this, rising urban populations typically stimulate city planning activity, leading to increased investment in road and public transport infrastructure.

[10] Based on the 50 countries in the study

2. Recent trends in infrastructure spending

Before presenting our forecasts of future infrastructure investment requirements, we briefly review trends in infrastructure spending in recent years, based on the data collected for this study. We estimate that global infrastructure spending across the seven sectors included in our study has gradually increased from $1.8 trillion in 2007 to $2.3 trillion in 2015. This represents an average annual growth rate of 2.9 percent per year.

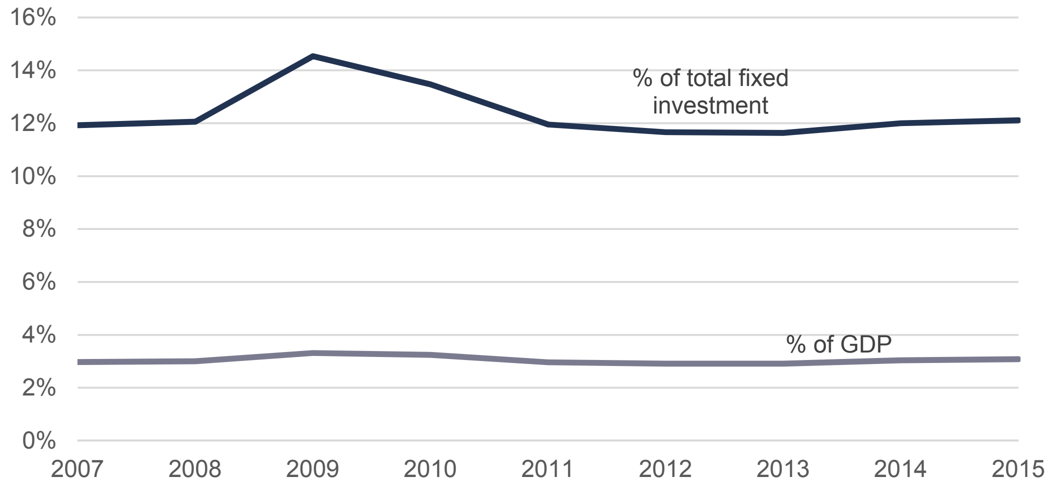
Fig. 11. *Global infrastructure spending 2007-2015*



Source: Oxford Economics

As a proportion of world GDP, global infrastructure spending has remained broadly constant at around three percent over the last decade. It has also accounted for around 12 percent of total global investment over most of this period, although it did rise to almost 15 percent of total investment in 2009 as infrastructure spending was sustained against a backdrop of falling investment in other parts of the economy. This reflects that infrastructure projects are long-term in their nature, meaning that infrastructure spending takes longer to respond to changing economic circumstances than business investment. As such, while overall investment growth bottomed-out in 2009, infrastructure spending growth did not reach its minimum until 2011.

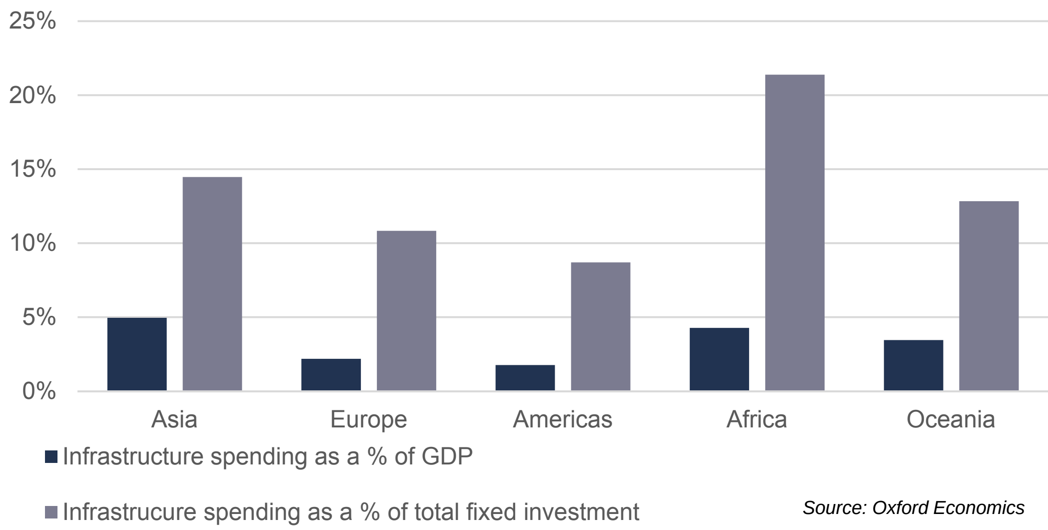
Fig. 12. *Global infrastructure spending as a proportion of GDP and total fixed investment, 2007-2015*



Source: Oxford Economics

By region there is considerable variation in the proportion of total fixed investment dedicated to infrastructure. Just over 20 percent of total fixed investment in Africa is dedicated to infrastructure, compared to nine percent in the Americas.

Fig. 13. *Regional infrastructure spending as a proportion of GDP and total fixed investment, 2007-2015*[11]

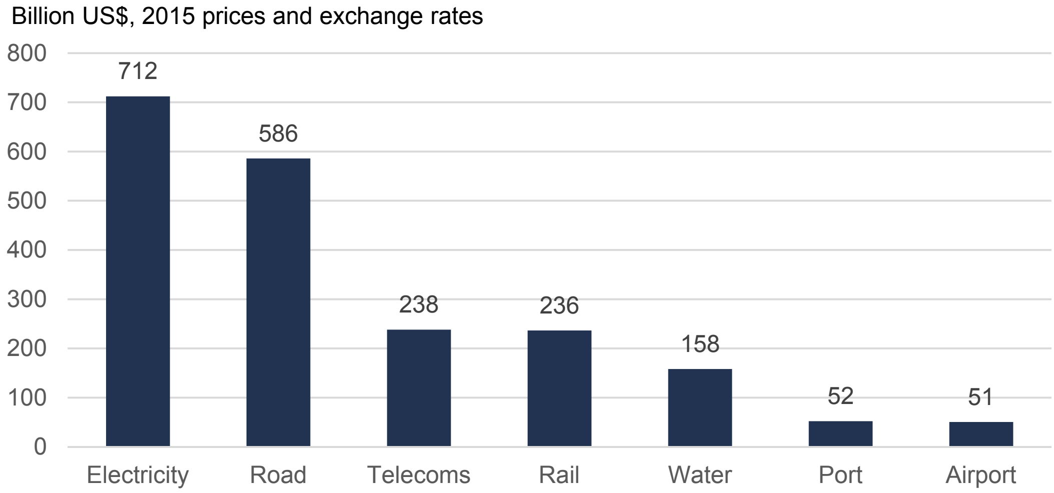


Source: Oxford Economics

[11] Based on the 50 countries in our study

Since 2007, global infrastructure spending has tended to be dominated by two sectors: electricity and roads, which account for almost two-thirds of total spending. Telecoms and rail have each contributed around one-eighth of total spending, and a similar amount comes from investment in water, ports and airports combined. The structure of infrastructure spending has remained largely consistent over the period since 2007, although growth of 33 percent in investment in the electricity sector enabled it to slightly increase its share of the total from 34 percent in 2007 to 36 percent in 2015.

Fig. 14. *Average annual investment by sector, 2007-2015*

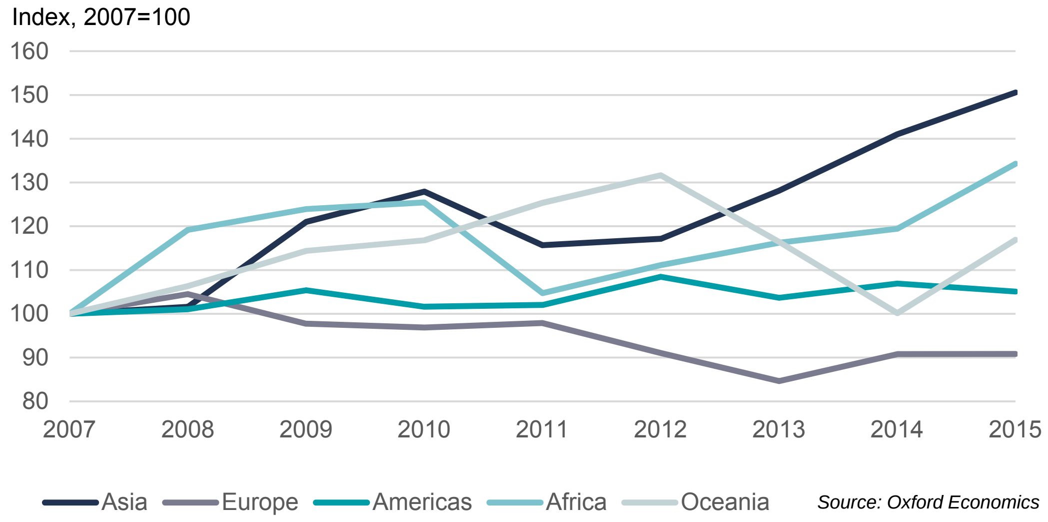


Source: Oxford Economics

Changes in the structure of global infrastructure spending are more apparent when data are viewed in terms of geography. Infrastructure investment in Asia increased by more than 50 percent between 2007 and 2015. China alone contributed more than half of this increase. In contrast, spending in Europe fell back between 2007 and 2015, partly in response to the constrained state of government finances.[12]

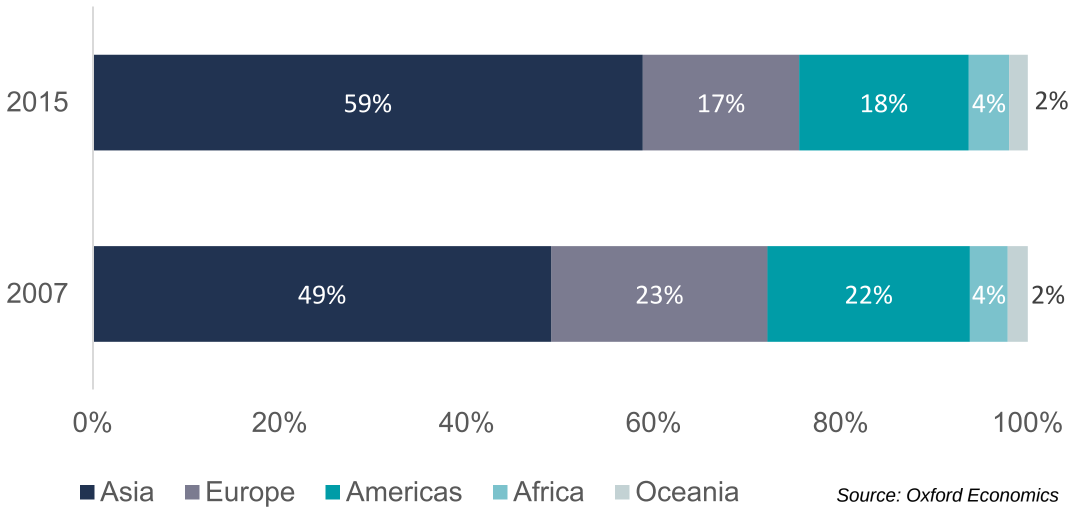
[12] Government investment fell in each year between 2010 and 2014 in real terms

Fig. 15. Regional infrastructure investment, 2007-2015



As a result of these trends, Asia lifted its share of global spending from 49 percent to 59 percent between 2007 and 2015. The fall in infrastructure spending recorded in Europe during this period meant that the region's share of the global infrastructure market fell by six percentage points.

Fig. 16. Share of global infrastructure investment by region, 2007-2015



3. Global infrastructure needs to 2040

The main objective of this study is to understand how much the world needs to spend on infrastructure in the years to 2040, given what we can anticipate in terms of economic and demographic changes, and in which countries and sectors this investment will be required.

Here we present the headline findings of our research for the world, sectors and regions, identifying the countries that appear to be on the right track, and by contrast, the regions that need to do more. First, we explore the global picture, before turning to a more detailed analysis of individual regions, and their constituent countries in sections five to nine. The full dataset of forecasts by country and sector is published alongside this paper to facilitate more detailed research.

As set out in section one, throughout this and subsequent sections, we present two sets of forecasts for global infrastructure investment:

- baseline forecasts to reflect infrastructure investment under the assumption that countries continue to invest in line with **current trends**, with growth occurring only in response to changes in each country's economic and demographic fundamentals; and
- an '**investment need**' forecast to demonstrate the investment that would occur if countries were to match the performance of their best performing peers, after controlling for differences in the characteristics of each country.

Within the commentary we also refer to the **'investment gap'**, which represents the difference between a country's investment need, and what would be spent under current trends.

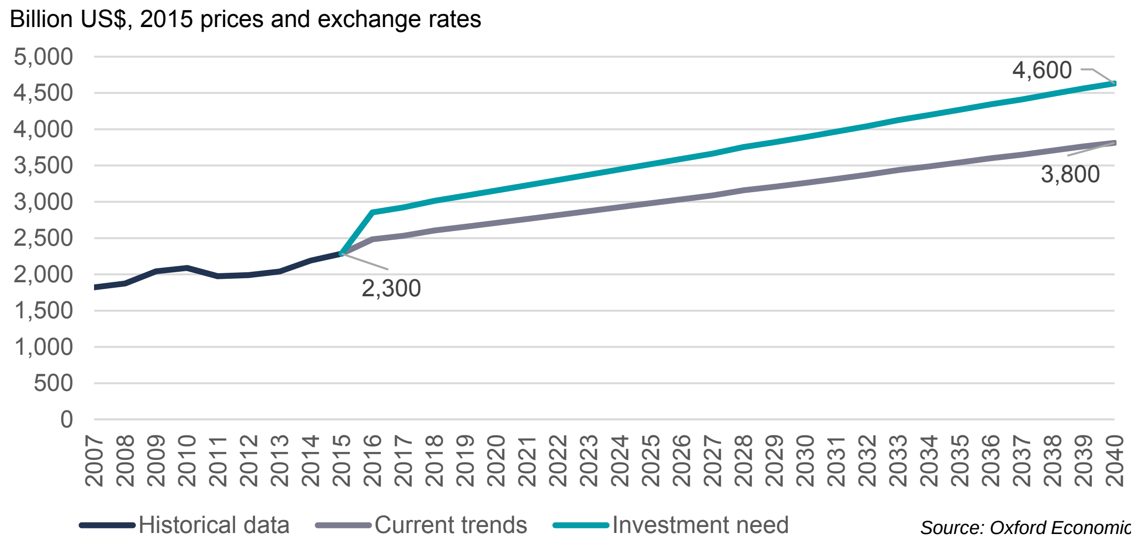
Further details of our approach, including how we assess and uplift the current trend forecasts to determine investment needs are presented in the technical appendix.

3.1 GLOBAL OVERVIEW

Our analysis suggests that if current trends continue, global infrastructure investment will reach $3.8 trillion in 2040, an increase of 67 percent over the 2015 value, in real terms. This reflects the economic growth and demographic shifts that are forecast over the timeframe to 2040, as explored in the previous chapter, and based on Oxford Economics' Global Economic Model.

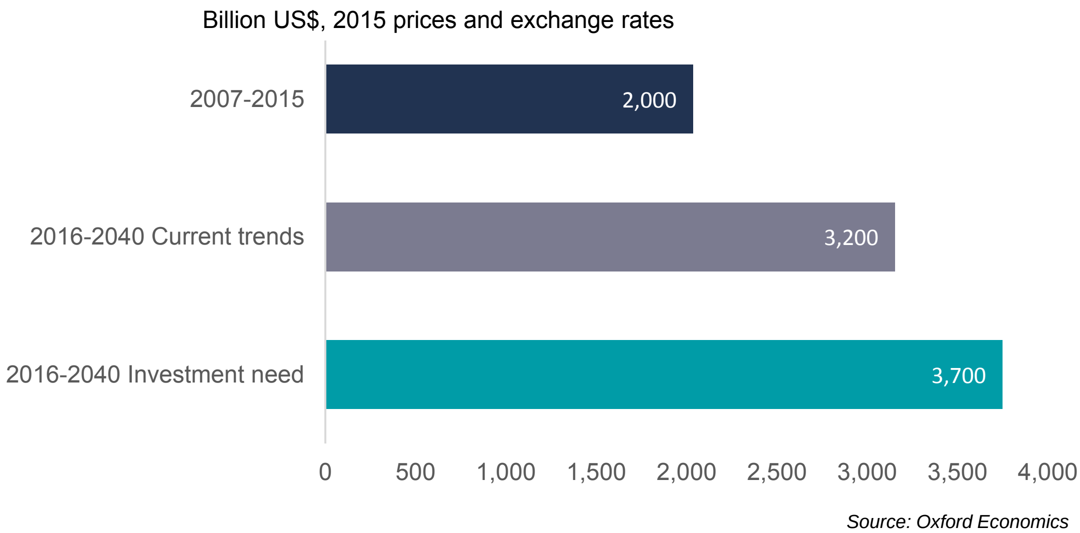
However, if countries wish to raise their game to match their best performing peers in terms of the resources they dedicate to infrastructure, the forecast value of infrastructure investment need rises to $4.6 trillion in 2040. That is, by 2040 there could be a gap of $820 billion between what would be spent if current trends continue and what could be spent if all countries matched their best performing peers.

Fig. 17. Global infrastructure spending, 2007-2040



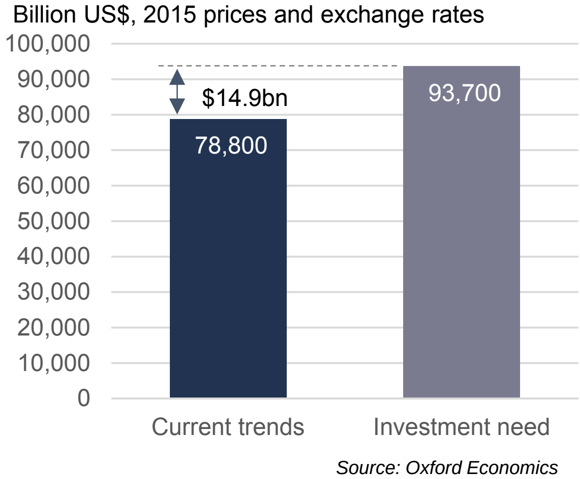
The current trends forecast is equivalent to an average of $3.2 trillion per year between 2016 and 2040, compared to $2.0 trillion between 2007 and 2015. Uplifting countries' spending to match best performing peers suggests an annual investment need of $3.7 trillion.

Fig. 18. Average annual global infrastructure spending requirement, 2016-2040



The cumulative value of global infrastructure investment under current trends over the entire forecast period is almost $79 trillion under the current trends scenario. This increases by 19 percent to almost $94 trillion under the investment need scenario.

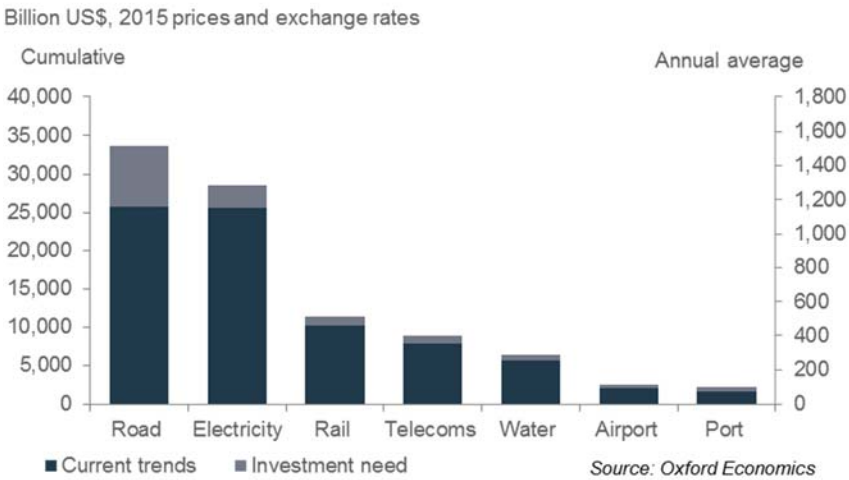
Fig. 19. Cumulative global infrastructure spending requirement, 2016-2040



3.2 OUTLOOK BY SECTOR

By sector, spending needs are greatest for electricity and roads, which together account for 65 percent of global infrastructure investment for the forecast period under the current trends scenario, or 67 percent under the investment need scenario. The gap between the two scenarios is proportionately greatest in the roads and ports sectors, where investment needs are just over 30 percent greater than the estimated spending under current trends. The gap is also relatively large for airports, where the spending requirement is 26 percent greater under the investment need scenario than under current trends.

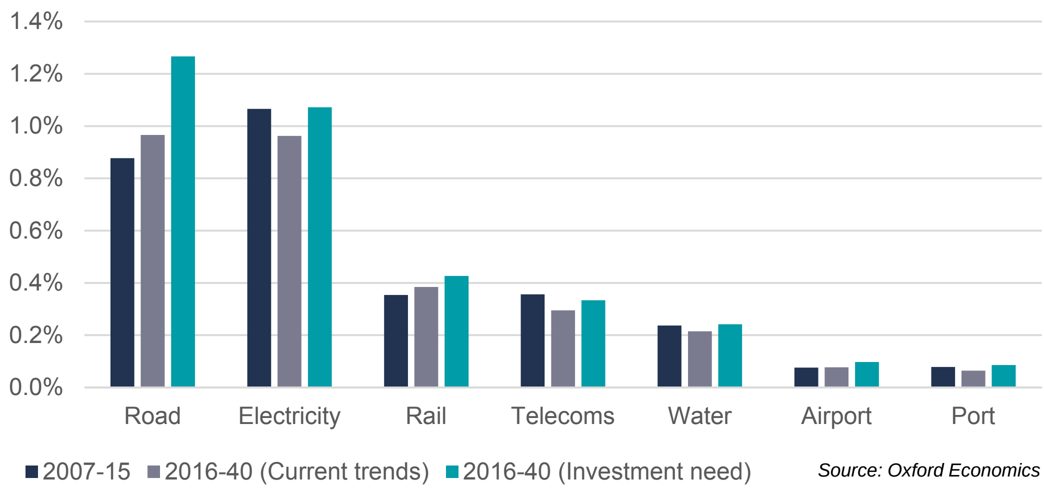
Fig. 20. Global investment requirements by sector, 2016-2040 cumulative (left scale) and annual average (right scale)



In absolute terms, we find that almost three-quarters of the $14.9 trillion global infrastructure gap between the two scenarios is attributable to the road and electricity sectors.

Our modelling suggests that under the current trends scenario, the world will need to continue to dedicate a similar proportion of GDP to infrastructure spending as in the past. This amounts to a total of 3.0 percent for the seven sectors combined. To deliver the infrastructure requirements identified by the more ambitious investment need scenario the proportion of GDP directed towards infrastructure investment would need to increase to 3.5 percent.

Fig. 21. *Global infrastructure spending by sector, percent of GDP, 2015 and 2040*



Source: Oxford Economics

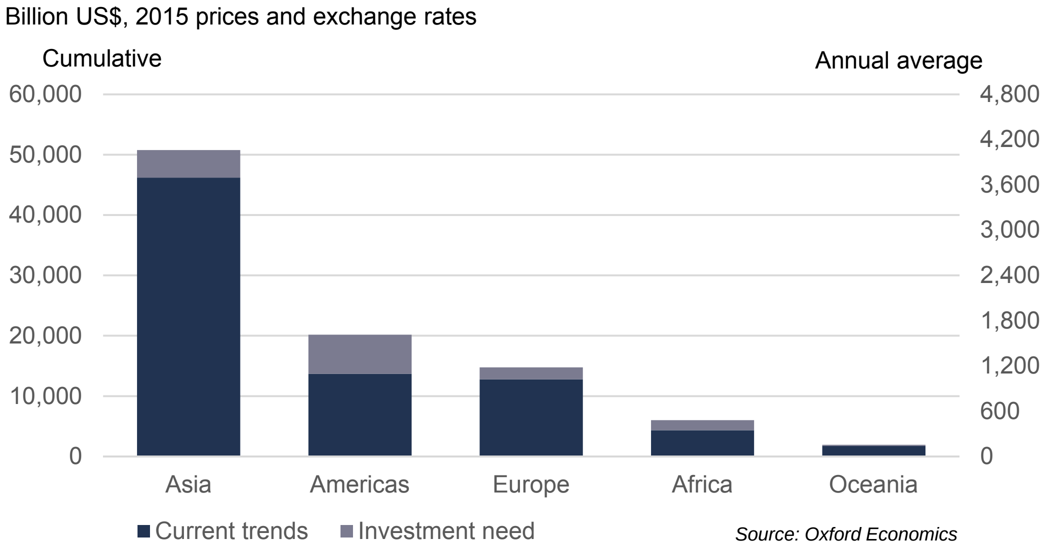
Our current trends forecasts assess how each countries' demand for infrastructure would be expected to respond to changes in a range of economic and demographic factors. As such, the forecast value for a particular sector can represent a different percentage of GDP than has been observed in the past. For example, we estimate that investment in roads was equivalent to 0.9 percent of global GDP between 2007 and 2015. Taking into account expected economic and demographic changes during the forecast period, we estimate that this will increase to 1.0 percent under the current trends scenario, rising to 1.3 percent under the investment need scenario.

3.3 OUTLOOK BY REGION

We can also look at how global infrastructure needs vary by region. Under the current trends scenario, 59 percent of estimated global infrastructure spending needs relate to Asia. A further 17 percent relate to the Americas, and 16 percent to Europe. The gap between the two scenarios is greatest for the Americas and Africa, where the forecast under the investment need scenario is 47 percent and 39 percent greater, respectively, than under current trends. This suggests that countries in these regions are most likely to lag behind their best performing peers in terms of the resources they dedicate to infrastructure. More than half of the gap for the Americas is attributable to the US.

In dollar terms, almost three-quarters of the global infrastructure investment gap between the two scenarios is attributable to Asia and the Americas.

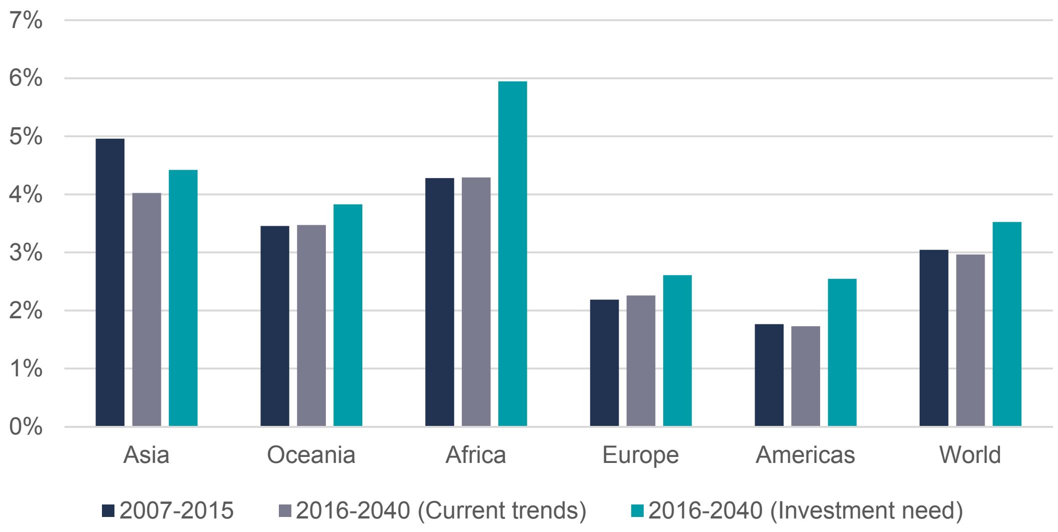
Fig. 22. *Global investment requirements by region, 2016-2040 cumulative (left scale) and annual average (right scale)*



Debate around infrastructure spending often focuses on developing economies, where there may be a need to put infrastructure in place for the first time to enable economic development and meet basic human needs. Nonetheless, Africa accounts for less than six percent of global infrastructure needs under the current trends scenario, equivalent to a cumulative total of $4.3 trillion for the entire forecast period. This increases to $6.0 trillion under the investment need scenario, or an average of $240 billion per year.

The observation that the infrastructure gap is proportionately smaller for Africa than for the Americas may, at first glance, appear counter-intuitive given that large elements of the population live without access to basic services in many African countries. However, this finding reflects our methodology, under which we benchmark countries against others at a similar income level, and therefore take into account what might be achieved based on observed experience in other countries. The analysis in section four shows that very different results are obtained if we instead assess need against the more challenging objective of universal access.

Fig. 23. *Global infrastructure spending by region, percent of GDP*



Source: Oxford Economics

As might be expected, the proportion of GDP that regions will need to dedicate to infrastructure under the current trends scenario is broadly equivalent to that recorded in the recent past. One exception to this, however, is Asia where our analysis suggests that infrastructure investment needs under current trends will be equivalent to four percent of GDP, down from five percent for 2007-2015. This reflects that certain Asian economies, most notably China, have invested very strongly in infrastructure in recent years and it will not be necessary to maintain quite the same rate of investment to accommodate economic and demographic growth in the years ahead. Nonetheless, as a proportion of GDP the current trends forecast for Asia is still higher than for all regions except Africa.

To meet their assessed investment need, all regions will need to increase spending as a proportion of GDP relative to what has been spent in the recent past, with the exception of Asia. The assessed need for Africa under this scenario is equivalent to 5.9 percent of GDP, up from 4.3 percent between 2007 and 2015.

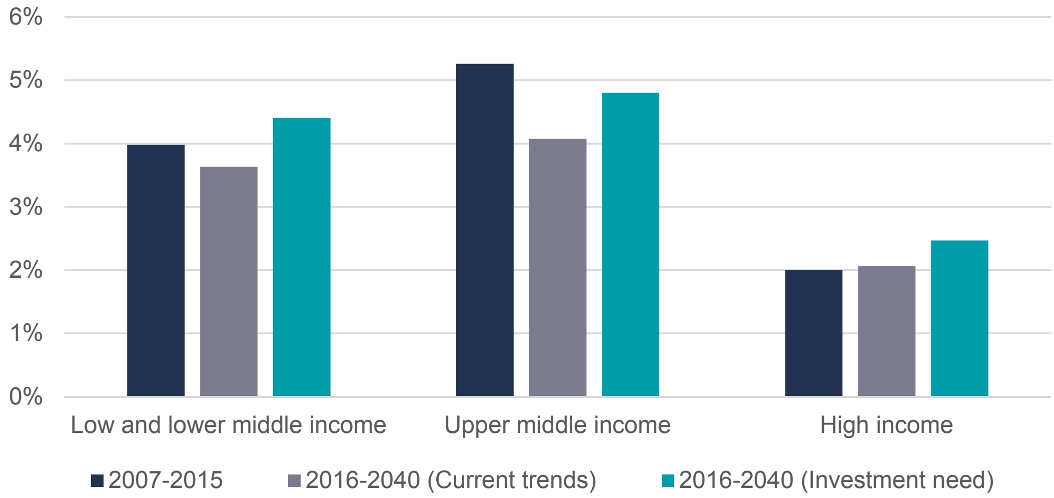
Infrastructure needs as a proportion of GDP are noticeably lower under both scenarios for Europe and the Americas, reflecting that countries in these regions are at a more advanced stage of development, and that infrastructure investment tends to focus more on replacement investment and incremental changes, as opposed to the step changes in provision required in developing economies. Oceania is represented by the developed economies of Australia and New Zealand within our analysis. The forecasts for this region are very strong under both scenarios, reflecting an expectation that the historical tendency of these countries to invest strongly in infrastructure will continue in the years ahead in support of strong demographic and economic growth.

To further explore differences in the intensity of infrastructure spending between countries at different levels of development, Fig. 24, below shows the proportion of GDP dedicated to infrastructure spending for the three income groups considered within our modelling. Consistent with the findings above, there is a clear tendency for high income countries to spend proportionately less on infrastructure.

For the other two income groups, however, differences are less clear. Intuitively it might be expected that the poorest countries may need to invest most heavily in infrastructure, to put in place basic utility and transport networks. Nonetheless, since 2007 upper middle income countries have spent an average of 5.3 percent of GDP on infrastructure, compared to 4.0 percent for low and lower middle income countries. Excluding China, infrastructure investment in the upper middle income group would have been 3.0 percent of GDP, less than the rate of investment for low and lower middle income countries. Aside from the influence of China, a further consideration is the ability of countries to realise the necessary investment. While infrastructure needs may be greatest in countries with the lowest incomes, this group is also likely to face the greatest challenges in terms of institutional factors and access to finance.

Looking ahead, the difference between the investment need forecasts for the lowest income group and the middle income group is smaller than the difference for past spending. This suggests that if other low and lower middle income countries were to match the performance of their best performing peers, infrastructure investment could increase to an average of around 4.4 percent of GDP. The equivalent figure for the upper middle income group is 4.8 percent.

Fig. 24. Global investment needs by income group, percent of GDP[13]



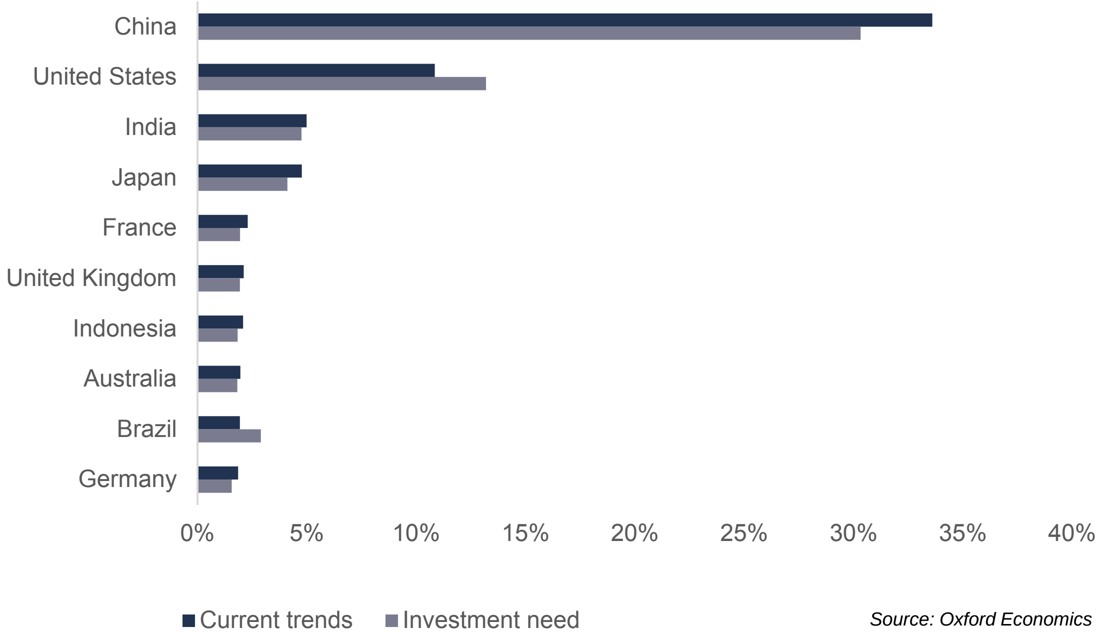
Source: Oxford Economics

While our focus in this part of the paper has been on regions, it is important to note that over half of the forecast infrastructure spending need to 2040 is contributed by just four countries: China, the US, India and Japan. China alone is estimated to account for one-third of global infrastructure spending under the current trends scenario. This is equivalent to a total of $26 trillion between 2016 and 2040. China's requirement increases only slightly to $28 trillion under the investment need scenario, reflecting that China is already investing strongly in infrastructure and the extent of uplift required to match its best performing peers is less than in many other countries. This means that its share of global investment is lower under the more ambitious scenario.

In contrast, our analysis suggests that the US would need to substantially increase the resources it dedicates to infrastructure to meet its investment needs. It is forecast to account for 11 percent of global infrastructure investment to 2040 under the current trends scenario, equivalent to $8.5 trillion. This increases by 45 percent to $12.4 trillion under the investment need scenario.

[13] Based on the 50 countries in our sample

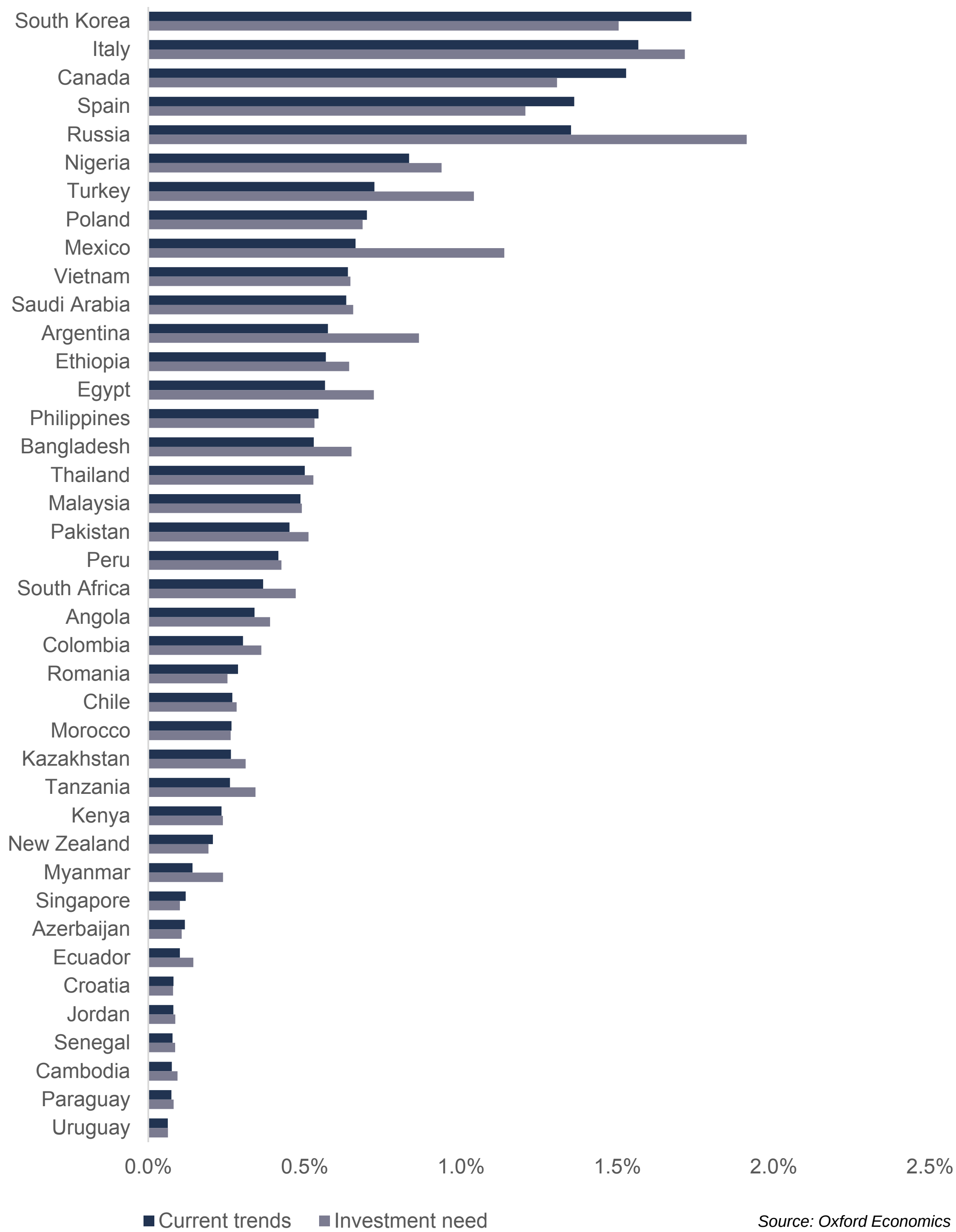
Fig. 25. *Infrastructure investment requirements 2016-2040: 10 largest markets, share of world total*



Source: Oxford Economics

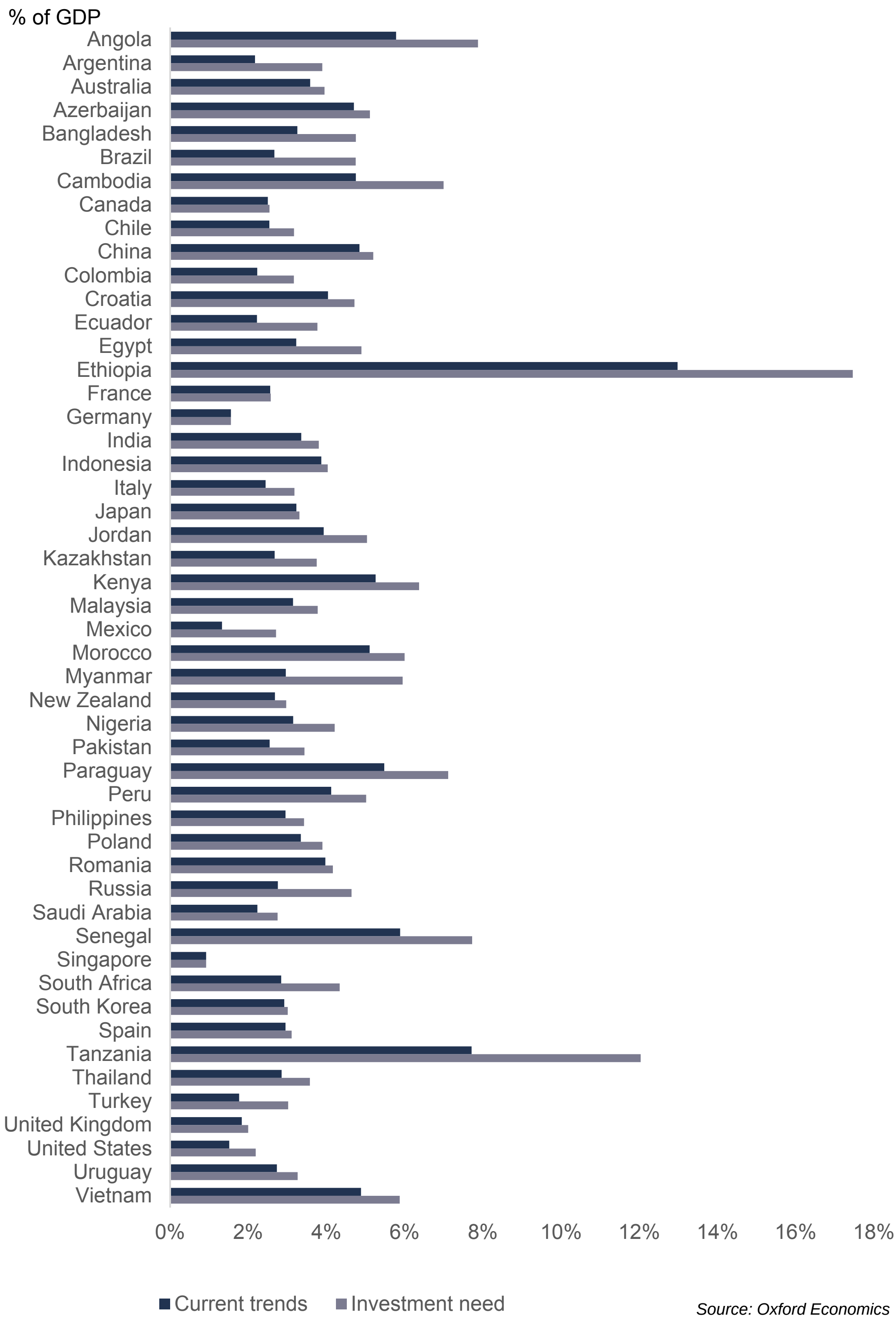
Our forecasts for all 50 countries in our sample are presented on the following page.

Fig. 26. Infrastructure investment requirements 2016-2040: other markets, share of world total



Source: Oxford Economics

Fig. 27. *Infrastructure forecasts by country, 2016-2040, percent of GDP*



Source: Oxford Economics

4. Alternative scenarios

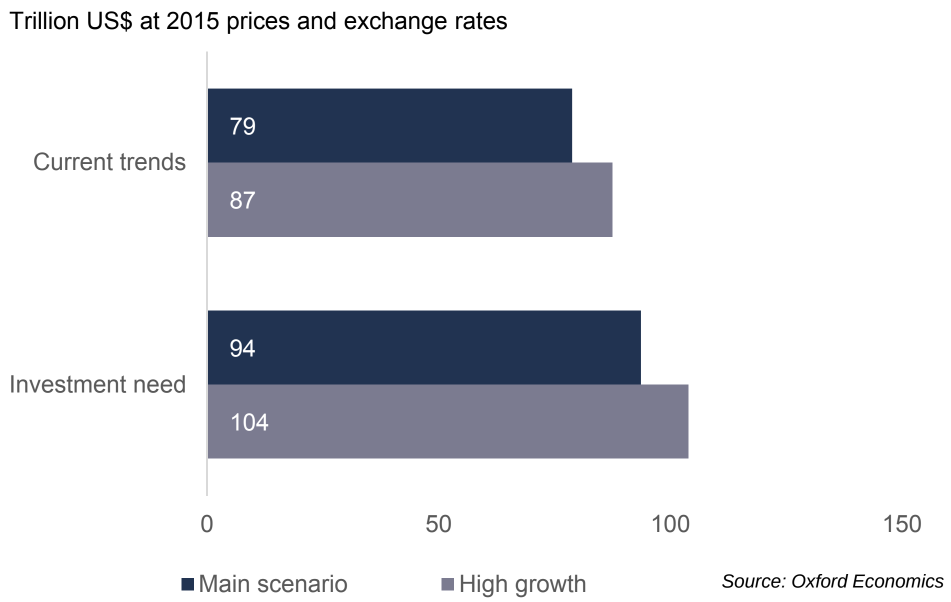
4.1 STRONGER ECONOMIC GROWTH

The forecasts of infrastructure investment presented in section three are based on our baseline forecasts of economic growth. Over a 25-year forecast period there is a high degree of uncertainty around the economic growth outlook for the world, and individual countries within it. To the extent that growth is faster than assumed in our main forecasts, there could be a need to invest larger amounts in infrastructure to accommodate that growth. In this section we explore how our forecasts of infrastructure need would be affected if we were to assume a stronger rate of economic growth throughout the forecast period.

In 2014, G20 Finance Ministers and Central Bank Governors set a goal to increase the GDP of the G20 countries by more than two percent by 2018, over and above the growth already forecast for that period. This was equivalent to an increase in the average annual GDP growth rate of 0.4 percentage points.[14] For our stronger growth scenario we apply this degree of uplift to the forecast economic growth rate, but we assume that it applies to all countries and is sustained throughout our entire forecast period to 2040.

The results are presented below and suggest that the total global spending requirement would be some $9-10 trillion or 11 percent greater than in our main forecast.

Fig. 28. *Global infrastructure needs under a high-growth scenario*



[14] Zia Qureshi, "G20 Growth Strategies", in *Let's talk development* <http://blogs.worldbank.org/developmenttalk/g20-growth-strategies> [accessed 12 May 2017]

4.2 SUSTAINABLE DEVELOPMENT GOALS FOR UNIVERSAL ACCESS TO ELECTRICITY, WATER AND SANITATION

The UN has identified a package of Sustainable Development Goals (SDGs) for the global economy to achieve by 2030 to stimulate action in five areas: people, planet, prosperity, peace and partnership.[15] In some cases, meeting these goals will require infrastructure investment to ensure that all of a country's residents are able to access basic services. Of particular interest to this study are objectives for the provision of water and power:

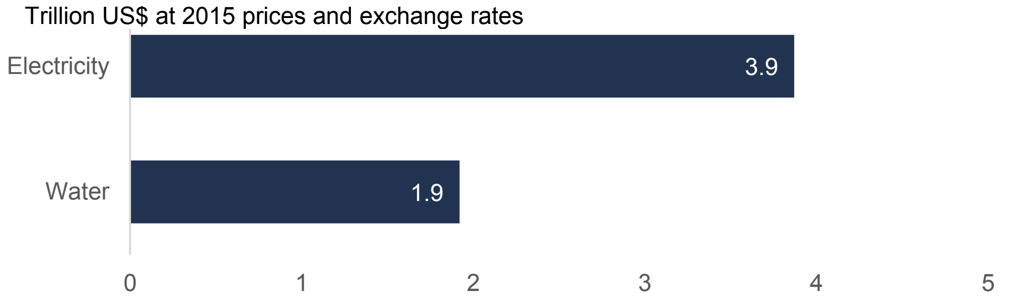
- SDG 6: "Ensure availability and sustainable management of water and sanitation for all"; and
- SDG 7.1: "Ensure access to affordable, reliable, sustainable and modern energy for all"

To explore this we have developed models to estimate how much the countries in our study might need to spend on electricity and water infrastructure to enable these objectives to be met. To do this we need to adopt a different analytical approach to the main part of our analysis, in order to create a direct link between the value of spending, expected population change, and access to electricity, water and sanitation.

Overview

Our analysis suggests that to meet the SDGs for universal access to electricity and water and sanitation in all low and middle income countries where access levels are currently less than 100 percent would cost a total of $5.8 trillion between 2016 and 2030. Two-thirds of this figure relates to electricity and one third to water (including sanitation).[16]

Fig. 29. *Investment required to meet SDGs for electricity, water and sanitation, 2016-2030*



Source: Oxford Economics

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[15] United Nations, "Sustainable Development Goals" < HYPERLINK "http://www.un.org/sustainabledevelopment/sustainable-development-goals/" http://www.un.org/sustainabledevelopment/sustainable-development-goals/ > [accessed 19 May 2017]

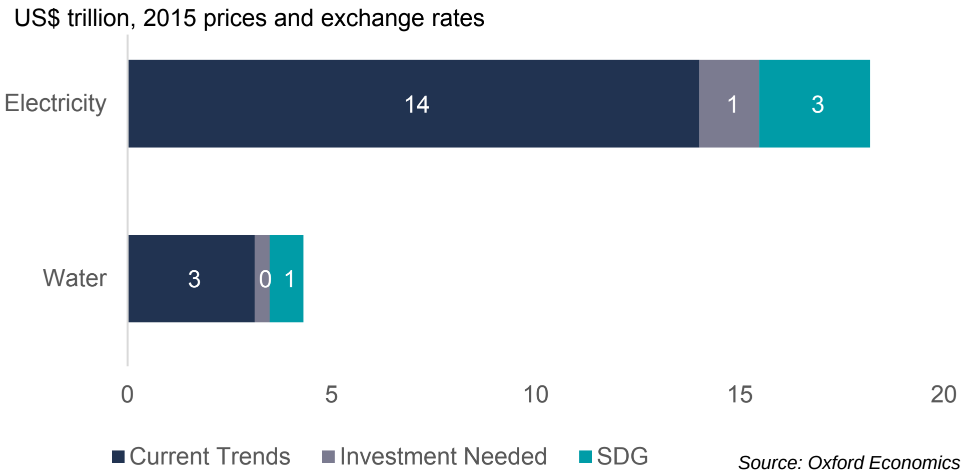
[16] These results are based on modelling of all countries for which the necessary data are available. This is in contrast to our main scenarios, where our results are modelled based on detailed analysis of 50 countries, and then scaled up using GDP shares to obtain regional and world totals. This reflects that investment needs to meet the population's basic requirements for water and electricity are likely to be greatest in countries with the lowest incomes. GDP shares are therefore unlikely to provide a reasonable proxy for missing countries in this part of our analysis.

Building on this analysis, we can also assess the extent to which the spending required to meet the SDGs would be delivered under our main investment need scenario. The figures shown above are not directly comparable with our main scenarios because they relate only to investment needed to meet households' electricity and water needs, whereas our main scenarios relate to the investment required to meet the needs of all sectors of the economy, including agriculture and industry, for example. We have therefore undertaken further analysis to estimate the share of electricity and water investment in our main investment need scenario which relates to household demand. This enables us to assess, for any given country, whether the SDG requirement would be delivered by the investment implied by our main investment need forecast.

We estimate that meeting the SDG for universal access to electricity would require an additional $2.7 trillion of investment, over and above that implied by our investment need scenario, between 2016 and 2030. For water, an additional $0.8 trillion of investment is required.

Taking these results together, we find that the total investment need for the electricity and water sectors between 2016 and 2030 increases from $19.0 trillion to $22.5 trillion when the goal of meeting the SDGs is included, an increase of 19 percent. That is, **the estimated global investment need between 2016 and 2030 would be $3.5 trillion higher if it included the cost of meeting the SDGs for universal access to water and electricity.**

Fig. 30. *Global investment needs for electricity and water, including SDGs, 2016-2030*



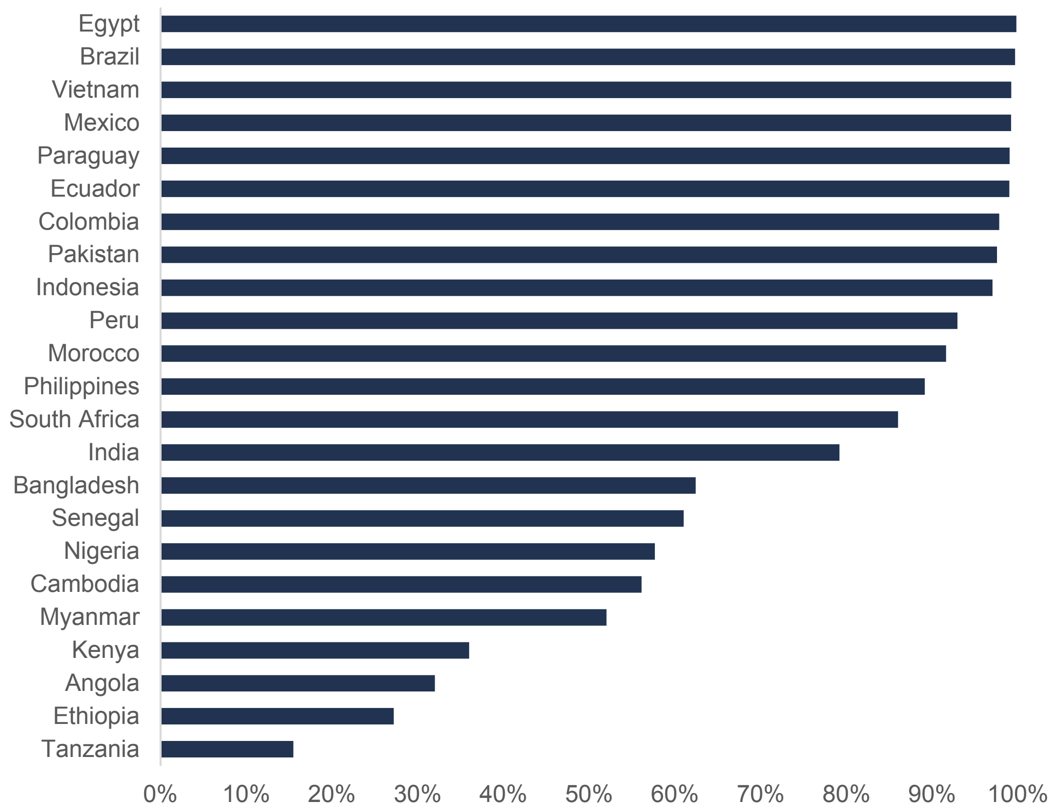
Source: Oxford Economics

The sections below outline our approach and more detailed findings for each of the electricity and water sectors, respectively.

Electricity

We start by reviewing current electricity access levels amongst the populations of the countries in our study. Our objective is to estimate the cost of installing generating capacity and associated transmission and distribution infrastructure that may be needed to ensure that by 2030 the entire population can access electricity. We identify 23 low and middle income groups within our sample in which less than 100 percent of the population currently has access to electricity.

Fig. 31. *Proportion of population with electricity access, 2014*



Source: World Bank World Development Indicators

OUR APPROACH TO ESTIMATING THE VALUE OF INFRASTRUCTURE INVESTMENT REQUIRED TO MEET SDG 7.1 FOR UNIVERSAL ACCESS TO ELECTRICITY

To identify the cost of providing universal access to electricity, we needed to establish an assumption regarding the level of provision available to everyone in the population. Previous studies into the cost of providing universal electricity access have identified a minimum level of electricity usage per person or per household, although there is no commonly agreed minimum level for the universal access condition to be met.[17] We took a slightly different approach and focused on the electricity infrastructure in place within countries which have recently achieved 100 percent provision. Specifically, we identify the level of electricity generating capacity available within each country at the point when it reached the 100 percent threshold.

While the main part of our study considers countries' overall electricity infrastructure needs, for the SDG scenario we focused on households' electricity needs. To do this, we assumed that the proportion of electricity generating capacity dedicated to household demand is equivalent to the household share of a country's electricity consumption.[18] We found that in nine countries which achieved 100 percent access within the last decade there was an average of 0.2 kW of household generating capacity per person, in the year when the 100 percent threshold was attained. We therefore based our cost estimates on the assumption that there should be at least 0.2 kW of electricity generating capacity, plus associated transmission and distribution infrastructure, per person and for domestic purposes. This approach results in a relatively higher average level of electricity provision per head than some previous studies, though is similar in magnitude to the level of provision reached by the end of the period assessed by the IEA.[19]

We estimated the additional capacity required in two steps. Firstly, we calculated the capacity required to increase average provision amongst those who already have electricity access to 0.2 kW per person. Secondly, we calculated the requirement needed to provide 0.2 kW per person for residents expected to enter the population between 2015 and 2030.[20]

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[17] See, for example, Erik Haites, Michael Levi, Mark Howells and Kandeh K. Yumkella Morgan Bazilian Patrick Nussbaumer, "Understanding the scale of investment for universal energy access", Geopolitics of energy, 32 (10 and 11) (2010).

[18] This is a simplifying assumption since, in reality, the same networks will often service domestic, industrial and other types of electricity demand. However, our intention in this scenario is to identify the infrastructure needed to reach universal domestic access to electricity. We therefore need a way of excluding electricity demand for industrial and other uses from the calculations. Data on the household share of electricity consumption were taken from the IEA: Invalid source specified.

[19] The IEA assume an initial minimum consumption threshold of 250 kWh per household per year for rural areas, and 500 kWh per year for urban areas. This is assumed to increase gradually over time, such that consumption per capita for those in newly connected households reaches an average of 800 kWh in 2030. Current average consumption per capita in the benchmark countries for our study is just over 700 kWh. See International Energy Agency, World Energy Outlook 2011 (Paris: OECD/IEA, 2011), pp. 473-74.

[20] In certain countries where less than 100 percent of the population currently have access to electricity, the average amount of generating capacity per person with access is already greater than 0.2 kW. In such cases, we assume that generating

The total capacity requirement was multiplied by estimates of investment costs per kW from the International Energy Agency (IEA).[21] The data are available for regions and a few key countries, so we match the countries in our study with the appropriate region.[22] The cost data are also available for a number of different technologies. We calculated averages to obtain a single cost for each energy generation sector and a single energy cost per country was estimated using the country's generating mix. For simplicity, we assumed this mix to be unchanged throughout the forecast period. We then uplifted each estimate to account for transmission and distribution infrastructure, again using data from the IEA.[23] For some regions this step more than doubled the estimated costs per kW.

Our model assumes that the net increase in capacity will be distributed evenly across the years from 2016 to 2030. As a final step we used the perpetual inventory model to estimate the value of replacement investment required over this period, to offset depreciation in both assets which are already in place, and in the new infrastructure to be built from 2016.[24]

Our analysis suggests that the 23 low and middle income countries in our sample which currently have less than 100 percent access to electricity would need to spend in the region of $2.7 trillion between 2016 and 2030 to meet the SDGs. The degree of challenge this represents will vary greatly amongst the countries in our sample. The investment required as a proportion of GDP is greatest for a number of African countries, most notably Ethiopia, which would need to dedicate 16 percent of GDP to electricity access over the next 15 years. While the situation is less extreme for other African countries, Tanzania, Kenya, Senegal, and Angola all have a SDGs need forecast in excess of two percent of GDP. A similar picture emerges for Myanmar, Cambodia and Pakistan.

In absolute terms, the SDGs need forecast is greatest for India, which we estimate would need to invest $1 trillion by 2030 to provide universal access to electricity. This is more than one-third of the total need identified for the 23 countries in our sample.

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capacity per person served remains constant amongst those who currently have access, but we calculate the cost of providing an average of 0.2kw of generating capacity to those who do not currently have access, or who will join the population between 2016 and 2030. In essence, we assume that universal access is achieved by adding new capacity, rather than re-distributing existing capacity.

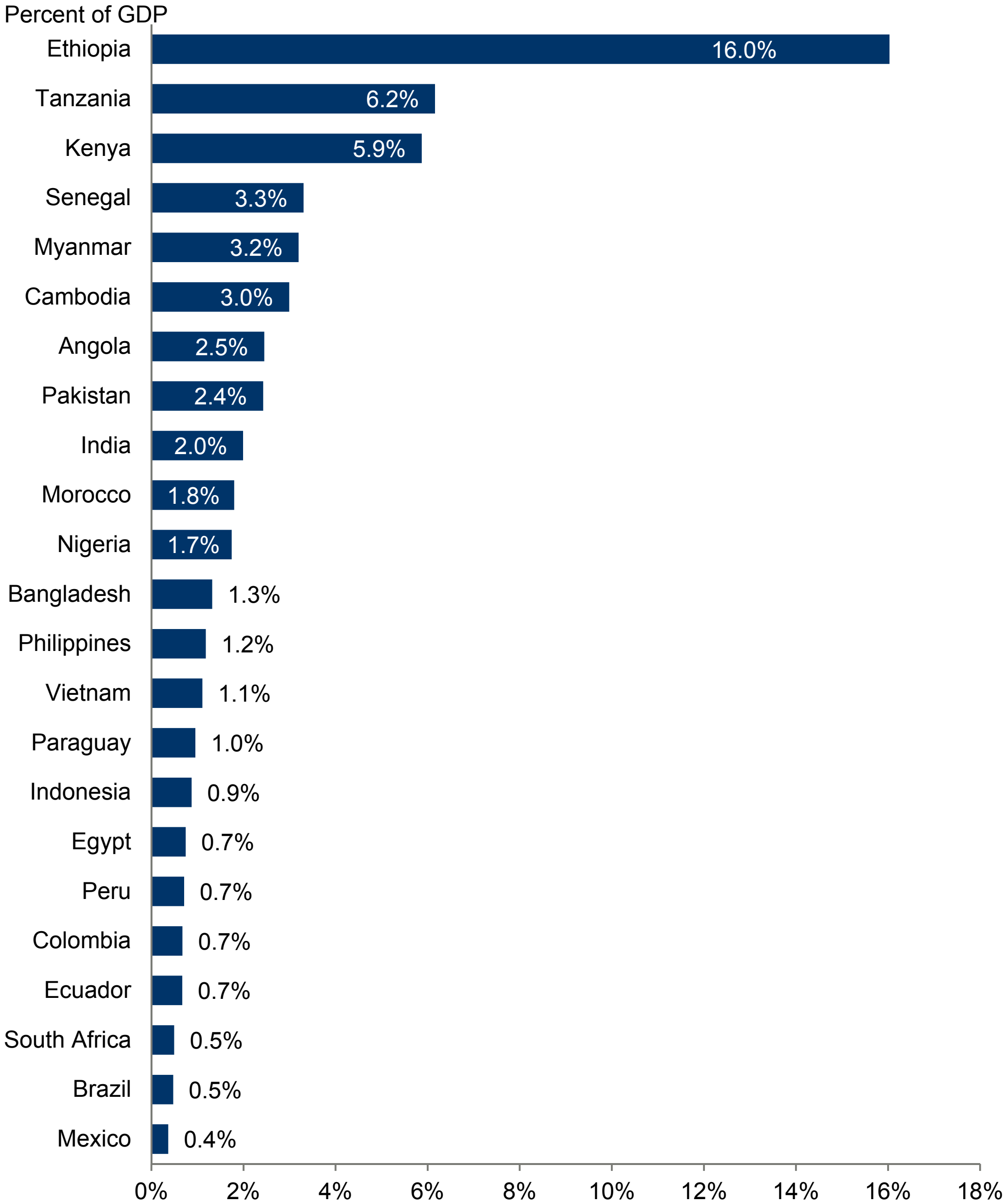
[21] International Energy Agency, *World Energy Outlook 2016* (Paris: OECD/IEA, 2016). For simplicity we assume that the identified level of generating capacity needs to be provided within each country. In reality it may be possible for countries to increase access by importing electricity from other countries. To the extent that it is possible to import excess power from other countries, it may also be possible to meet the SDG requirement with less investment in generating capacity than is implied by our analysis.

[22] Where a country lies outside of the defined regions, we have used data for the closest region, geographically and economically.

[23] Op. cit.

[24] Consistent with the rest of our modelling approach above, we only calculate the replacement investment that is estimated to be required to serve domestic demand.

Fig. 32. *Investment required to meet the SDG for universal access to electricity, 2016-2030, percent of GDP*

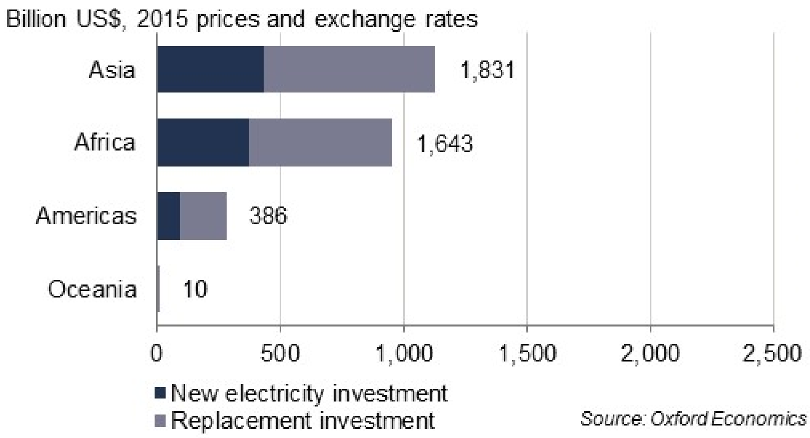


Source: Oxford Economics

We can also extend our approach to other low and middle income countries which are outside the 50 countries considered by our study. This suggests a total global investment need of $3.9 trillion between 2016 and 2030 to deliver universal access to electricity in low and middle income countries where access is currently below 100 percent. Around $2.4 trillion of this total consists of new investment, and $1.5 trillion is replacement investment.

At a regional level, the SDGs investment is dominated by Asia and Africa. The former accounts for 47 percent of the global requirement, while Africa accounts for 42 percent.[25]

Fig. 33. *Regional electricity infrastructure spending requirements to meet the SDGs for universal electricity access in low and middle income countries by 2030*[26]



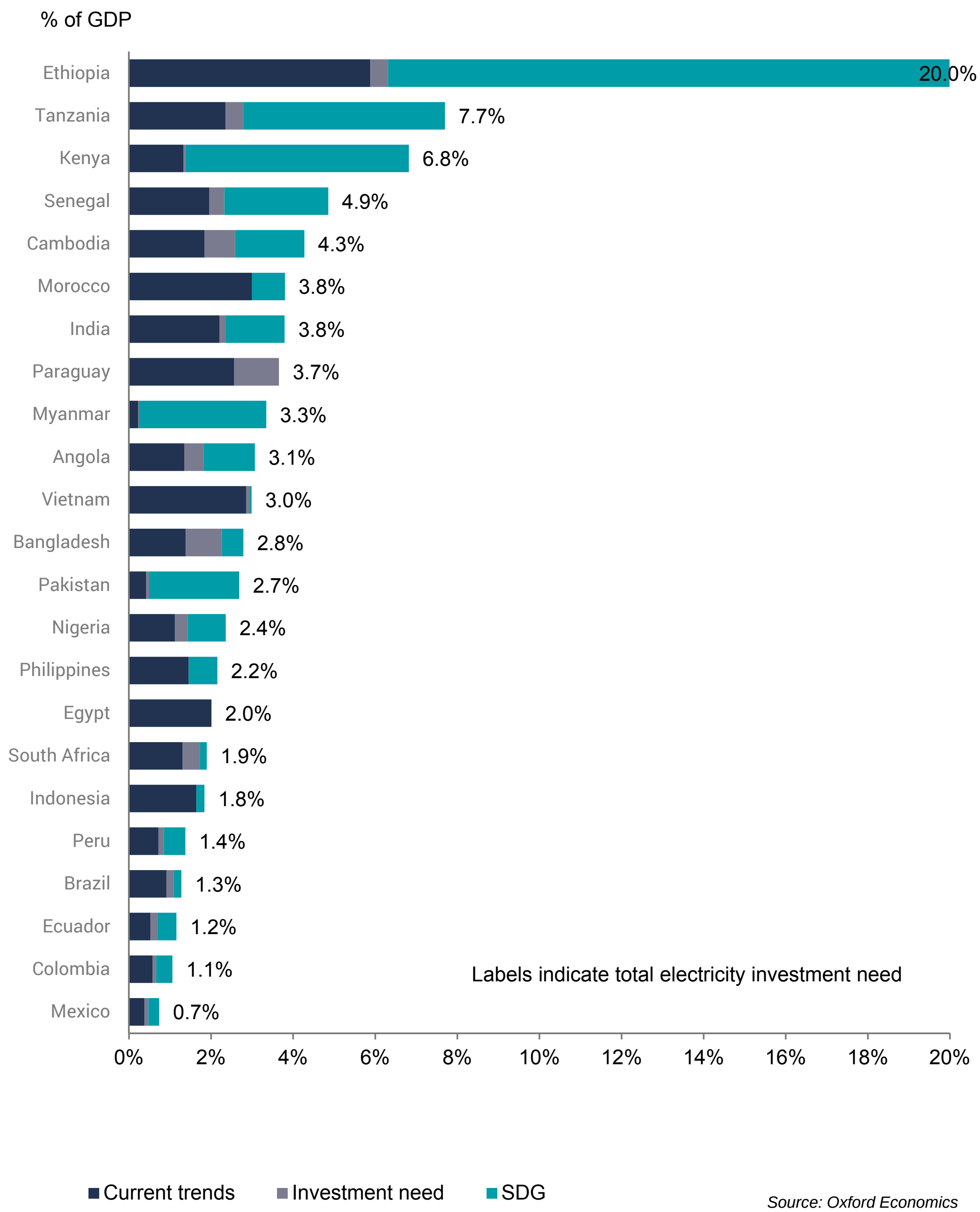
Above we have presented our estimates of the value of investment required to achieve universal access to electricity. Building on this, we can also assess the extent to which our main estimates of investment need might increase if the requirement to achieve the electricity SDG is included.

To explore this we compared the results from the SDG scenario to those from the current trends and investment need scenarios discussed in section three. In doing so we needed to estimate the share of our main scenario forecasts which would be dedicated to fulfilling households' electricity needs (as opposed to those of industry or other sectors). To do this we assumed that the share of investment going to household provision was equivalent to the household share of electricity consumption in each country.

[25] To estimate global and regional totals under the SDG scenario we extend our modelling approach to other low and middle income countries for which the required data are available, and make a small adjustment for countries missing from the dataset. This is different to the approach taken elsewhere in the study where we estimate regional totals by scaling up results for our 50 countries based on GDP shares.

[26] No value is shown for Europe because we did not identify any low or middle income countries in that region where access to electricity is less than 100 percent

Fig. 34. Total electricity infrastructure investment needs, including to deliver universal access to electricity, percent of GDP, 2016-2030



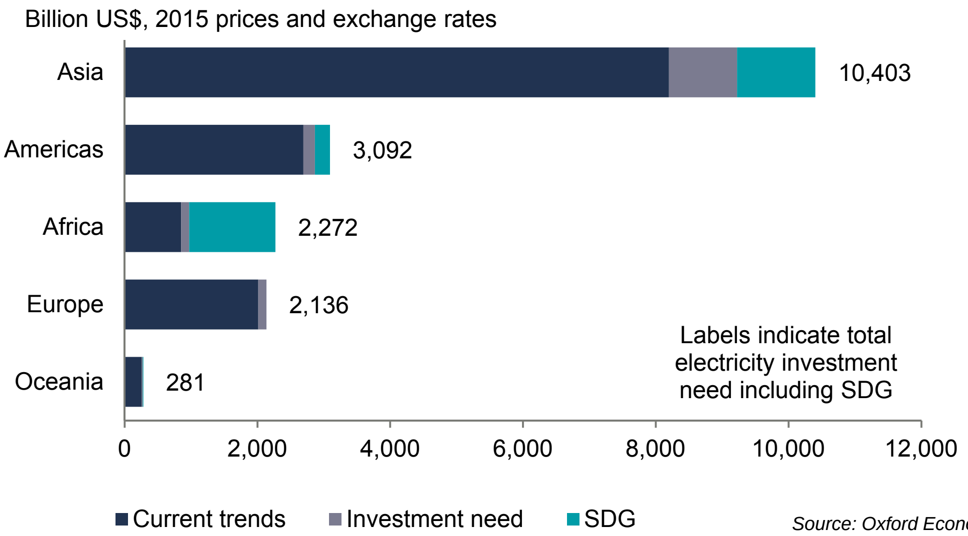
Source: Oxford Economics

This analysis confirms the scale of the challenge faced by African economies, in particular. The total electricity investment need for Ethiopia for 2016 to 2030 increases from 6.3 percent of GDP in our main scenario to 20 percent of GDP once the SDG is included. For Tanzania the investment need increases from 2.8 percent to 7.7 percent of GDP, and for Kenya it increases from 1.4 percent to 6.8 percent. At the other extreme, we estimate that Paraguay would meet the SDG if it achieves our main investment need forecast, while Egypt should meet the SDG under current trends.

Also noticeable in this analysis is that the difference between the current trends and investment need scenario is frequently small relative to the challenge of meeting the SDG requirement. That is, increasing investment performance to match best performing peers would have relatively little impact on the incremental investment requirement to achieve the SDG for many countries. This reflects that our main investment need scenario is benchmarked against what countries with similar income levels have actually achieved, while the SDG scenario incorporates the much more challenging objective of universal access.

At a global level, we estimate that meeting the electricity SDG would add $2.7 trillion of investment to our investment need scenario between 2016 and 2030. 48 percent of the additional requirement relates to Africa, and 43 percent to Asia. India contributes almost three-fifths of the additional requirement for Asia.

Fig. 35. Total electricity infrastructure investment needs, including to deliver universal access to electricity, percent of GDP, 2016-2030



Source: Oxford Economics

THE PARIS CLIMATE CHANGE AGREEMENT

The Paris Agreement aims to keep "global temperature rise this century well below two degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius."[27] Alongside this, the agreement seeks to build the capacity to enable countries to adapt to the effects of climate change. Given that infrastructure-intensive sectors such as transport and electricity generation are amongst the largest sources of greenhouse gas emissions, and that infrastructure developers in all sectors will need to build in resilience to the effects of climate change in the coming years, it is natural to ask how infrastructure investment needs might be affected by countries' commitments under the Paris Agreement.

We explored this question with a number of stakeholders during the course of our research. Our investigations suggest that, at the time of writing, too little detail is available to be able to make robust estimates of the costs of meeting Paris obligations for individual countries and sectors. Countries have put forward 'nationally determined contributions' to set out the principles of how they plan to meet their commitments, but there is currently insufficient detail and consistency within these plans to assess how our forecasts of infrastructure spending needs could be affected.[28] This is at least partly because many national governments have not yet themselves worked out the detail of their plans. Nonetheless, in some areas existing evidence can provide a guide to the potential implications of Paris commitments for investment needs. Some of the main examples are:

- A 2017 report by the International Energy Agency (IEA) and International Renewable Energy Agency (IRENA) assesses the steps necessary to limit the global temperature rise to less than two percent, with a probability of 66 percent.[29] The research suggests that to meet this objective there would need to be a dramatic shift towards low-carbon energy sources. They estimate that between 2016 and 2050 there would need to be $39.6 trillion of investment in the power sector, which is 40 percent higher than under the IEA's baseline 'New Policies Scenario'.[30]

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[27] UN Framework Convention on Climate Change, "The Paris Agreement" <http://unfccc.int/paris_agreement/items/9485.php> [accessed 12 May 2017]

[28] One specific line of enquiry was the future evolution of countries' electricity generating mix, since obligations under the Paris Agreement might be expected to lead to the more rapid take up of renewable technologies. While such estimates have been made for a small number of countries, typically those which make the greatest contribution to global emissions, they are not available for the majority of countries in our sample of 50.

[29] International Energy Agency and International Renewable Energy Agency, *Perspectives for the energy transition, investment needs for a low-carbon energy system* (Paris: OECD/IEA and IRENA, 2017).

[30] Op.Cit. pp.78

- The Asian Development Bank estimate that the Asia-Pacific region's infrastructure spending needs for 2016-2030 would increase from $22.6 trillion to $26.2 trillion once climate change measures are incorporated.[31] The additional cost reflects both the additional investment required to invest in low-carbon power generation to achieve the two-degree objective ($200 billion per year), and to adapt infrastructure to increase its resilience to climate change ($41 billion per year).
- A 2014 paper by New Climate Economy assesses the additional investment required to limiting the average global temperature increase to two degrees Celsius.[32] That analysis suggests that additional investment required in low-carbon power generation between 2015 and 2030 could be more than offset by reduced capital investment in fossil fuels and transmission and distribution costs.
- A 2017 report by the International Bank for Reconstruction and Development and the World Bank highlights the role that energy efficiency measures and renewable energy could play in supporting both climate change and electricity access objectives.[33]

Water and sanitation

The UN identifies a number of targets and indicators within SDG 6.[34] We focus on two of the targets which are most directly linked to investment in infrastructure:

- SDG 6.1: "By 2030, achieve universal and equitable access to safe and affordable drinking water for all". This is to be measured based on the "Proportion of population using safely managed drinking water services"; and
- SDG 6.2: "By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations". This is to be measured according to the "Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water".

To assess current provision for each of these indicators we refer to data from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.[35] For access to drinking water we look at access to a piped on- premises water supply, and for sanitation we look at access to advanced sanitation. For this part of the analysis we focus on the 33 low and middle income countries in our sample, all of which have less than 100 percent access to either clean drinking water or sanitation, as shown below.

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[31] Asian Development Bank, *Meeting Asia's Infrastructure Needs* (Manila: 2017), pp.43.

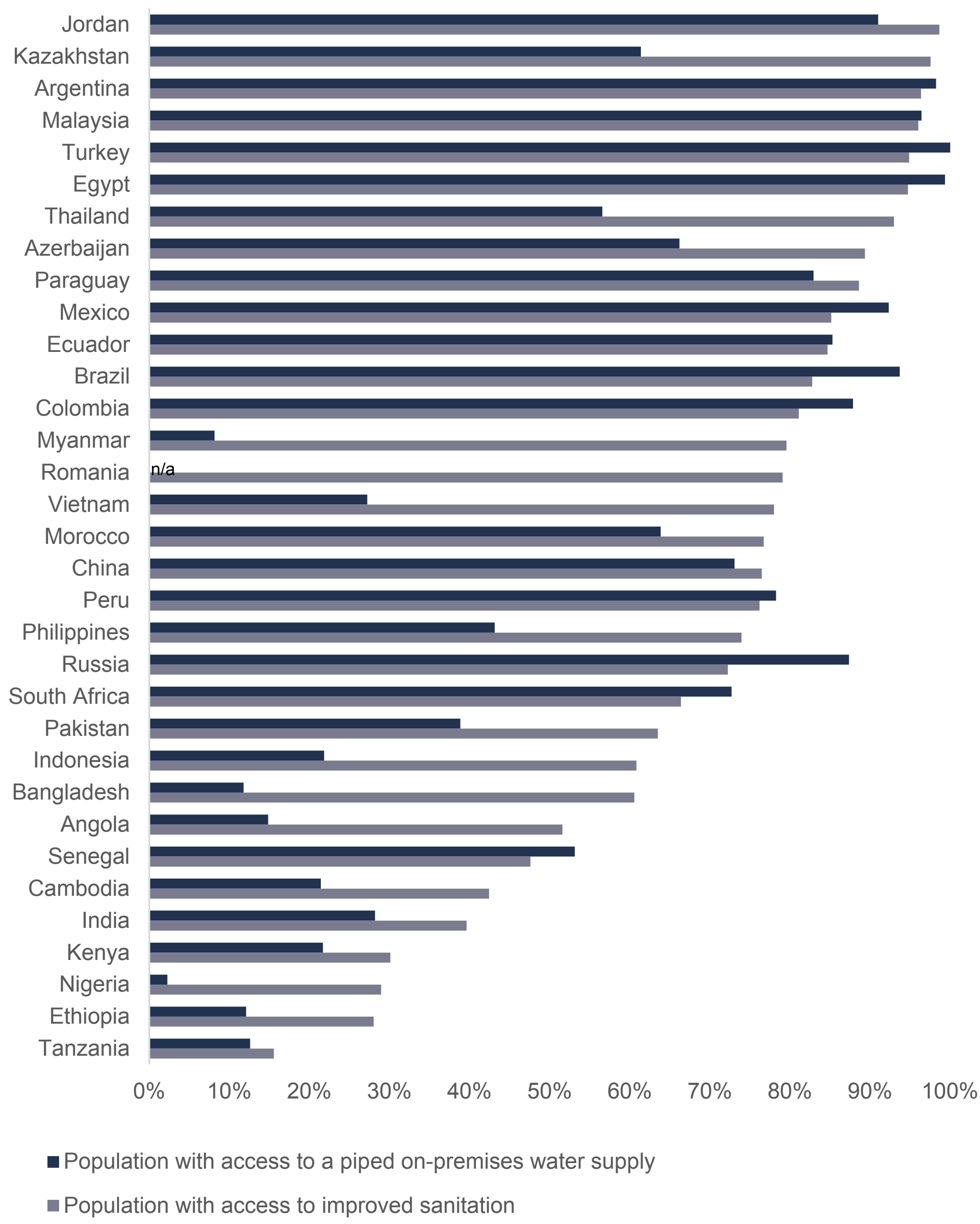
[32]33 Global Commission on the Economy and Climate, New Climate Economy Technical Note: Infrastructure investment needs of a low-carbon scenario (2014).

[33] International Bank for Reconstruction and Development and The World Bank, *State of Electricity Access Report* (Washington, 2017).

[34] United Nations, "Sustainable Development Goals" <http://www.un.org/sustainabledevelopment/sustainable-development-goals/> [accessed 19 May 2017]

[35]WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation <https://www.wssinfo.org/data-estimates/tables/> [accessed 28 April 2017]

Fig. 36. Proportion of population with access to a piped on-premises water supply and improved sanitation, 2015



Source: WHO/ UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation

OUR APPROACH TO ESTIMATING THE VALUE OF INFRASTRUCTURE INVESTMENT REQUIRED TO MEET SDGS 6.1 AND 6.2 FOR WATER AND SANITATION

For access to clean drinking water, our starting point was data from the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation on the proportion of the urban and rural population with access to a piped on premises water supply.[36] To identify the infrastructure needed to meet SDG 6.1 we estimated the net increase in the number of people who will need a water connection to achieve 100 percent coverage on this indicator by 2030, based on the current level of provision and expected population growth. The net increase in the number of people requiring access was multiplied by the cost of providing a connection. Costs were taken from previous research by Hutton and Varughese.[37]

For sanitation we took a very similar approach, but this time our starting point was JMP data on the proportion of the urban and rural population with access to 'improved sanitation'.[38] We again estimated the number of additional people who will require access to meet the 100 percent target, based on current provision and expected population growth. For urban areas we used capital cost estimates from Hutton and Varughese for the cost of providing sewerage with treatment, while for rural areas we used estimates for the capital cost of providing a pit latrine with FSM.[39]

The last step was to use a perpetual inventory model to add an allowance for replacement investment, to replace both existing infrastructure which is in place at the start of the forecast period, and to offset depreciation in new infrastructure built between 2016 and 2030.[40]

We estimate that to provide universal access to both clean drinking water and sanitation in all 33 of these countries by 2030 would cost $823 billion. Adding in replacement investment costs takes the total to $1.4 trillion.

Relative to the size of their economy, water spending needs to meet the SDGs are greatest in African economies, which is consistent with the evidence presented above showing that these countries also have amongst the lowest levels of provision at present. The challenge appears to be particularly great for Tanzania and Ethiopia, which we estimate would need to dedicate between three and five percent of GDP to water and sanitation provision between 2016 and 2030 to meet the SDGs.

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[36] Our use of this indicator is consistent with Hutton and Varughese

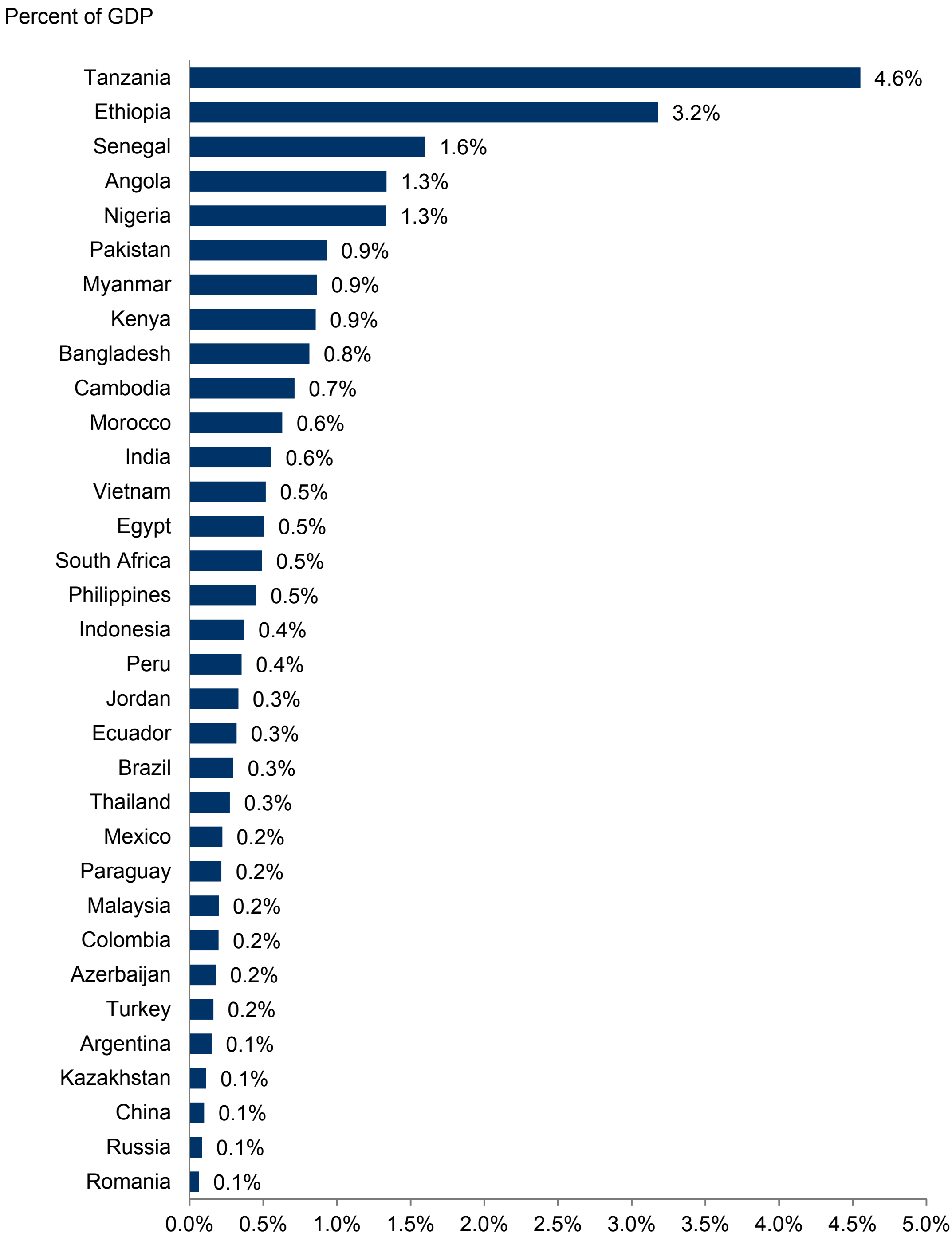
[37] We adopt the 'advanced' drinking water cost estimates from Guy Hutton and Mili Varughese, *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene* (Washington DC: World Bank, 2016).

[38] Under the JMP's definition, 'Improved sanitation' includes a flush toilet, piped sewer system, septic tank, flush/pour flush to pit latrine, ventilated improved pit latrine, pit latrine with slab, or a composting toilet.

[39] Faecal Sludge Management

[40] For replacement investment, we estimate the proportion of water infrastructure which is likely to relate to domestic drinking water and wastewater services. Our approach to doing this is discussed later in this section.

Fig. 37. *Drinking water and sanitation infrastructure spending requirements to meet SDG, percent of GDP, 2016-2030*

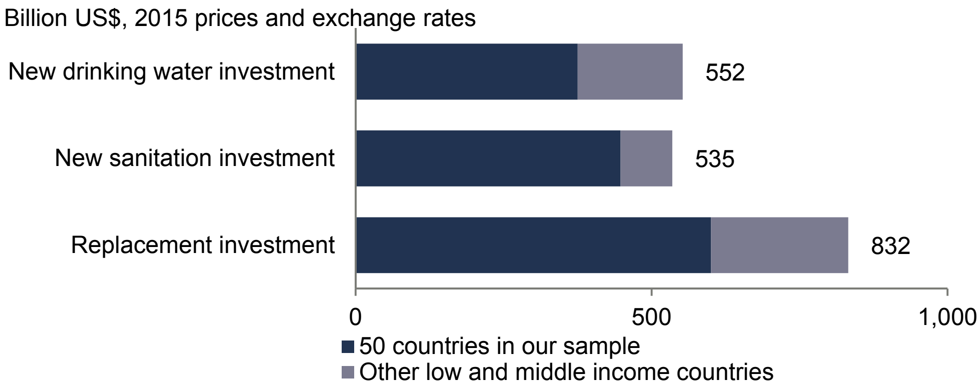


Source: Oxford Economics

In absolute terms, the spending need under the SDG scenario is greatest in India, where $291 billion of investment is needed by 2030, and China ($257 billion). However, the overall size of these economies means that the challenge appears relatively affordable relative to GDP: the requirement is equivalent to 0.1 percent of GDP for China and 0.6 percent for India. One important difference between these two large developing economies, however, is that for China just over half of the SDG investment need relates to new investment and the remainder to replacement investment. For India, only about a third of the total investment is replacement investment, reflecting that current access levels are much lower there.

The results above relate to countries within the sample of 50 included in this study. To obtain a figure for the total global spending requirement to meet the SDG for universal provision of clean drinking water and sanitation we extend the analysis to include other low and middle income countries which currently have less than 100 percent provision for either drinking water or sanitation (and for which the relevant data are available).[41] Adding results for these countries to our analysis suggests a total global spending need of $1.9 trillion. For this total, almost $1.1 trillion relates to new investment, and $0.8 trillion relates to replacement investment.

Fig. 38. *Global drinking water and sanitation infrastructure spending needs to achieve SDGs in low and middle income countries, 2016-2030*

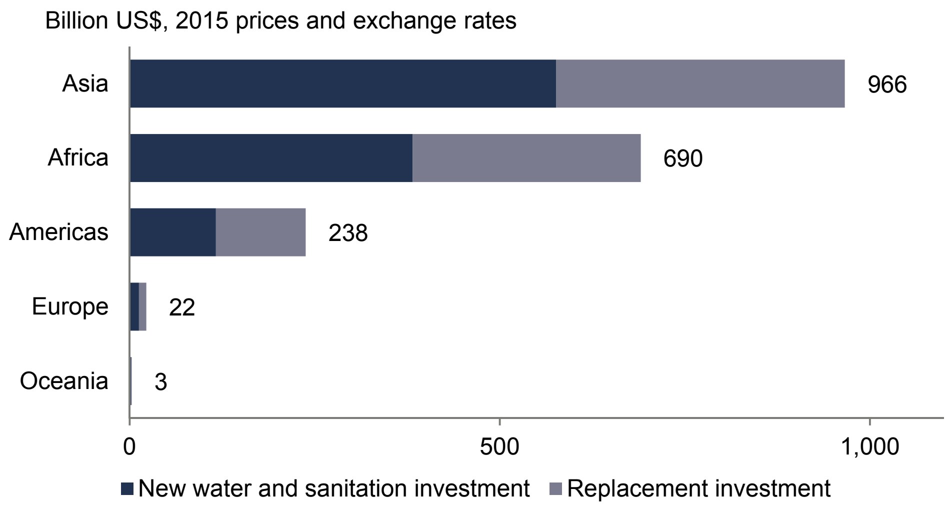


Source: Oxford Economics

[41] As with the electricity SDG scenario, global and regional totals are based on country-level modelling of countries outside of our sample of 50. This is in contrast to the approach for the main current trends and investment need scenarios, where we scale up results for the 50 countries using GDP shares.

Regional results are presented below. We find that 50 percent of the global requirement accrues within Asia and 36 percent within Africa.

Fig. 39. *Global drinking water and sanitation infrastructure spending needs to achieve SDGs for water and sanitation in low and middle income countries, for 2016-2030*



Source: Oxford Economics

As with our analysis of the electricity sector, it is informative to consider the incremental value of water and sanitation investment required, over-and-above what would be delivered under our main investment need scenario. Once again, our estimates under the SDG scenario relate to the infrastructure required for domestic water and sanitation, whilst our current trends and investment needs results relate to water and wastewater infrastructure needed for all sectors of the economy. We therefore need a basis for disaggregating the current trends and investment need forecasts so that we can separately identify the portion of investment needed for domestic purposes.

The study team was unable to identify a cross-country data source suitable for this purpose. However, stakeholders suggested using data from the Food and Agriculture Organization of the United Nations on the proportion of water consumption by the agricultural, industrial and municipal sectors.[42] Again upon the advice of stakeholders, we used the municipal share of water consumption within total non-agricultural consumption as the best-available proxy for the proportion of investment which relates to household use.[43]

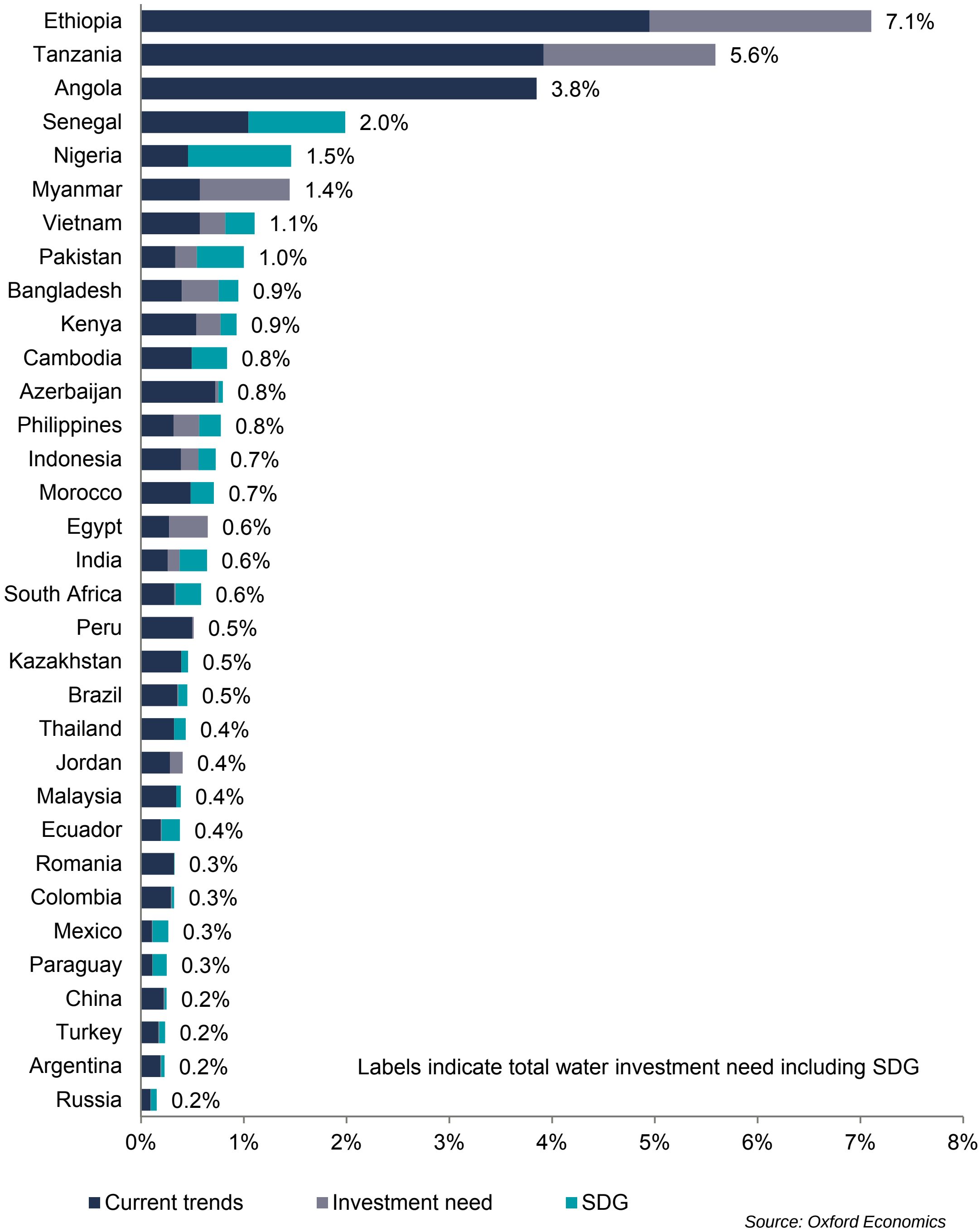
We find that the incremental investment requirement to deliver universal access to clean water and sanitation, over and above what would be delivered under our investment need scenario, is more modest than for the electricity access SDG. Our analysis suggests that Ethiopia and Tanzania would meet the SDGs by 2030 if they can deliver the level of investment suggested by our main investment need scenario, although they would each need to dedicate more than five percent of GDP to water infrastructure in the period to 2030 to achieve this objective. Angola would meet the SDGs if it achieves the current trends forecast, which would require dedicating almost four percent of GDP to water infrastructure.

Myanmar, Egypt, Peru and Jordan would also meet the SDGs if they achieve the forecasts implied by our investment need scenario. In contrast, the gold sections on the charts indicate countries which would need to raise investment beyond the levels implied by our investment scenario to achieve the water and sanitation SDG. This is most notably the case for Senegal, Nigeria, Vietnam and Pakistan.

[42] Food and Agriculture Organization of the United Nations, "Aquastat", in FAO <http://www.fao.org/nr/water/aquastat/data/query/results.html?regionQuery=true&yearGrouping=SURVEY&showCodes=false&yearRange.fromYear=1958&yearRange.toYear=2017&varGrpIds=4250%2C4251%2C4252%2C4253%2C4257&cntIds=&regIds=9805%2C9806%2C9807%2C9808%2C9809&edit> [accessed 12 June 2016]

[43] We exclude consumption by the agricultural sector from our calculation because this is assumed to be largely self-provided, and so not dependent on investment in the kinds of public water infrastructure which will make up much of the investment reflected within our database. Nonetheless, the share of municipal water within total non-agricultural consumption is still a somewhat imperfect proxy. Firstly, industrial water consumption is defined to include only self-provided water that industry sources from wells, rivers, etc. It is possible that at least some of the investment in the water infrastructure used by such users is not captured within the data we have collected on water infrastructure investment (it might instead be measured within investment for the respective industrial sector, for example). Secondly, municipal water may be an imperfect measure of household consumption, because it includes non-domestic consumption which relies on public water networks.

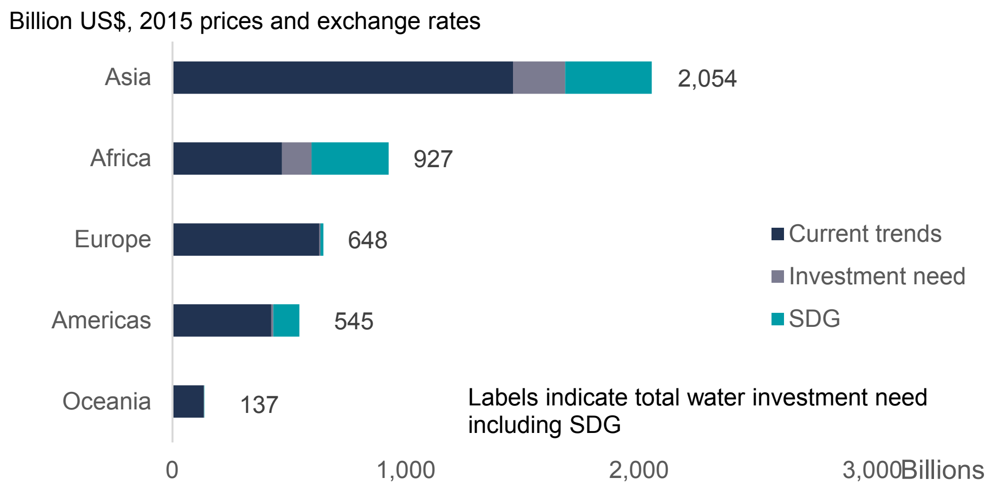
Fig. 40. *Total water infrastructure investment needs, including to deliver universal access to clean drinking water and sanitation, percent of GDP, 2016-2030*



Source: Oxford Economics

We can also extend this analysis to regions. We find that the total water infrastructure investment need for the period to 2030 increases from $1.7 trillion to $2.1 trillion once we include the cost of achieving the SDGs for water and sanitation. The additional investment need to achieve the SDGs is, nonetheless, proportionately greater for Africa, where the total investment need increases by 55 percent to $927 billion when we incorporate the cost of meeting the SDGs.

Fig. 41. *Total water infrastructure investment needs, including to deliver universal access to water and sanitation, percent of GDP, 2016-2030*



Source: Oxford Economics

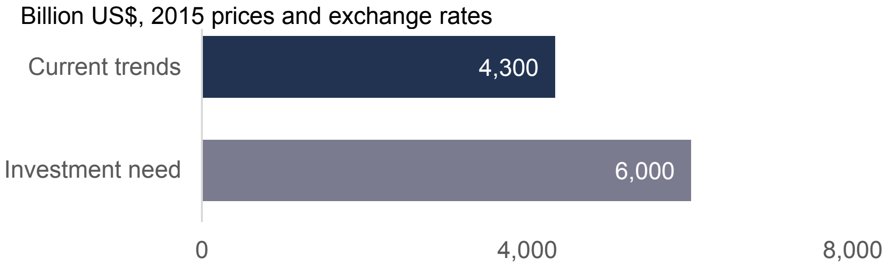
For the world as a whole, we estimate that the incremental infrastructure investment requirement to meet the water and sanitation SDG, over and above what would be delivered under our investment need scenario, is $0.8 trillion. Asia accounts for 45 percent and Africa accounts for 40 percent of this total.

5. Regional infrastructure needs: **Africa**

5.1 AFRICA REGIONAL SPENDING NEEDS

Under our current trends scenario, the total infrastructure investment forecast for Africa to 2040 is projected to be $4.3 trillion, or $174 billion per year. If African economies were able to raise their performance to match that of their best performing peers the total investment need would be $6.0 trillion, or $240 billion per year—a difference of almost 40 percent.

Fig. 42. *Total infrastructure spending needs, 2016-2040*



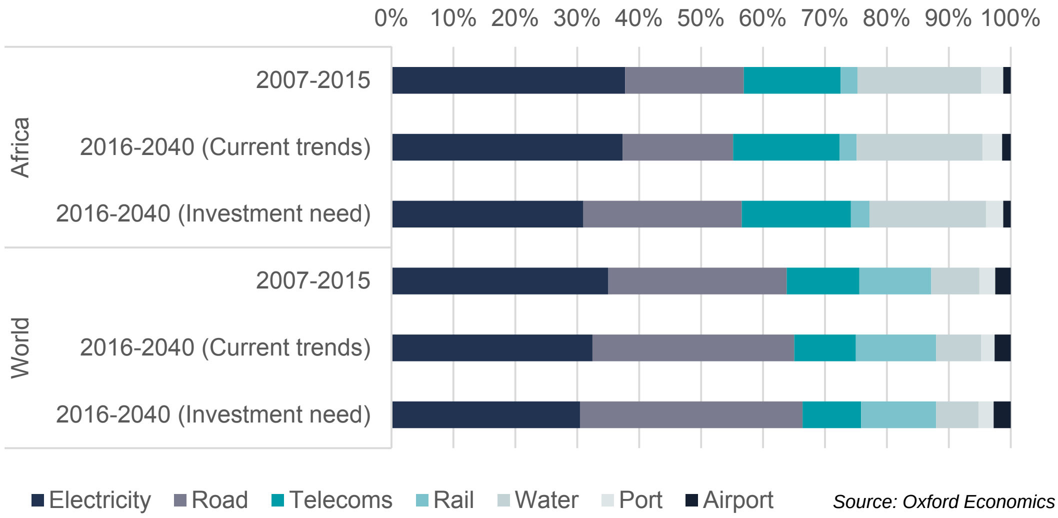
Source: Oxford Economics

Since 2007, we estimate that 38 percent of infrastructure investment in Africa has been directed towards the electricity sector, with 20 percent going to water. Given the low proportion of the population with access to electricity, water and sanitation services (as discussed in section four), the focus on these infrastructure sectors is perhaps unsurprising. While the proportion of investment going to electricity is similar to the world average, the share of investment dedicated to water infrastructure is more than twice the world average.

The flip side of a strong focus on utilities infrastructure is that Africa dedicates a below-average proportion of investment to the transport sector: this accounted for 27 percent of the total between 2007 and 2015, compared to the world average of 45 percent. The difference is particularly striking for rail, which receives just three percent of infrastructure investment in Africa, compared to the world average of 12 percent.

The distribution of infrastructure spending is expected to remain broadly similar under both of the forecast scenarios, although the transport sector assumes greater prominence under the investment need scenario.

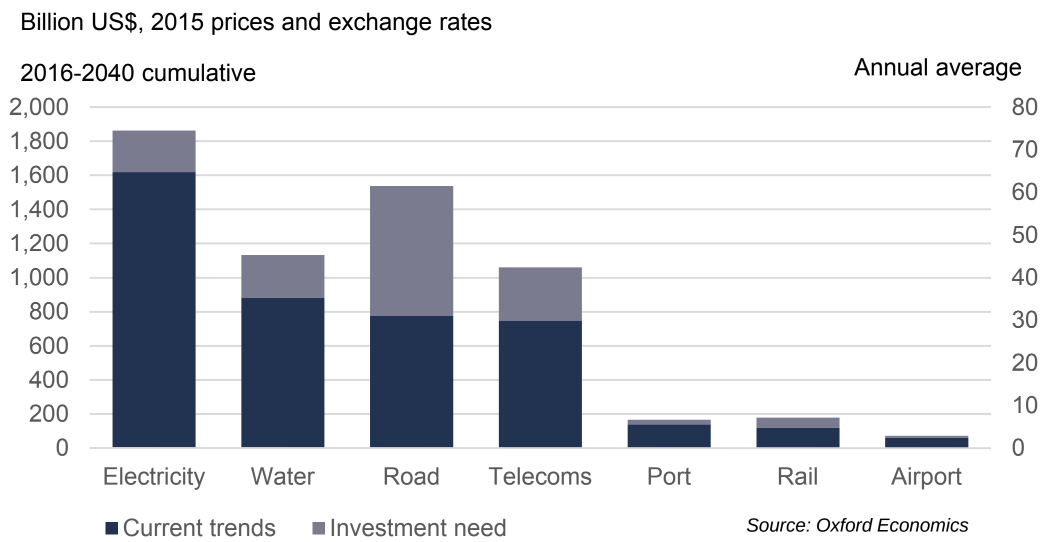
Fig. 43. *Africa sectoral pattern of infrastructure investment, 2007-2040*



Source: Oxford Economics

In dollar terms, electricity is forecast to receive around $1.6 trillion of investment between 2016 and 2040 under current trends, with water, roads and telecoms each receiving between $700 billion and $900 billion. The gap between the current trends and investment need scenarios is proportionately largest for roads, where the investment need forecast is almost twice the current trends forecast.

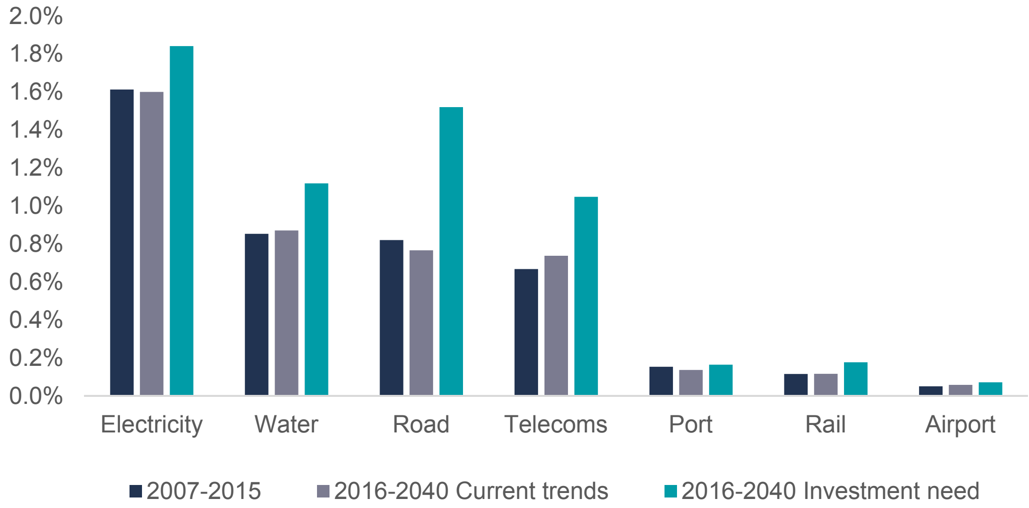
Fig. 44. *Africa infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)*



Source: Oxford Economics

Total infrastructure investment in Africa was equivalent to 4.3 percent of GDP between 2007 and 2015. The continent will need to maintain investment at around this proportion of GDP to accommodate economic and population growth to 2040. This rises to 5.9 percent under the investment need scenario. While this will clearly be challenging, our analysis suggests that since 2007 Ethiopia, Morocco, Tanzania and Angola have all achieved infrastructure investment levels of 5.5 percent of GDP or more.

Fig. 45. *Africa infrastructure spending needs by sector, 2007-2040: percent of GDP*



Source: Oxford Economics

5.2 COUNTRY SPENDING NEEDS

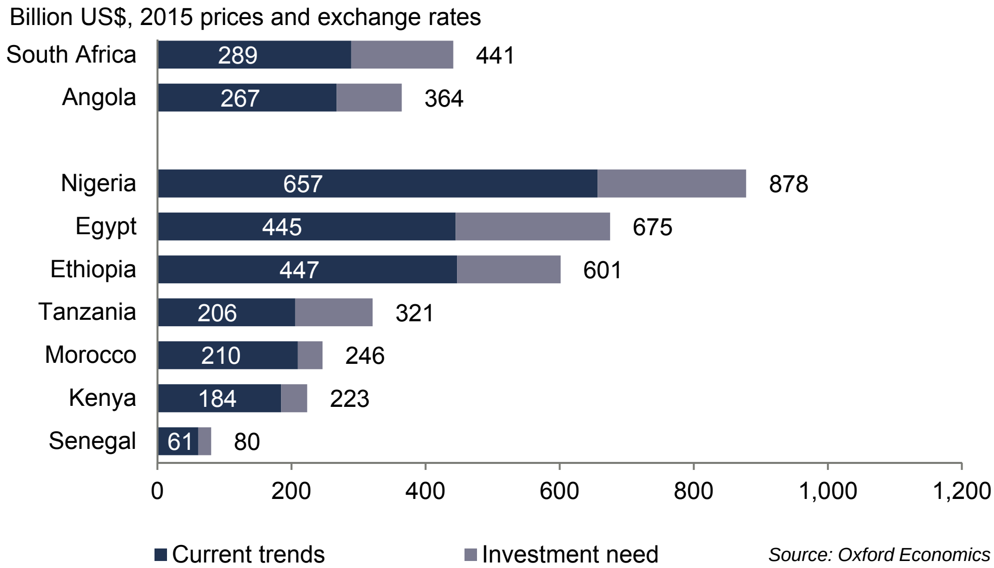
The nine African countries in our study account for just over 60 percent of the continent's GDP. By far the largest infrastructure market in Africa is Nigeria, which is estimated to have contributed 16 percent of investment between 2007 and 2015. Other large African infrastructure markets included in our study include South Africa, Morocco, Ethiopia and Egypt, which have each contributed between six and 11 percent of Africa's infrastructure investment since 2007.

Our forecasts of the value of total infrastructure investment needs for each country are presented below. A small gap between the current trends and investment need scenario indicates that a country is already performing well, given its economic and demographic characteristics, while a large gap between the two scenarios suggests that a country lags behind its best performing peers.

On this basis, our analysis suggests that Morocco and Kenya are performing relatively strongly amongst the African economies in our study: the investment need forecast is no more than 21 percent higher than the current trends forecast for each of these countries.

In contrast, the gap is much greater for Egypt, South Africa and Tanzania, where the investment need forecast is just over 50 percent higher than the current trends forecast. For Angola, Ethiopia, Nigeria and Senegal the investment need is around one-third greater than would be delivered under current trends.

Fig. 46. *Africa infrastructure spending needs, 2016-2040 cumulative*



Source: Oxford Economics

The infrastructure investment forecasts for Egypt, Nigeria and South Africa appear the most affordable out of the African countries in our sample, and amount to no more than 3.2 percent of GDP in the current trends scenario, or no more than 4.9 percent of GDP under the investment needs scenario.

In contrast infrastructure investment needs under the higher scenario represent the largest share of GDP for Ethiopia (17 percent), Tanzania (12 percent) and Senegal and Angola (both eight percent). For all of these countries except Ethiopia, this investment need would represent a noticeable uplift over the investment achieved in recent years (the strong past trend for Ethiopia reflects exceptionally strong spending in the electricity and water sectors).

The charts below present our forecasts of infrastructure need for individual countries and sectors. For the **roads** sector our model suggests that the need to increase spending observed in Fig. 45 is common to most countries, with the exception of Kenya and Ethiopia. In the case of the latter, data from the International Road Federation and World Bank suggest that investment was extremely strong between 2007 and 2015. Indeed, the World Bank report that Ethiopia increased the length of its road network by 70 percent between 2005 and 2012.[44] Given this recent focus on road development, Ethiopia is assessed to meet its road infrastructure needs through a continuation of current trends.

A tendency to under-invest in transport infrastructure is also in evidence for most countries in the **rail** sector, where only Egypt and Morocco are estimated to meet their future needs under current trends. A similar picture emerges for **airports**, although in this case Angola, Egypt and Ethiopia are the only countries on track to meet their needs under current trends. While the latter has seen improvements to its airport infrastructure over the last decade, spending is estimated to have been the lowest amongst all African economies in our sample as a proportion of GDP. Nonetheless, given the country's stage of development (it has the lowest value of GDP per head amongst all countries in this study), maintaining current investment trends should be sufficient to meet airport infrastructure needs throughout the forecast period.

Ports investment is estimated to have been substantially higher in Nigeria than in other African countries since 2007, boosted by the government's Port Reform Programme, which proved successful in attracting private investment to address limitations in the country's ports sector.[45] While Tanzania has a number of large ports, data from the Tanzania Port Authority suggest extremely low levels of investment. Despite this, Tanzania manages to out-perform higher-spending countries such as Nigeria and Angola on the WEF ports infrastructure performance measure. This may reflect that the available data do not fully capture investment in Tanzania's ports, and our modelling implies that a continuation of low levels of investment should be sufficient to meet the country's future ports needs.

As discussed in section 4.2, access to **electricity** remains a key challenge for many African countries. Our SDG scenario suggests that African economies would need to spend a total of $1.6 trillion to deliver universal access to electricity by 2030, *for residential purposes alone*. However, the forecasts of infrastructure need in this section suggest that most countries require only a relatively modest uplift over historical levels to meet their infrastructure needs. This is because the forecasts presented in this section are benchmarked against what the best performing countries at similar income levels have actually delivered in the past. In contrast, the SDGs results reflect the more stretching objective of universal access, irrespective of the achievability of the levels of spending implied.

[44] World Bank, *Ethiopia Public Expenditure Review 2015* (Washington DC: World Bank Goup, 2016), pp.4.

[45] James Leigland and Gylfi Palsson, *Port reform in Nigeria* (Washington DC: World Bank, 2007), Gridlines Note No. 17.

Data from the World Bank suggest that Ethiopia spent almost six percent of GDP on electricity infrastructure between 2007 and 2015, helping to increase the proportion of the population with access to electricity from 17.5 percent in 2006 to 27 percent in 2014.[46] However, there is clearly a long way to go still and the country's investment need for 2016 to 2040 remains in excess of five percent of GDP. This is substantially greater than other African countries, where our analysis suggests an investment need of between one and three percent.

In the **water** sector, estimates based on government statistics suggest that Tanzania invested strongly between 2007 and 2015. However the proportion of the population with access to an improved water source remained at around 55 percent throughout this period, suggesting that investment was relatively ineffective at improving access. As such, our modelling suggests an uplift in performance will be needed to deliver Tanzania's water needs. Another country which spent strongly between 2007 and 2015 is Ethiopia. In contrast to Tanzania, Ethiopia achieved a noticeable increase in the proportion of population with access to an improved water source, from 42 percent to 57 percent. Ethiopia spent an estimated $3.9 billion per year on water infrastructure between 2007 and 2015. This is an exceptionally high amount, particularly in relation to the size of the Ethiopian economy, and may be difficult to sustain in the longer term. Our modelling suggests a future investment need of just under six percent of GDP.

Finally, within the **telecoms** sector, African countries are divided into two groups. South Africa, Angola, Morocco, Egypt and Nigeria are estimated to have investment needs of less than one percent of GDP. In contrast, Senegal, Kenya, Tanzania and Ethiopia are estimated to need to spend 2.5 to 3.5 percent of GDP developing their telecoms networks. For most countries in the latter group, the quality adjustment step within our model increases the forecast under the investment need scenario, suggesting that past investment has failed to deliver the expected infrastructure outcomes (measured in terms of connections per head), and a higher level of spending will therefore be needed to meet future needs.

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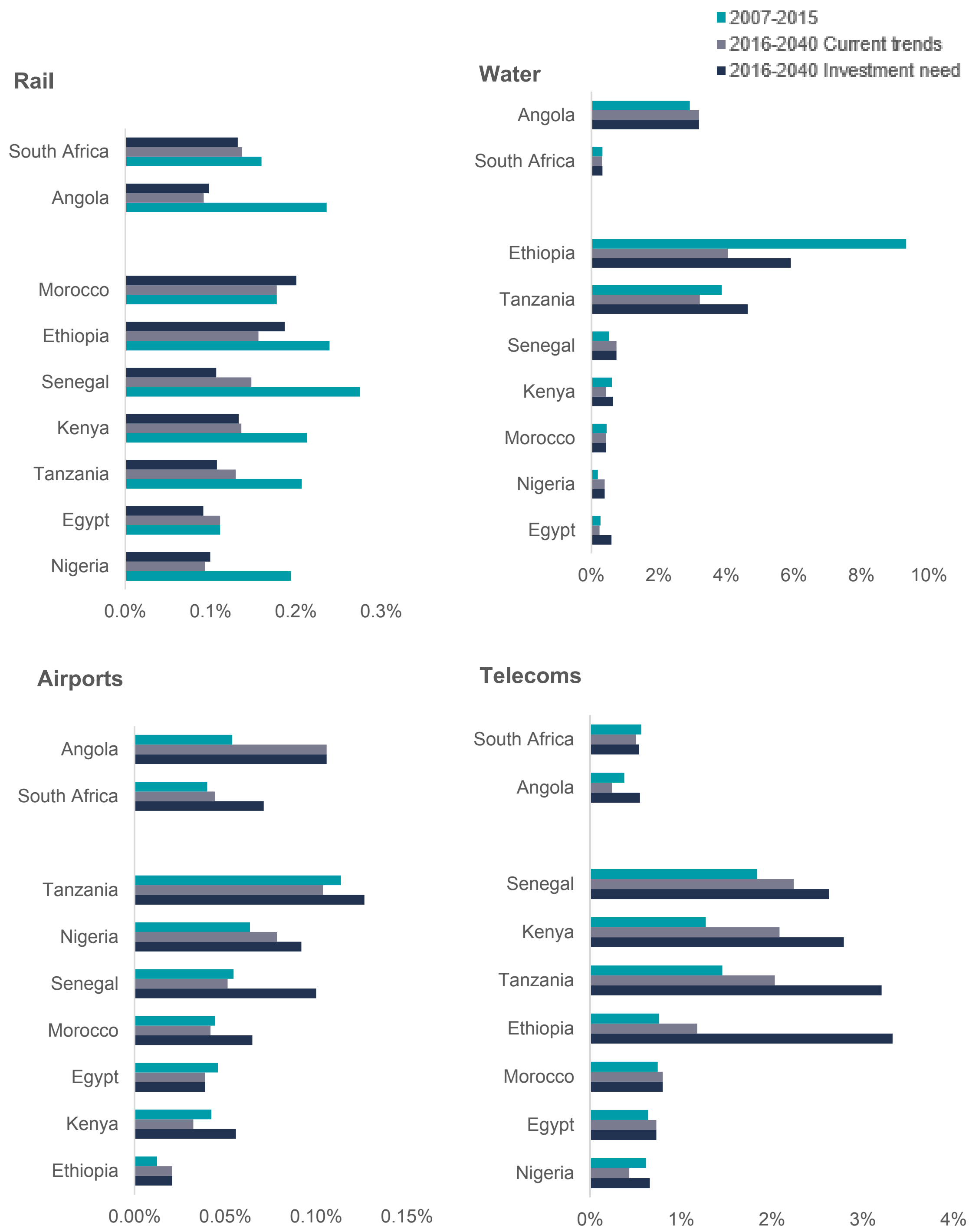
[47] World Bank, "World Development Indicators online tables" <http://wdi.worldbank.org/tables> [accessed 16 August 2016]

Fig. 47. Africa infrastructure spending needs by country and sector, 2007 to 2040


2007-2015
2016-2040 Current trends
2016-2040 Investment need
Rail
South Africa
Angola
Morocco
Ethiopia
Senegal
Kenya
Tanzania
Egypt
Nigeria
0.0%
0.1%
0.2%
0.3%
Water
Angola
South Africa
Ethiopia
Tanzania
Senegal
Kenya
Morocco
Nigeria
Egypt
0%
2%
4%
6%
8%
10%
Airports
Angola
South Africa
Tanzania
Nigeria
Senegal
Morocco
Egypt
Kenya
Ethiopia
0.00%
0.05%
0.10%
0.15%
Telecoms
South Africa
Angola
Senegal
Kenya
Tanzania
Ethiopia
Morocco
Egypt
Nigeria
0%
1%
2%
3%
4%

AMERICAS

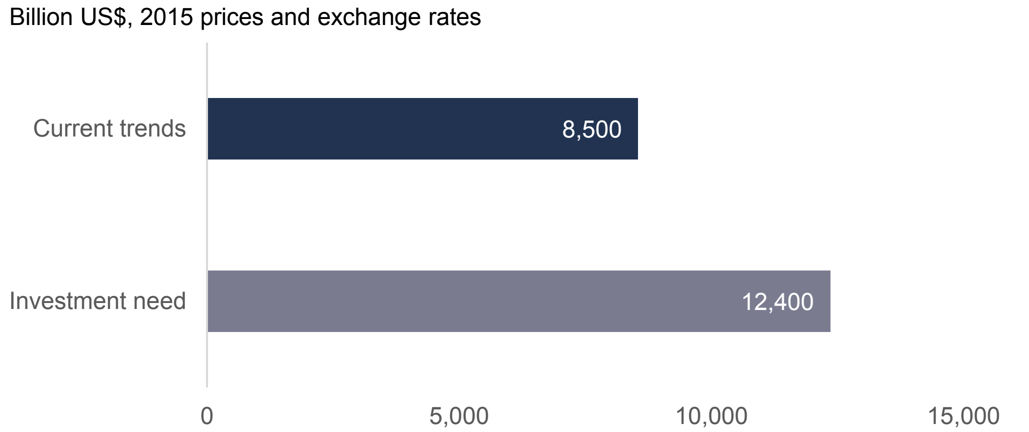
6. Regional infrastructure needs: **Americas**

The 11 countries in our dataset account for more than 95 percent of GDP in the Americas. The region's infrastructure market is dominated by the US, which on its own contributed an estimated 60 percent of regional infrastructure spending between 2007 and 2015. In light of this dominance we start by presenting our results for the US, while the second part of the chapter presents results for the rest of Americas region, and then for other individual countries within our sample.

6.1 THE US

We estimate that under current trends the US is likely to invest \$8.5 trillion in infrastructure between 2016 and 2040 to accommodate expected economic and demographic growth. However, we estimate that infrastructure needs in the US are around 45 percent higher at \$12.4 trillion. The latter figure is equivalent to an average of \$494 billion per year.

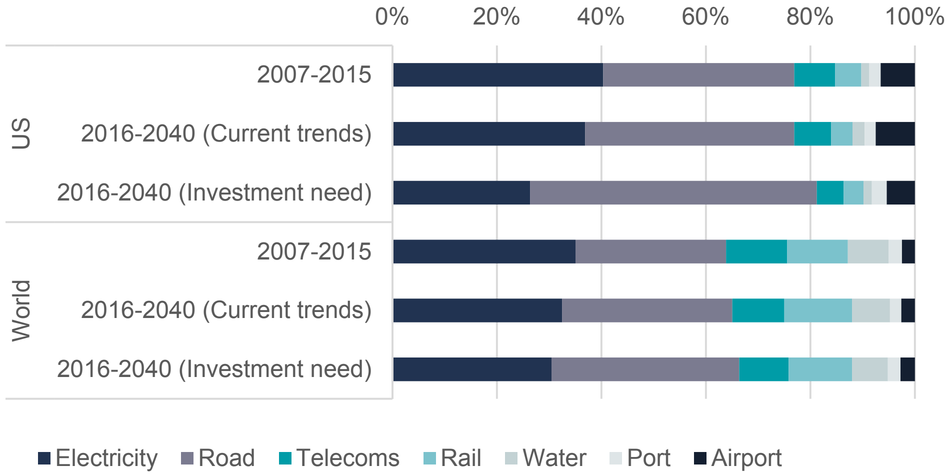
Fig. 48. *US total infrastructure spending needs, 2016-2040*



Source: Oxford Economics

The dominance of road and air travel within the US is reflected in the distribution of infrastructure investment: the US tends to dedicate a greater share of infrastructure spending to roads and airports than across the world as a whole. On the other hand, the share dedicated to rail was less than half the global average between 2007 and 2015. The main change to this picture under our forecasts is that roads are expected to take an even larger share of investment, particularly within the investment need scenario.

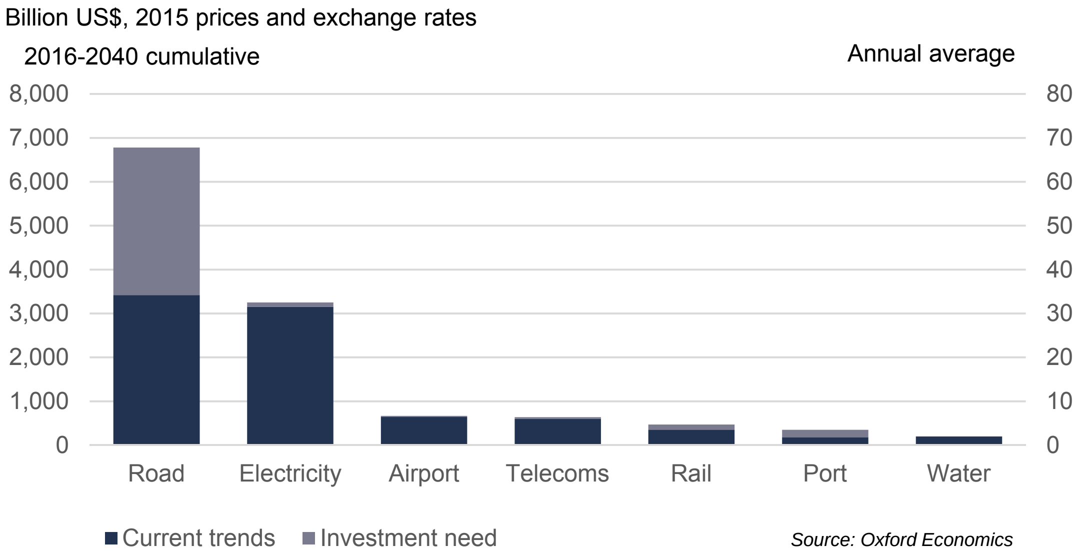
Fig. 49. US sectoral pattern of infrastructure investment, 2007-2040



Source: Oxford Economics

The road and electricity sectors are each estimated to require just over $3 trillion of investment between 2016 and 2040 under current trends. This is three quarters of the total estimated investment requirement. Investment needs in other sectors range from $197 billion (water) to $642 billion (airports).

Fig. 50. US infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)



Source: Oxford Economics

The most notable finding under the investment need scenario is the large uplift for the **road** sector, where the investment requirement is almost double that under the current trends forecast. In this case, and based on the advice of stakeholders, we have made a manual adjustment to our best performer forecast so that the level of investment is broadly aligned with that from previous research by American Society of Civil Engineers, who identified a substantial requirement for investment in new highways and bridges, to both mitigate congestion from rising traffic levels, and to rectify deficiencies in the current network.[47]

In the case of **telecoms** and **water**, the available data suggest that the US has invested less than other developed economies in recent years. However, access levels to these utilities are very high, suggesting that only a marginal uplift over the current trends forecast will be sufficient to meet future investment needs. A similar result is obtained for **electricity**, where past investment appears to have been lower than for other high income countries, but WEF evidence suggests the quality of the infrastructure is amongst the highest of the countries in our sample and so only a small uplift beyond the current trends forecast is identified.

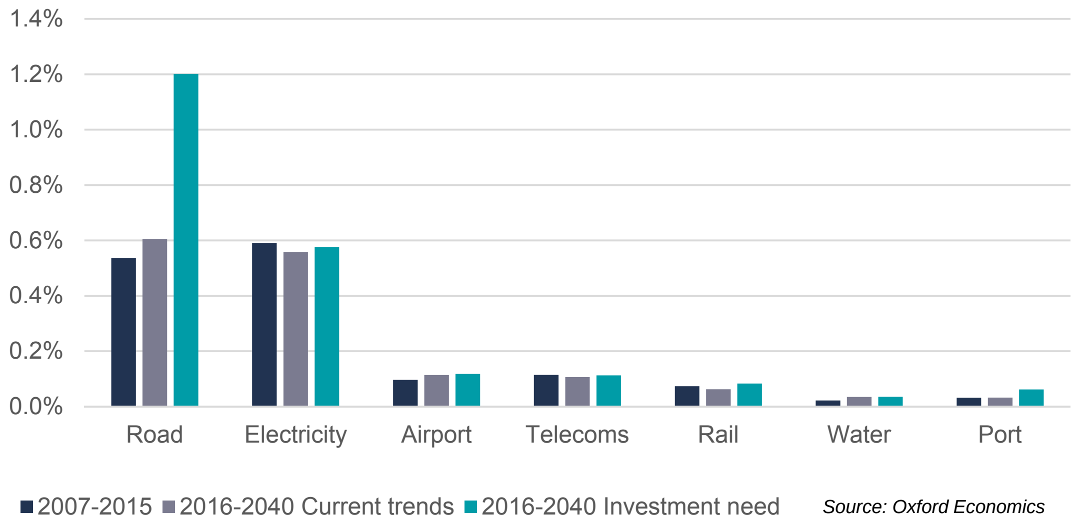
The US has substantially less **rail** infrastructure than many other developed economies, reflecting that rail is not widely used for intercity travel in the US, as it is in Europe, for example. To raise the value of rail stock per capita to European levels would require an extremely large uplift in investment. However, the WEF quality measure for US rail is higher than for countries with much denser rail networks, such as Italy and the UK. This may reflect differences in expectations between respondents to the WEF survey in different countries, but suggests that Americans are reasonably satisfied with the current availability of rail infrastructure, given the investment it receives. Once we adjust our forecast based on the WEF evidence we identify an investment need one-third greater than would be delivered under current trends.

Our modelling does, however, suggest that a substantial uplift in investment may be needed in the **ports** sector, where the investment need forecast is more than 90 percent higher than the current trends forecast. However, we were unable to identify a satisfactory source of historical data in this case. The conclusion therefore relies on estimated values and should be treated with caution.

[47] Economic Development Research Group Inc., *Failure to act: closing the infrastructure investment gap for America's economic future, update* (Boston: American Society of Civil Engineers, 2016) and Economic Development Research Group Inc., *Failure to act: the impact of current infrastructure investment trends in surfact transportation infrastructure* (Boston: American Society of Civil Engineers, 2011).

The US invested the equivalent of 1.5 percent of GDP in the seven types of infrastructure included in our study between 2007 and 2015. This would remain constant as a share of GDP for the 2016-2040 period under the current trends scenario. Under the investment need scenario the US would need to increase the share of GDP allocated to infrastructure investment to 2.2 percent, primarily reflecting greater expenditure on roads.

Fig. 51. *US infrastructure spending needs by sector, 2007-2040: percent of GDP*



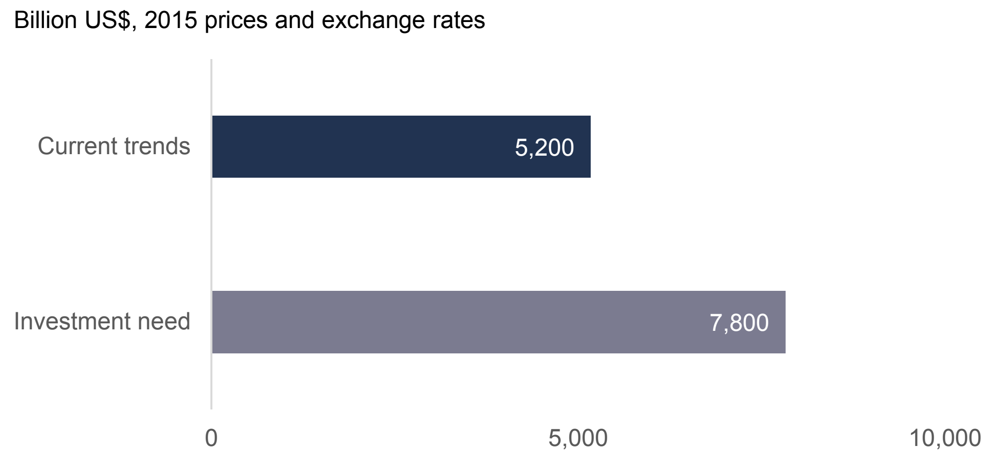
Source: Oxford Economics

6.2 REST OF THE AMERICAS: REGIONAL SPENDING NEEDS

Away from the US, we estimate that if countries in the Americas continue to invest in line with current trends their estimated infrastructure investment to 2040 is likely to be just over $5 trillion. This would increase by almost 50 percent to $7.8 trillion in the investment need scenario. The latter is equivalent to 3.4 percent of GDP, or 3.7 percent excluding Canada. While this places our investment need forecast towards the lower end of the range identified in previous research into investment needs in Latin America, at least some of the difference may be accounted for by maintenance expenditures. The latter are included in many previous studies, whereas we do not include ongoing maintenance costs (although we do include capital investment for replacement purposes).[48]

[48] Luis Alberto Andres, Charles Fox, Ulf Narloch, Stephane Straub, Michael Slawson Marianne Fay, *Rethinking infrastructure in Latin America and the Caribbean, spending better to achieve more* (Washington: International Bank for Reconstruction and Development and The World Bank, 2017), pp. 18.

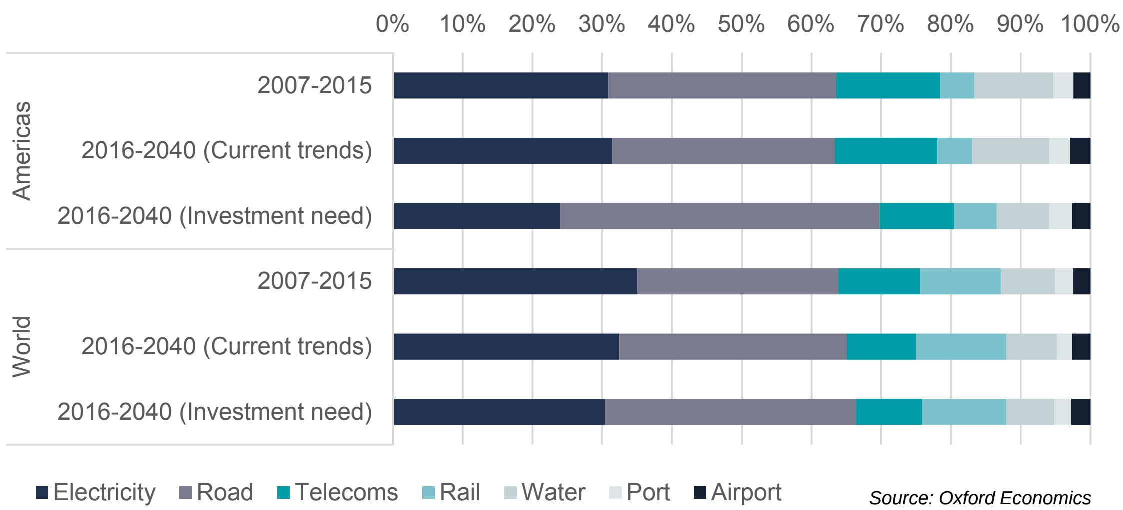
Fig. 52. *Rest of the Americas total infrastructure spending needs, 2016-2040*



Source: Oxford Economics

Similar to the US, other countries in the Americas tend to dedicate a smaller share of infrastructure investment to the rail sector, but slightly more to roads. The current pattern of investment would be sustained under the current trends scenario, but the investment need scenario leads to a much higher share of infrastructure investment going to roads, with corresponding reductions in the share of most other sectors.

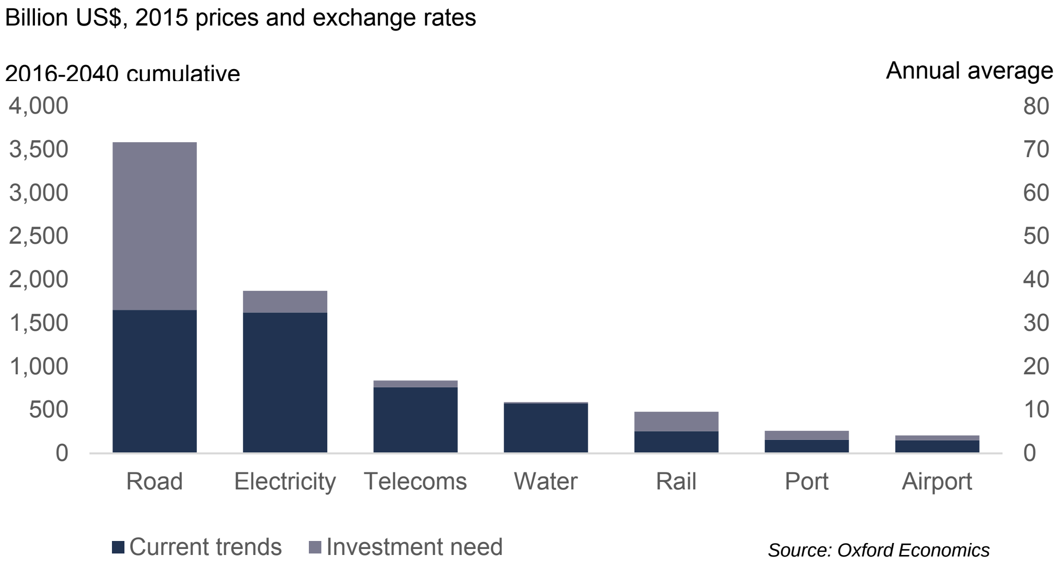
Fig. 53. *Rest of the Americas sectoral pattern of infrastructure investment, 2007-2040*



Source: Oxford Economics

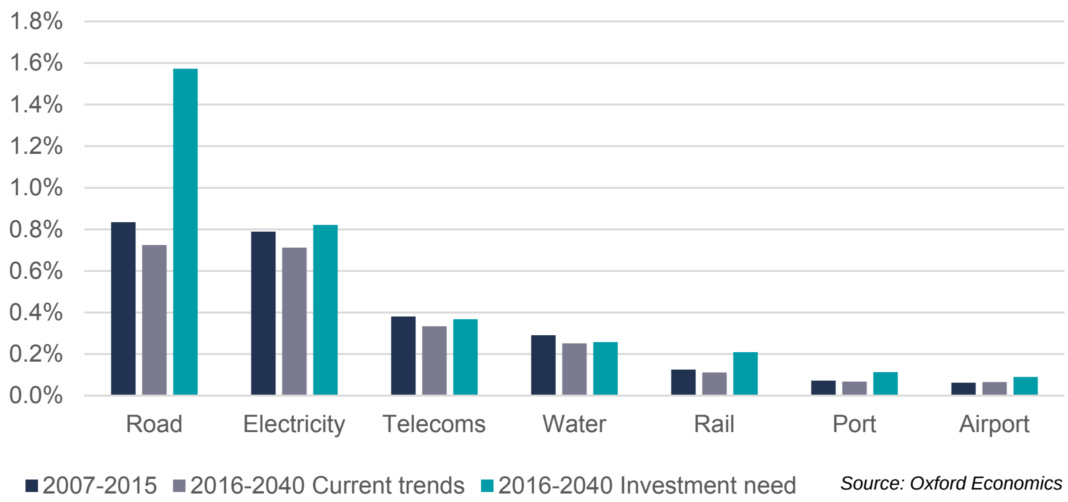
The electricity and roads sectors are each estimated to receive around $1.6 trillion of investment between 2016 and 2040 under the current trends scenario, which is more than 60 percent of the total investment requirement. Nonetheless, our analysis suggests that the American countries in our dataset under-invest in roads infrastructure compared to other countries at a similar stage of development: the forecast for road infrastructure is more than twice as high under the investment need scenario as under the current trends scenario. The gap between the two scenarios is also large for the rail sector. This may reflect that the continent's geographical characteristics do not favour rail transport. Nonetheless, there is also evidence of an investment gap in the international transport sectors: the investment need forecast is some two-thirds higher than current trends for ports, and one-third higher for airports.

Fig. 54. *Rest of the Americas infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)*



The American countries in our dataset invested the equivalent of 2.6 percent of GDP in the seven types of infrastructure included in our study between 2007 and 2015. This would ease slightly to 2.3 percent for the 2016-2040 period under the current trends scenario, but increase to 3.4 percent under the investment need scenario, with the difference primarily driven by the road sector.

Fig. 55. Rest of the Americas infrastructure spending needs by sector, 2007-2040: percent of GDP

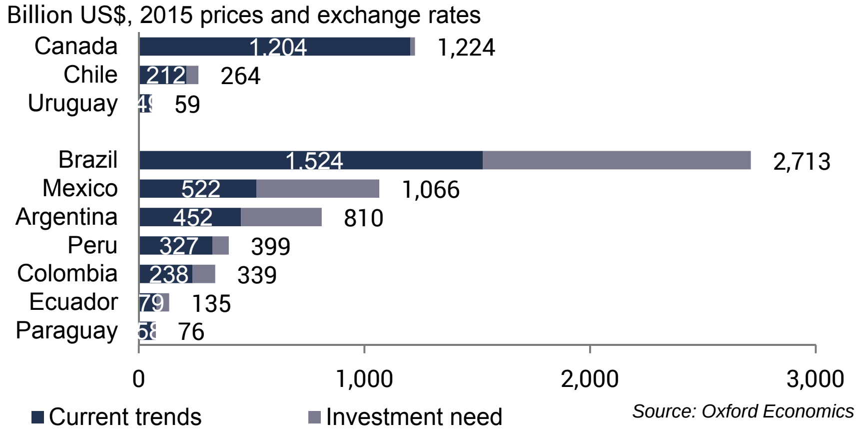


Source: Oxford Economics

6.3 REST OF THE AMERICAS: COUNTRY SPENDING NEEDS

Comparing the forecasts under the two scenarios enables us to assess which individual countries are performing well, and which ones have most need to increase the resources they dedicate to infrastructure. On this basis, the strongest performer is Canada, for which the investment need forecast is only two percent greater than the current trends forecast. Peru, Chile and Uruguay also perform well on this indicator: the gap between the two scenarios is less than 25 percent for this group. In contrast, the three largest markets appear to be significantly under-performing relative to their peers: for Brazil and Argentina the investment need forecast is almost 80 percent greater than the current trends forecast, and for Mexico the gap is more than 100 percent. Together these three countries contribute 86 percent of the infrastructure spending gap for the 10 countries shown in the chart below.

Fig. 56. Rest of the Americas infrastructure spending needs, 2016-2040 cumulative



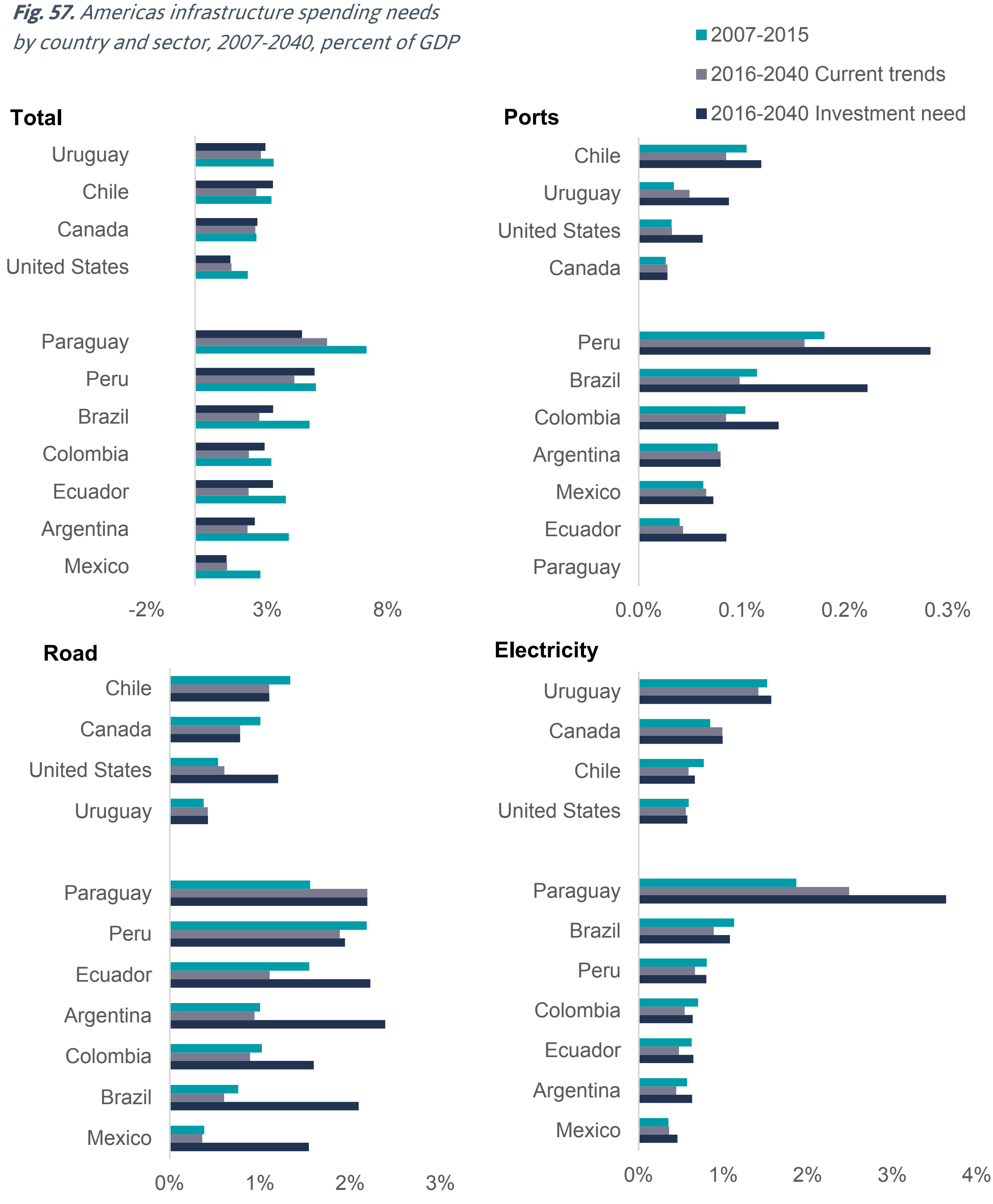
Between 2007 and 2015, infrastructure spending was particularly strong in Peru and Paraguay, which each invested more than four percent of GDP. At the other end of the scale, Mexico is estimated to have invested just 1.3 percent of GDP. In a number of countries, the forecast of spending under current trends suggests that investment is likely to represent a lower share of GDP in future than in the past. This result reflects that the current trends forecast is based on expected changes in a number of economic and demographic factors, as well as expected GDP growth. As such, we find that while infrastructure investment is forecast to grow in future if past investment behaviours continue, the rate of growth is likely to be lower than that of GDP for some of the countries in our sample.

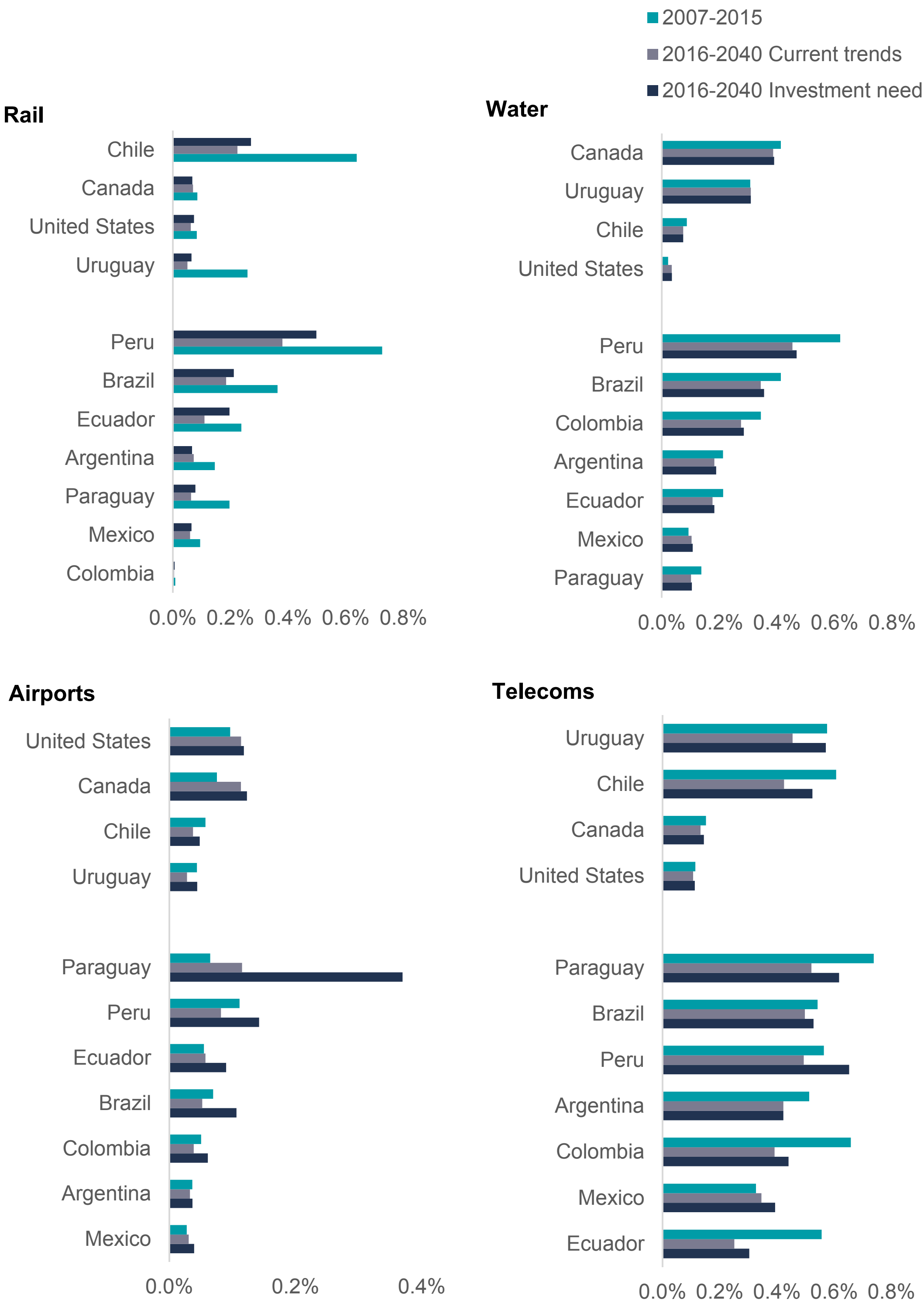
Turning to the detailed results for individual countries and sectors, there is a clear need for a step change in **roads** investment across most of the upper middle income countries in our sample. This is particularly true for Argentina, Brazil and Mexico, where our analysis suggests a large gap between what is needed and what would be delivered under current trends.

All of the countries in our sample are estimated to be under-investing in **rail** infrastructure. Rail investment has been strongest as a proportion of GDP in the recent past in Chile and Peru. Despite this, WEF rail quality data suggest that the quality of rail infrastructure lags behind that achieved by other middle income countries with a similar level of investment performance, suggesting that a further increase in investment will be needed to meet these countries' rail infrastructure needs.

The use of the WEF scores also has a notable effect on the investment need forecasts for Paraguay. For **airports**, the country receives the lowest infrastructure quality score amongst all 50 in our sample, and is level with Myanmar. This suggests that substantial investment may be needed to raise the quality of airport infrastructure to a level comparable with that for other upper middle income countries. Similar factors are at work for **electricity**, where despite relatively strong investment in recent years, the quality of electricity infrastructure remains relatively low.

Fig. 57. *Americas infrastructure spending needs by country and sector, 2007-2040, percent of GDP*



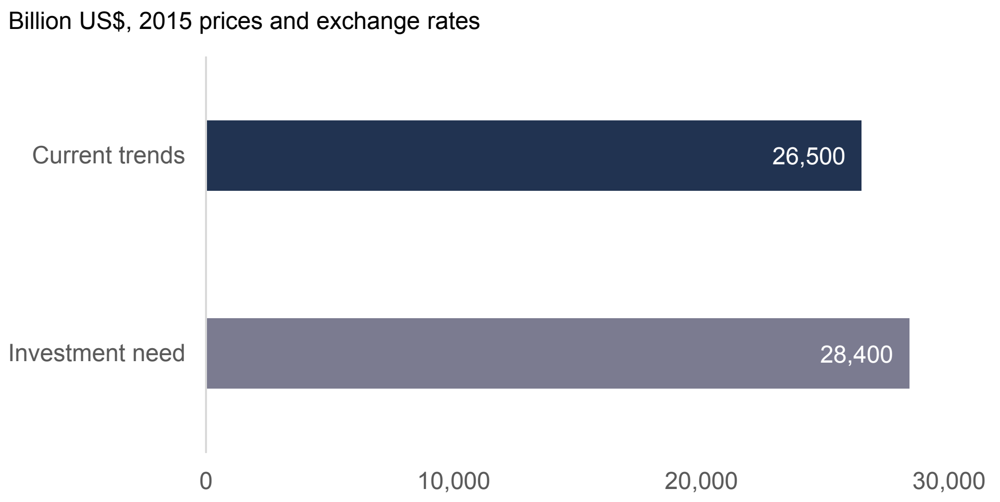

2007-2015
2016-2040 Current trends
2016-2040 Investment need
Rail
Chile
Canada
United States
Uruguay
Peru
Brazil
Ecuador
Argentina
Paraguay
Mexico
Colombia
0.0% 0.2% 0.4% 0.6% 0.8%
Water
Canada
Uruguay
Chile
United States
Peru
Brazil
Colombia
Argentina
Ecuador
Mexico
Paraguay
0.0% 0.2% 0.4% 0.6% 0.8%
Airports
United States
Canada
Chile
Uruguay
Paraguay
Peru
Ecuador
Brazil
Colombia
Argentina
Mexico
0.0% 0.2% 0.4%
Telecoms
Uruguay
Chile
Canada
United States
Paraguay
Brazil
Peru
Argentina
Colombia
Mexico
Ecuador
0.0% 0.2% 0.4% 0.6% 0.8%

7. Regional infrastructure needs: **Asia**

7.1 CHINA

Rapid economic development in China over the last decade has been accompanied by a huge programme of infrastructure investment, such that between 2007 and 2015 we estimate that China accounted for almost 30 percent of all global infrastructure investment. While we expect the rate of infrastructure investment growth to moderate during the forecast period, in common with the pattern for overall investment within the Chinese economy, we expect China to maintain a similar share of global infrastructure investment in future. Under current trends, we estimate China's infrastructure investment to be slightly over $26 trillion, or $1.1 trillion per year. Given China's strong recent infrastructure investment performance, relatively little uplift in investment is required for China to match the performance of its top performing peers. As such, the infrastructure need forecast is just seven percent higher than under current trends.

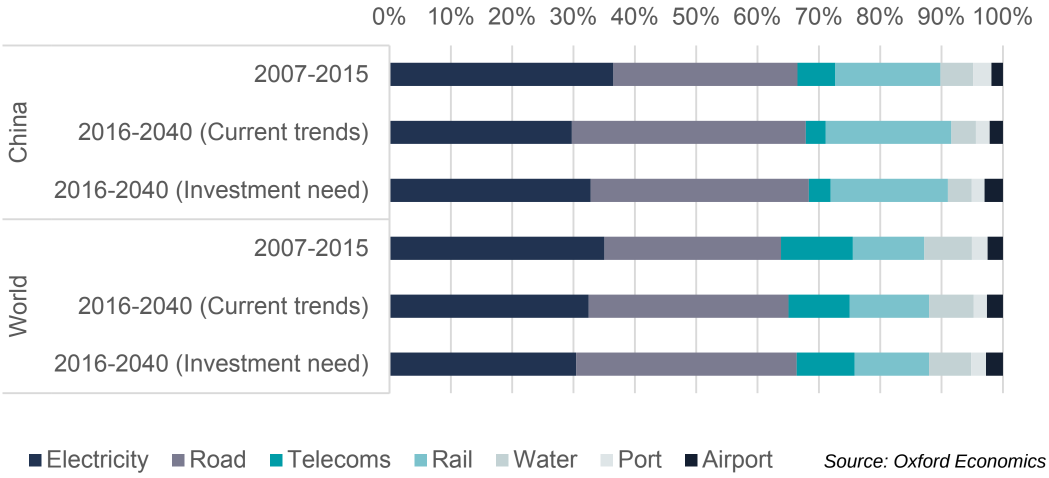
Fig. 58. *China total infrastructure spending needs, 2016-2040*



Source: Oxford Economics

China's infrastructure boom has been relatively broad-based, and the distribution of investment across sectors is similar to the global average, although the country has invested an above-average share in rail infrastructure, and a below-average share in telecoms. Our analysis suggests the proportion of investment going to rail and road infrastructure could increase in future, while electricity may account for a slightly smaller share of investment than in the past.

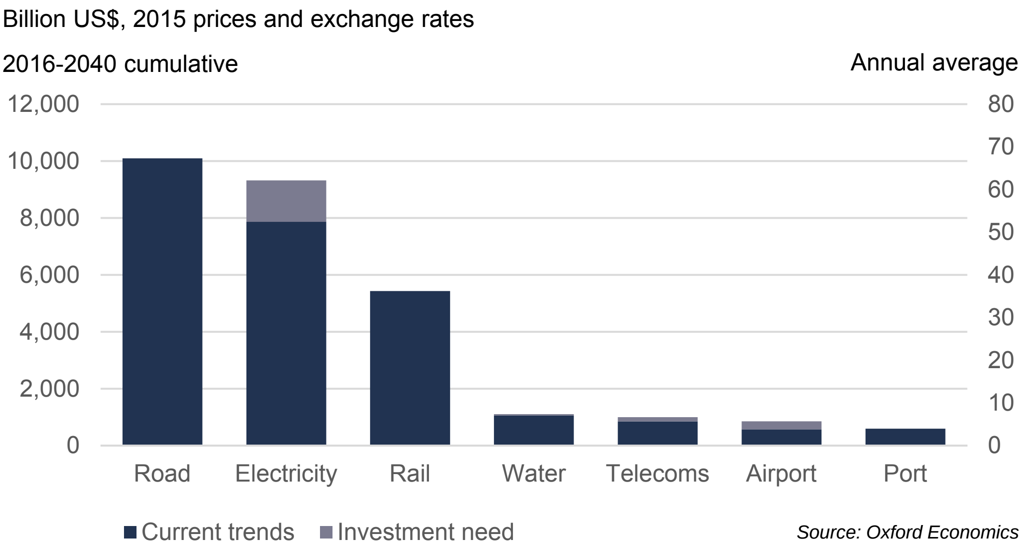
Fig. 59. China sectoral pattern of infrastructure investment, 2007-2040



Source: Oxford Economics

In common with the pattern observed elsewhere in this study, the road and electricity sectors account for a large proportion of China's estimated future spending need: together they account for $18 trillion out of the $26 trillion total spending forecast under current trends. However, rail also plays an unusually prominent role within the Chinese infrastructure market as the country continues to develop a network of high-speed lines to link its major cities. Under current trends, $5.4 trillion of investment in rail infrastructure is expected between 2016 and 2040.

Fig. 60. China infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)

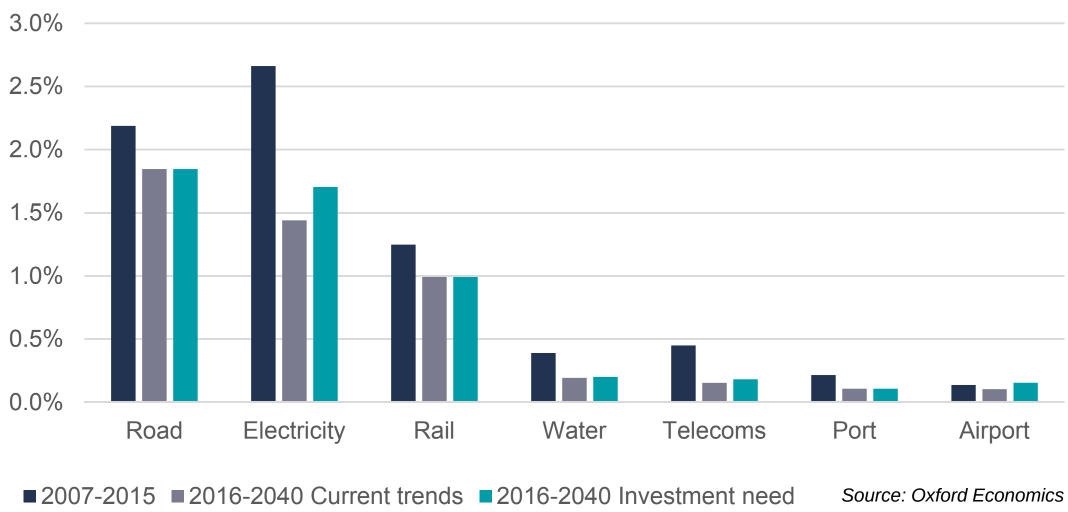


Source: Oxford Economics

As noted above, in most sectors China does not require a significant uplift in its investment performance to match its best performing peers in the investment need scenario because it tends to be one of the best performing countries within the upper middle income group. One exception to this, however, is **electricity** where our modelling suggests that China has invested less than would be expected given its economic and demographic characteristics. As such, the investment need forecast is around 18 percent higher than the current trends forecast for this sector. **Airports** is another area where there is scope for improvement. In this sector, the WEF score for China is below what would be expected given the value of past investment and, as such, our model suggests a need for an increase in investment above what would be delivered under current trends.

While our forecasts for China suggest the country will need to continue to increase spending in the years ahead, these requirements appear affordable because they represent a lower proportion of GDP than has been spent in the past. Overall, we estimate that China's future infrastructure spending will be around 4.8 percent of GDP under current trends, or 5.2 percent of GDP under the investment need scenario. This compares to 7.3 percent between 2007 and 2015.

Fig. 61. *China infrastructure spending needs by sector, 2007-2040: percent of GDP*



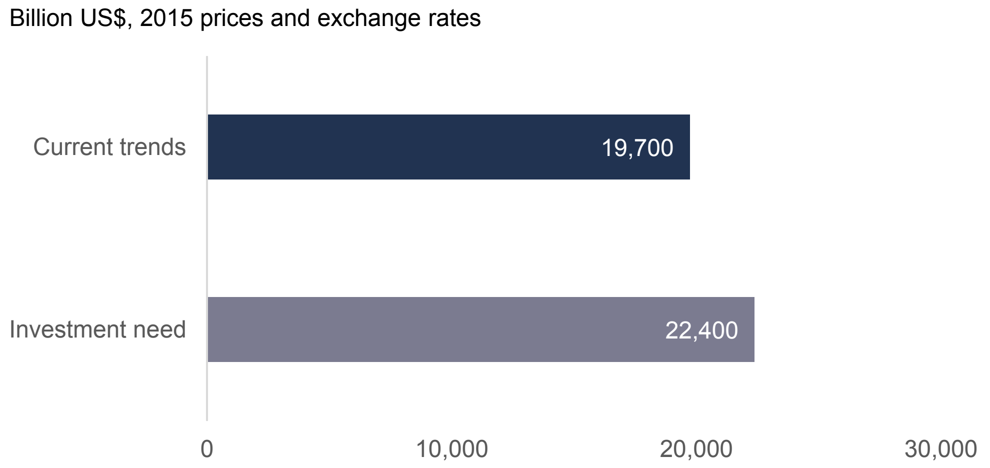
Source: Oxford Economics

7.2 REST OF ASIA: REGIONAL SPENDING NEEDS

The 17 Asian economies within our sample, including China, account for 85 percent of regional GDP and there is considerable diversity within this group: in 2015 GDP per head ranged from less than $1,500 per person in countries such as Cambodia and Myanmar, up to $53,000 in Singapore. The trends outlined below therefore encompass a set of countries with widely varying infrastructure needs, whether that be to provide access to basic services for the population, or develop world-leading transport and communications infrastructure.

Our modelling suggests that Asia, excluding China, will invest $19.7 trillion between 2016 and 2040 under current trends. This increases by around 13 percent to $22.4 trillion under the investment need scenario, or $895 billion per year.

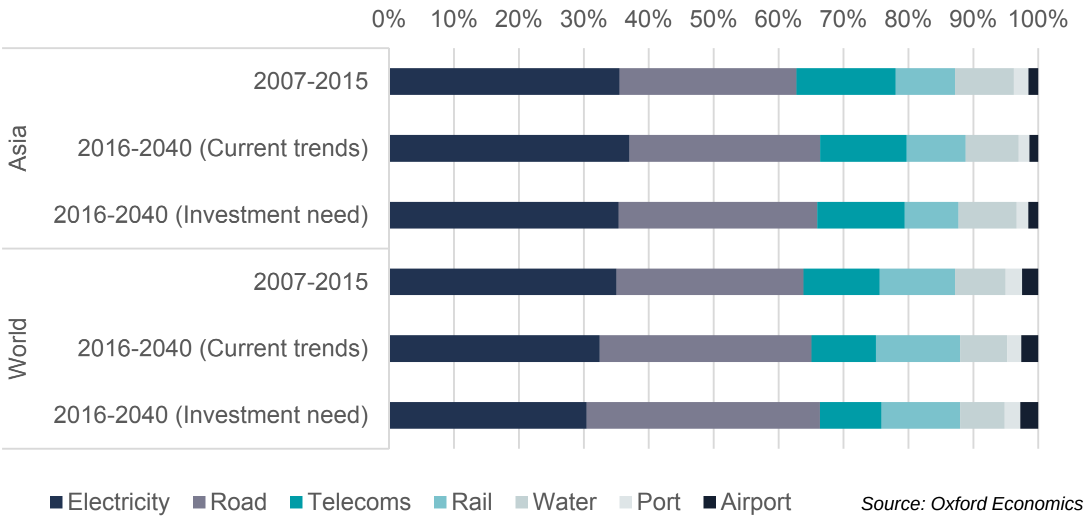
Fig. 62. *Rest of Asia total infrastructure spending needs, 2016-2040*



Source: Oxford Economics

The pattern of infrastructure investment across sectors has been broadly in line with global trends in recent years, and is expected to remain fairly stable over the forecast period.

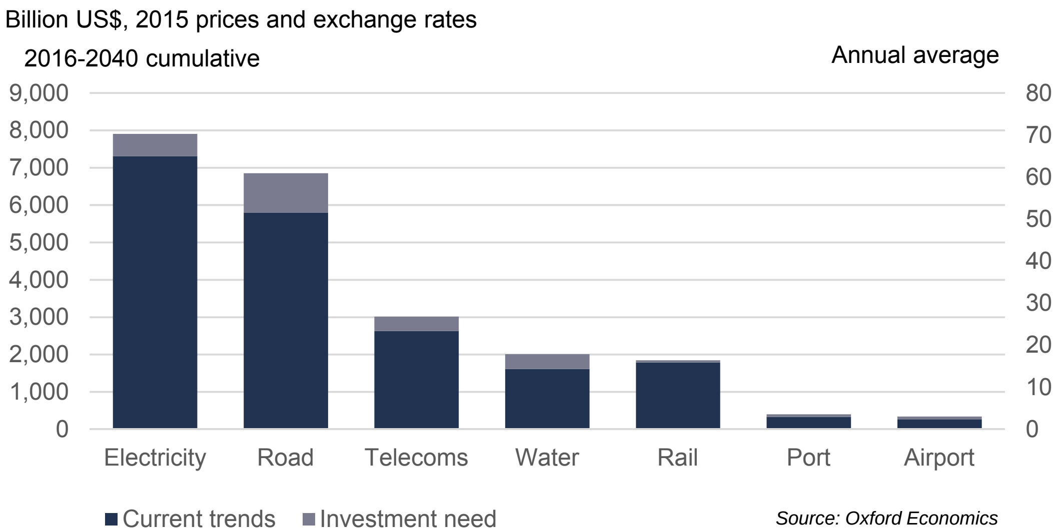
Fig. 63. Rest of Asia sectoral pattern of infrastructure investment, 2007-2040



Source: Oxford Economics

The chart below shows investment under our two scenarios, by sector. The gap between the two scenarios is proportionately greatest in the water, airports and ports sectors, where the investment need forecast is around one-quarter higher than the forecast based on current trends.

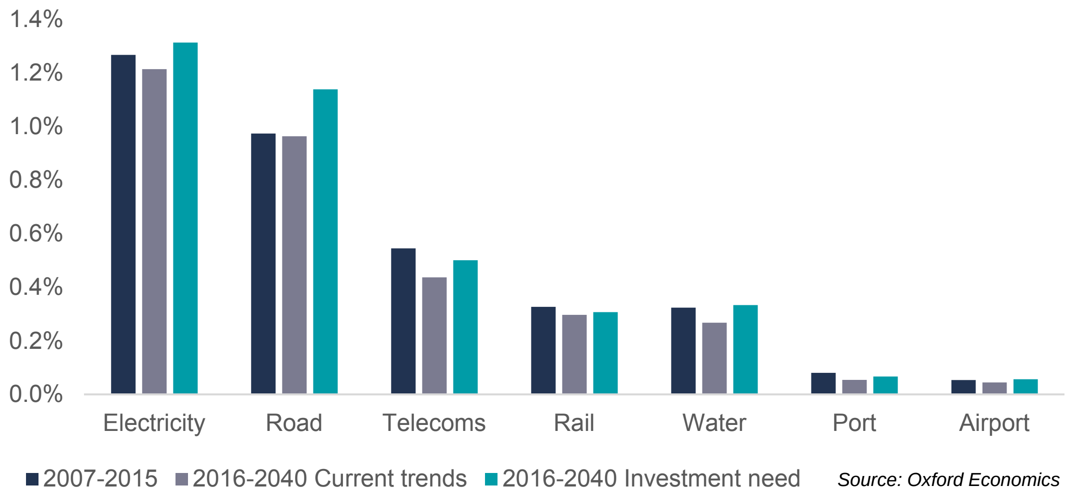
Fig. 64. Rest of Asia infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)



Source: Oxford Economics

Between 2007 and 2015 infrastructure investment in Asia, excluding China, averaged 3.6 percent of GDP. The investment required under the current trends forecast appears relatively affordable, at 3.3 percent of GDP in total, which also implies that infrastructure investment will grow less strongly than GDP in future. Delivering the infrastructure requirement suggested by the investment need forecast will require increasing investment only very slightly from the historic level to around 3.7 percent of GDP.

Fig. 65. *Rest of Asia infrastructure spending needs by sector, 2007-2040: percent of GDP*



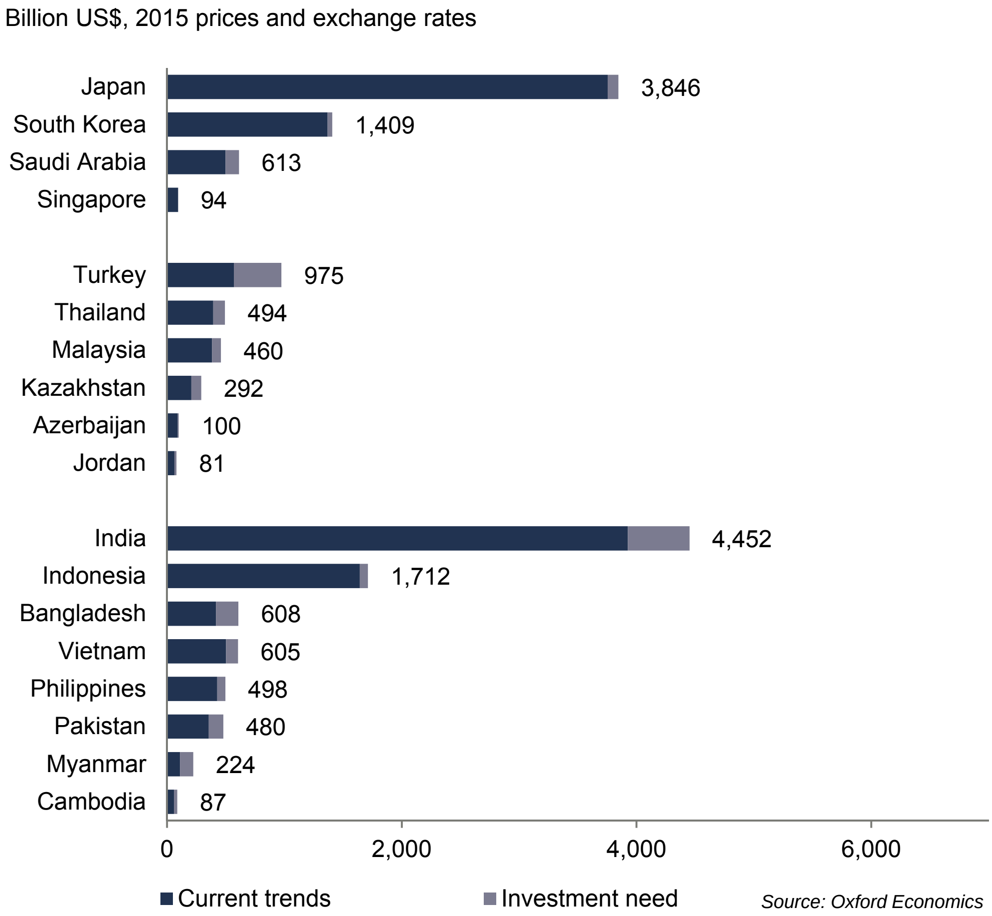
Source: Oxford Economics

7.3 REST OF ASIA: COUNTRY SPENDING NEEDS

In terms of future needs, the second largest infrastructure market in Asia after China is India. The country's GDP per head currently stands at $1,600 and is forecast to rise to $4,800 by 2040, which is still some way below the *current* level in China of $8,000. As such, while population growth in India is expected to drive significant demand for infrastructure in India over the next 25 years, in absolute terms this infrastructure requirement will be substantially lower than in China, which is at a more advanced stage of development. As India develops, we estimate the country will need to invest $3.9 trillion under current trends, increasing to $4.5 trillion under the investment need scenario.

The high income countries in our sample already benefit from high quality infrastructure and, as such, there is a very small gap between the current trends and investment need forecasts. As might be expected, the gap is greater amongst low and middle income countries. The three Asian economies in our sample with the lowest levels of GDP per head also have amongst the largest gaps, relative to what would be spent under current trends: Bangladesh, Cambodia and Myanmar.

Fig. 66. Rest of Asia infrastructure spending needs, 2016-2040 cumulative



Source: Oxford Economics

In the **electricity** sector our modelling suggests that Cambodia and Bangladesh need to substantially increase investment compared to what would be delivered under current trends. This is in contrast to Pakistan and Myanmar, which have similar levels of GDP per head, but much lower infrastructure need forecasts. The contrasting forecasts for these pairs of countries result from the quality adjustment step within the modelling. The data available for Pakistan and Myanmar suggest that the value of infrastructure stock per person is very low in these countries. However, the quality of electricity infrastructure WEF indicator is relatively good, *given the amounts invested*, implying that Pakistan and Myanmar are relatively effective at converting investment into infrastructure provision. As such, the quality adjustment substantially reduces their estimated requirement under the investment need scenario.

In the **water** sector, our modelling suggests that a step change in investment is required amongst almost all of the Asian countries in the lowest income group. Our model also implies a relatively low need forecast for Saudi Arabia, relative to the country's past investment. No source of historical data could be identified in this case, so the modelling is based on econometric estimates of the value of water stock which draws on the relationships established for all countries in our sample. However, stakeholders report that the costs of water provision are likely to be relatively high in Saudi Arabia, given its reliance on desalination. In the absence of data to validate this it was not possible to reflect this within the modelled values, but our forecast here should be regarded as conservative.

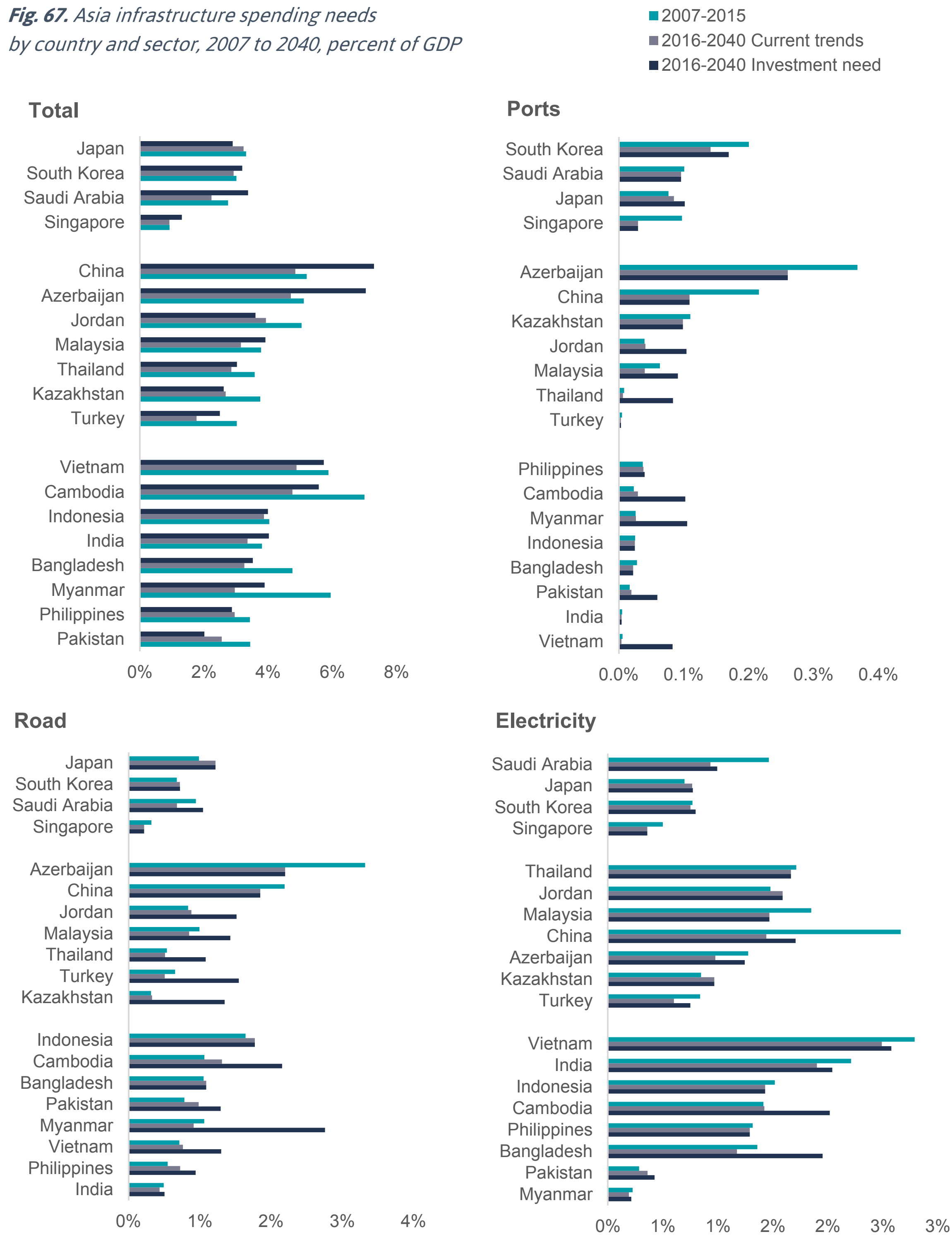
Based on the available OECD data, the rate of investment in **ports** appears extremely low in India. However, India scores relatively well on the WEF ports infrastructure quality measure, given its low level of income per head and past investment. Our model therefore determines that a continuation of the past levels of investment will be sufficient to meet future infrastructure needs. Amongst the low income countries in our sample, Pakistan, Cambodia, Myanmar and Vietnam are all estimated to require a substantial uplift in investment in ports infrastructure to support their development. In contrast, Indonesia is amongst the top performing countries in this income group, suggesting that a continuation of investment in line with current trends will be sufficient to meet its future ports infrastructure needs.

In the **telecoms** sector, official statistics suggest that investment in Singapore has been relatively low in recent years compared to other developed economies. At the same time, Singapore is widely regarded as having very high quality telecoms infrastructure[49] (though no WEF indicator is available for this sector). Low levels of investment may reflect that the cost per person of telecoms infrastructure is considerably lower in a densely populated city state than in a country with a lower population density. As such, the quality adjustment step within the modelling determines that investment in line with past trends will be sufficient to meet Singapore's telecoms needs in future.[50]

[49]See, for example, HYPERLINK "https://www.akamai.com/us/en/multimedia/documents/report/q3-2015-soti-connectivity-final.pdf" https://www.akamai.com/us/en/multimedia/documents/report/q3-2015-soti-connectivity-final.pdf which suggests that Singapore has very high broadband connection speeds, and is amongst the top countries in the world for adoption of fast broadband.

[50]Our modelling initially produced an implausibly high forecast of telecoms infrastructure need for Cambodia. This has therefore been manually capped at the maximum obtained for other countries in the same income group. Similarly, the investment need forecast for roads in Kazakhstan implied an implausibly large uplift over the current trends forecast. In that case we capped the uplift applied at the level of the next highest country.

Fig. 67. Asia infrastructure spending needs by country and sector, 2007 to 2040, percent of GDP



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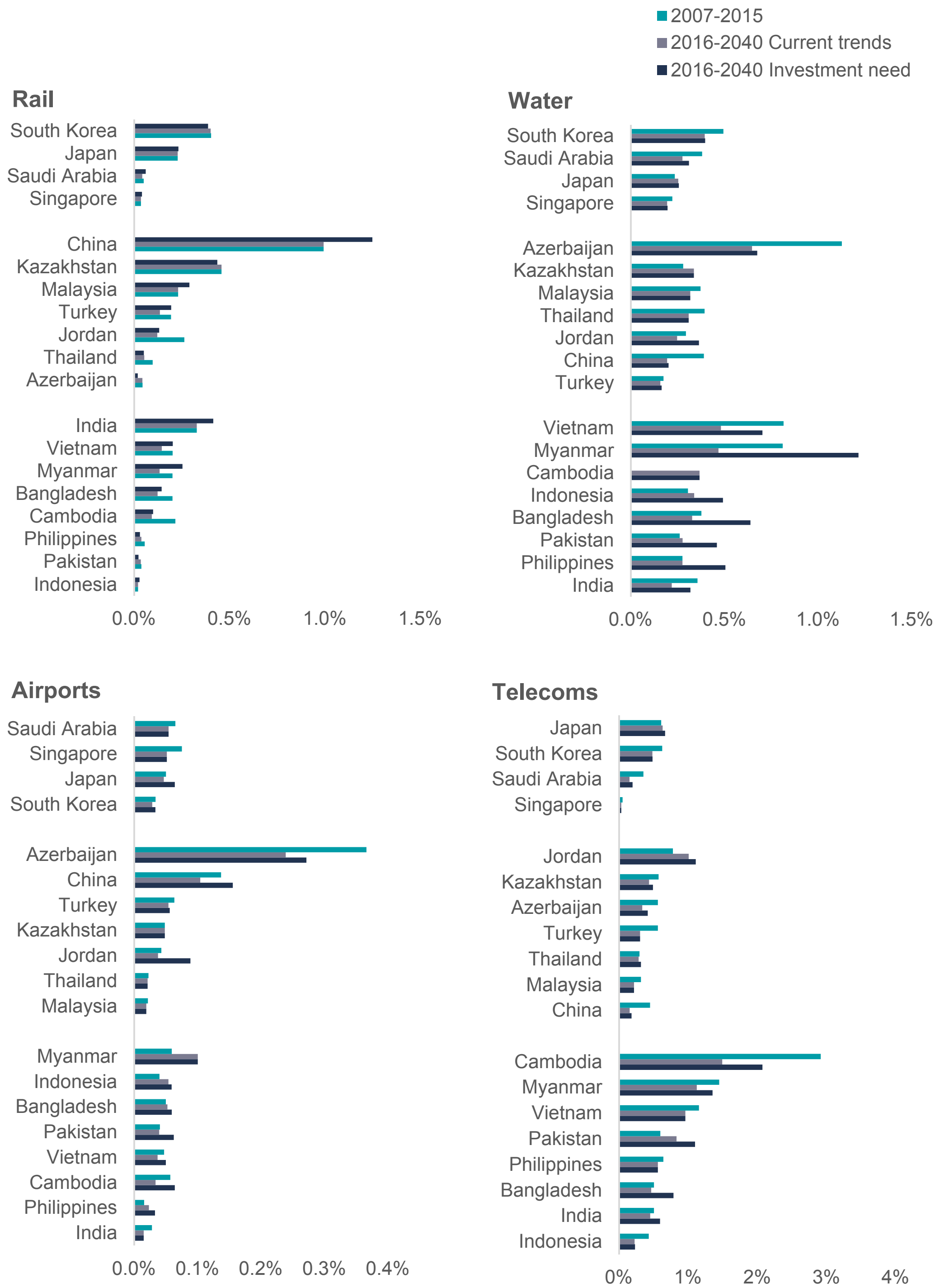
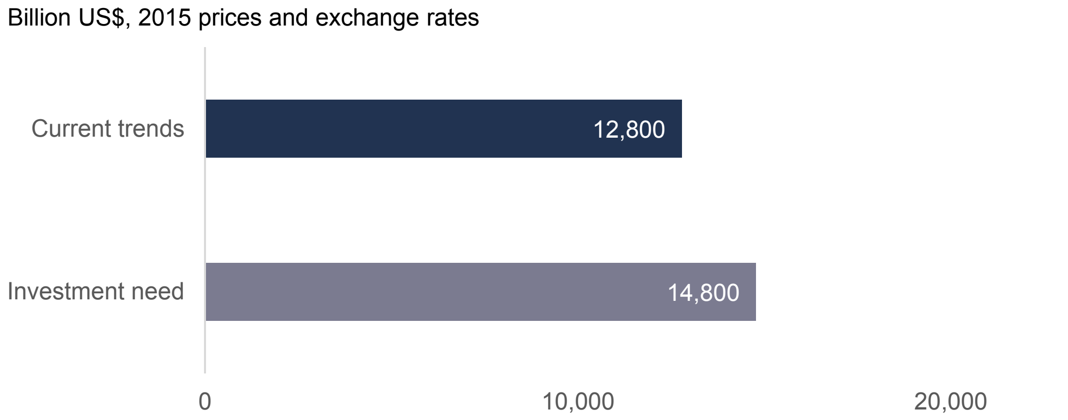

2007-2015
2016-2040 Current trends
2016-2040 Investment need
Rail
South Korea
Japan
Saudi Arabia
Singapore
China
Kazakhstan
Malaysia
Turkey
Jordan
Thailand
Azerbaijan
India
Vietnam
Myanmar
Bangladesh
Cambodia
Philippines
Pakistan
Indonesia
0.0%
0.5%
1.0%
1.5%
Water
South Korea
Saudi Arabia
Japan
Singapore
Azerbaijan
Kazakhstan
Malaysia
Thailand
Jordan
China
Turkey
Vietnam
Myanmar
Cambodia
Indonesia
Bangladesh
Pakistan
Philippines
India
0.0%
0.5%
1.0%
1.5%
Airports
Saudi Arabia
Singapore
Japan
South Korea
Azerbaijan
China
Turkey
Kazakhstan
Jordan
Thailand
Malaysia
Myanmar
Indonesia
Bangladesh
Pakistan
Vietnam
Cambodia
Philippines
India
0.0%
0.1%
0.2%
0.3%
0.4%
Telecoms
Japan
South Korea
Saudi Arabia
Singapore
Jordan
Kazakhstan
Azerbaijan
Turkey
Thailand
Malaysia
China
Cambodia
Myanmar
Vietnam
Pakistan
Philippines
Bangladesh
India
Indonesia
0%
1%
2%
3%
4%

8. Regional infrastructure needs: **Europe**

8.1 REGIONAL SPENDING NEEDS

We estimate that under current trends Europe is likely to invest $12.8 trillion in infrastructure between 2016 and 2040. This increases by 16 percent to $14.8 trillion under the investment need scenario, or $590 billion per year.

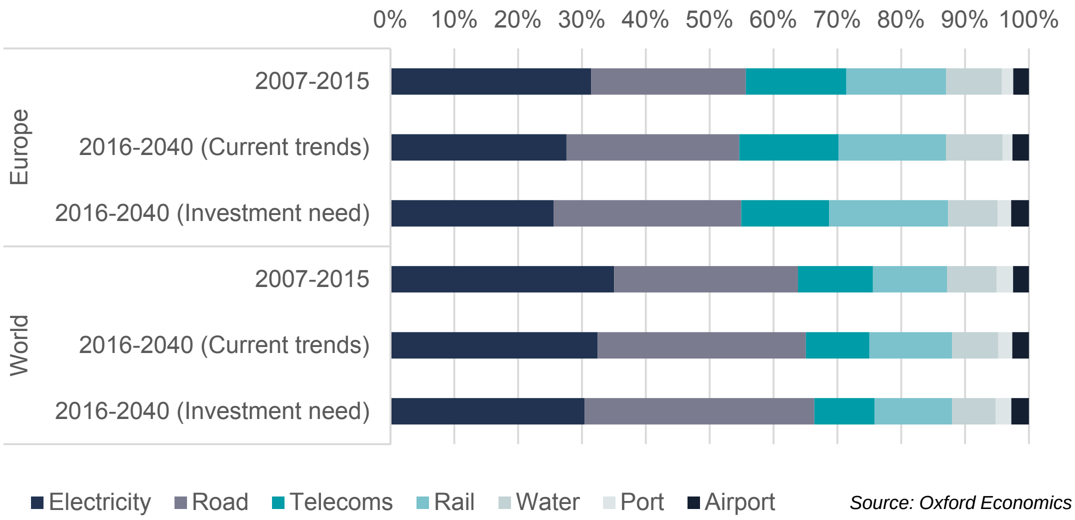
Fig. 68. *Europe total infrastructure spending needs, 2016-2040*



Source: Oxford Economics

The distribution of spending in Europe in recent years has been broadly in line with the global average, although Europe tends to dedicate a slightly above-average proportion of infrastructure investment to rail transport, and less to road. The share of investment going to the telecoms sector is also relatively high in Europe, while the continent allocates slightly less than average to electricity.

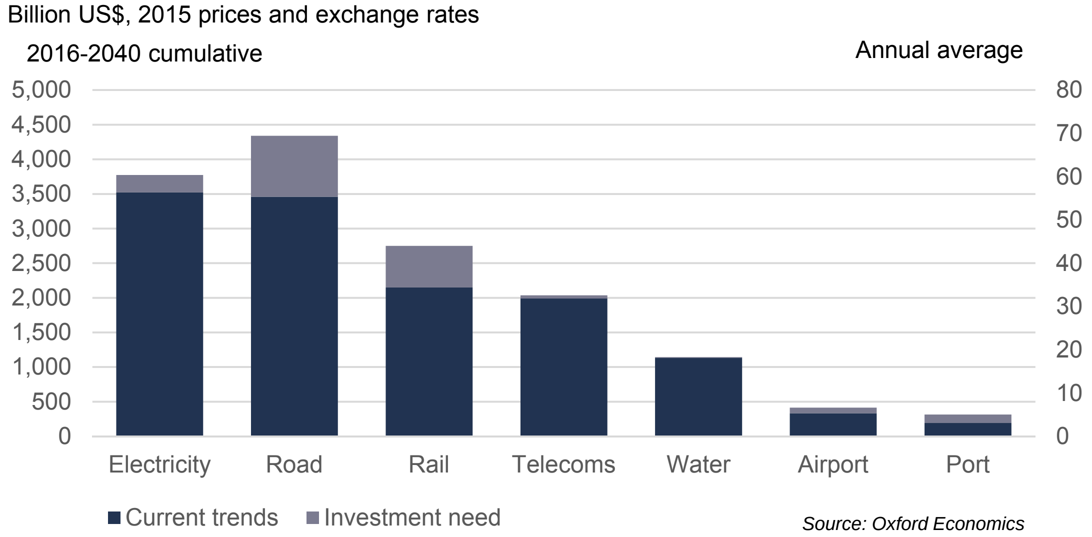
Fig. 69. *Europe sectoral pattern of infrastructure investment, 2007-2040*



Source: Oxford Economics

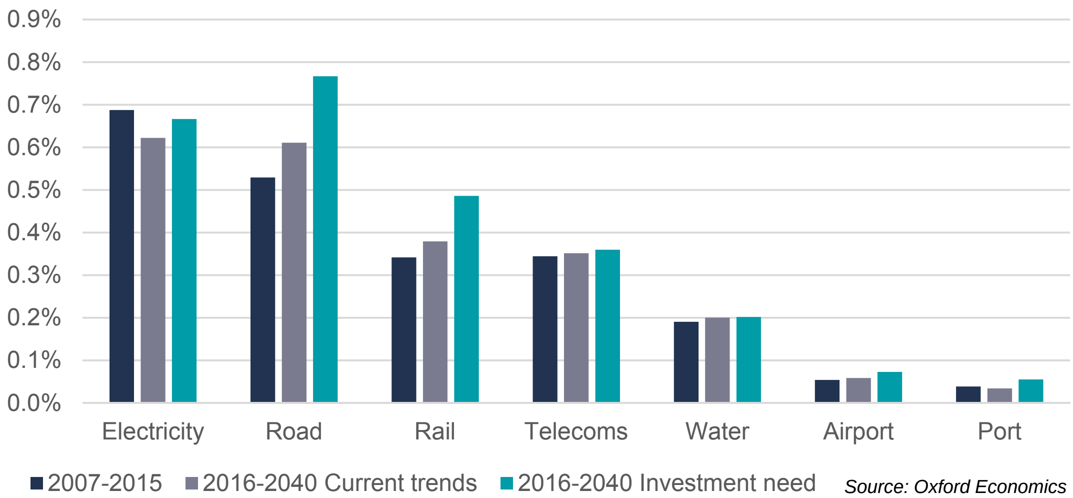
We estimate infrastructure investment in the two largest sectors, electricity and roads, to be $7 trillion under the current trends scenario between 2016 and 2040, which is just over half the total. The gap between the two scenarios is proportionately greatest for ports, where the estimated investment need is 62 percent greater than the current trends forecast. Railways, roads and airports also have investment gaps of more than 20 percent. In contrast, there is only a very small gap between the investment need and current trends forecasts for the water and telecoms sectors.

Fig. 70. *Europe infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)*



As a relatively mature infrastructure market, Europe tends to invest less in infrastructure as a proportion of GDP than regions which include more low and middle income countries. Overall, Europe invested 2.2 percent of GDP in infrastructure between 2007 and 2015. This is the second lowest proportion amongst the regions in our study, behind only the Americas. To deliver the infrastructure investment identified by our current trends forecast Europe would need to maintain spending at a similar share of GDP between 2016 and 2040, or increase it slightly to 2.6 percent of GDP to deliver the investment need forecast. Overall, meeting the region’s infrastructure needs appears to be affordable, though the size of the increase is greater in certain sectors: investment in road and rail infrastructure would need to increase by 0.2 percent and 0.1 percent of GDP respectively to deliver the investment need forecast, over and above what would be spent under current trends.

***Fig. 71.** Europe infrastructure spending needs by sector, 2007-2040: percent of GDP*



Source: Oxford Economics

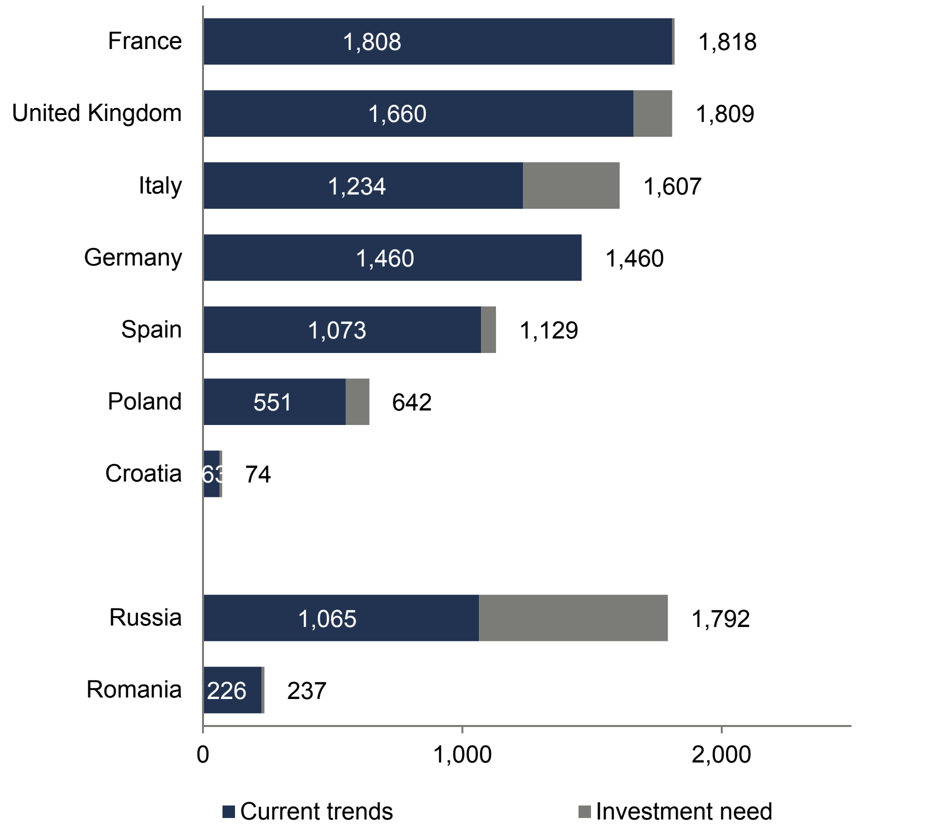
8.2 COUNTRY SPENDING NEEDS

Our sample includes seven high income and two upper middle income countries in Europe, which together account for just over 70 percent of European GDP. Just four countries have accounted for almost half of total European infrastructure spending in recent years: France, the UK, Russia and Germany.

France and Germany, in particular, have very high quality infrastructure in place across most sectors and, as such, our modelling suggests that a continuation of past investment trends will be virtually sufficient to meet those countries' future infrastructure needs. In contrast, for countries with lower income levels there is a larger difference between our forecasts under the two scenarios: Russia's infrastructure need is 68 percent greater than would be delivered under current trends, while it is 17 percent for both Croatia and Poland. The gap is also relatively large for Italy, where the investment need is 30 percent greater than would be delivered under current trends.

Fig. 72. Europe infrastructure spending needs, 2016-2040 cumulative

Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

Consistent with the discussion above, our modelling suggests that the lower income countries in our sample will generally need to invest more in infrastructure, as a proportion of GDP than European countries with higher incomes.

According to WEF data, the quality of Russian **roads** lags behind that in many other upper middle income countries, which is consistent with the relatively low levels of investment suggested by the data we have collected. Our model therefore suggests that a step change in investment will be needed to deliver the investment need forecast.

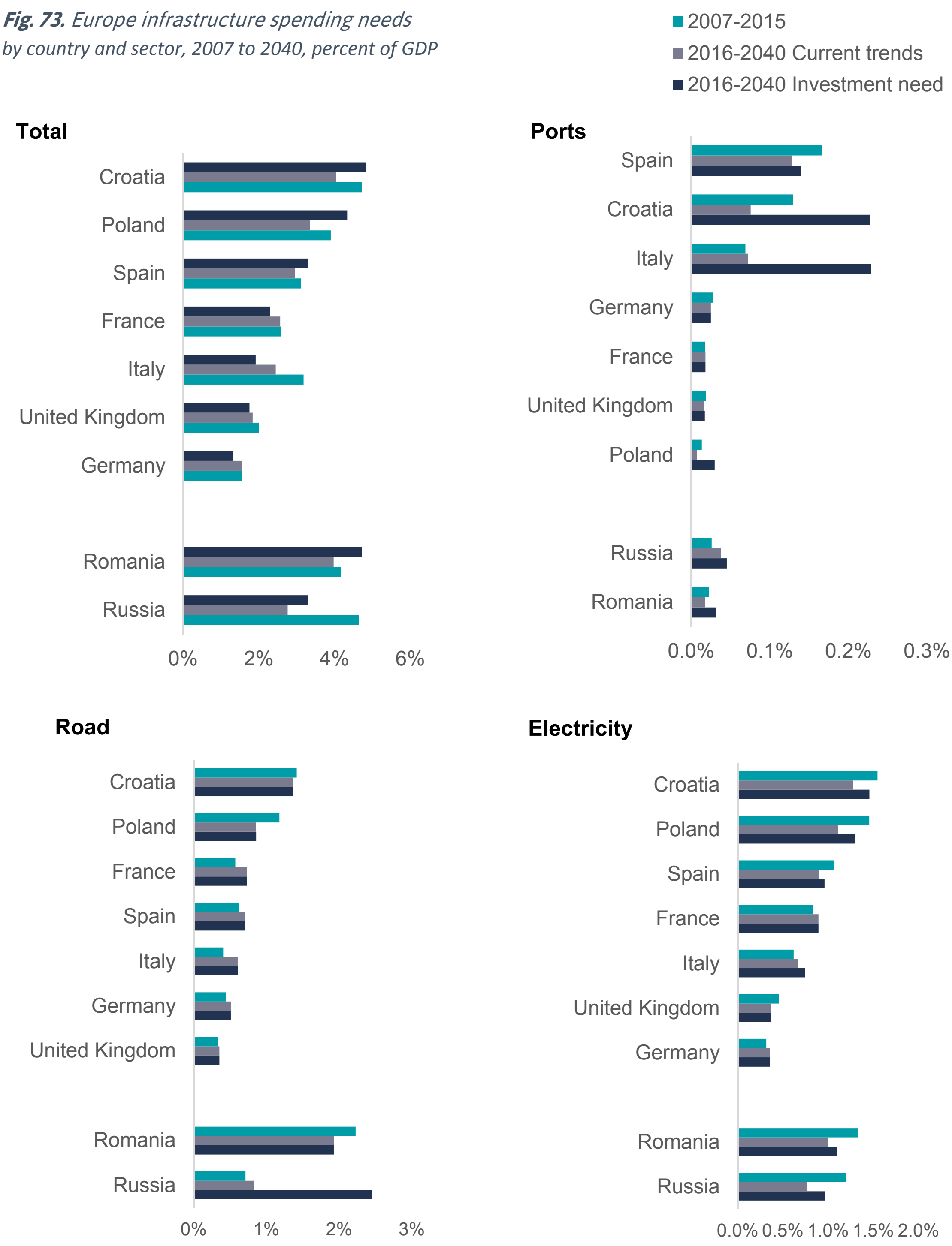
Despite high levels of investment in the Italian **railways** in recent years as the country has expanded its high-speed network, the country's WEF rail quality score remains well below those in other wealthy European economies. Taken together this evidence implies that Italy is relatively inefficient at converting high levels of investment into quality infrastructure provision.[51] To account for this, the quality adjustment phase in our modelling increases the uplift applied to Italy as, all else equal, a higher level of investment will be needed to meet the country's future rail infrastructure needs.

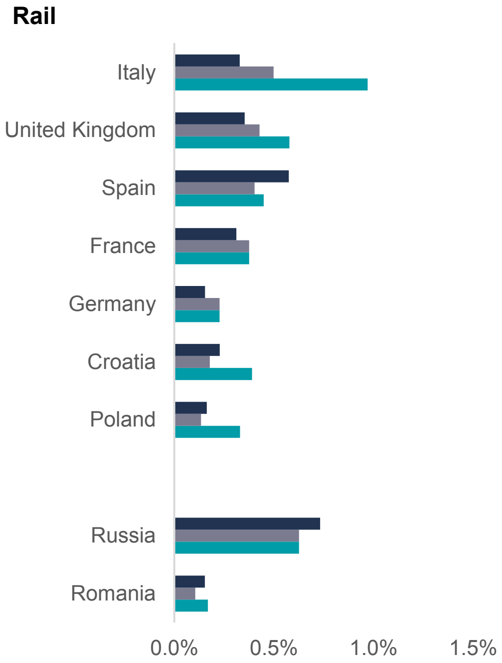
For **airports** our modelling suggests a large gap between the two scenarios for Croatia and Russia, in particular. In the case of Russia, the large uplift identified again stems from the quality adjustment process—the WEF score for Russia's airports is low relative to the value of past investment, leading to an increased investment need forecast. For Croatia, the estimated value of airport infrastructure stock is low relative to what would be expected given the country's economic characteristics. As such, the investment need forecast suggests that an uplift in investment is required to match the performance of Croatia's better performing peers.

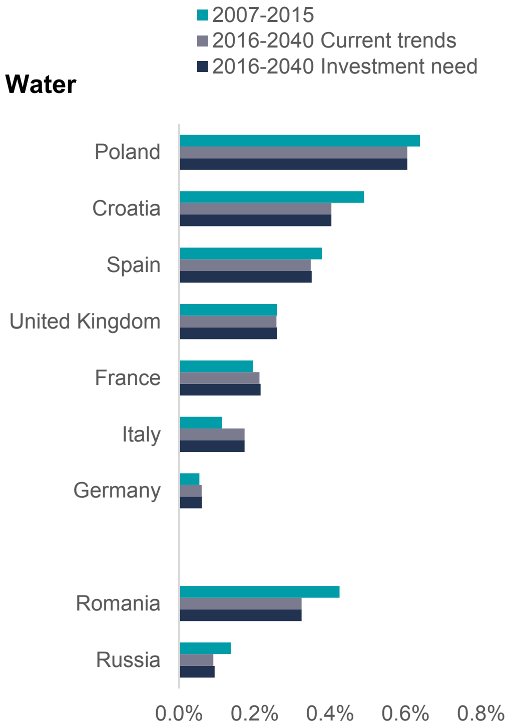
Similar factors drive the large uplift identified for Croatia and Italy in the **ports** sector. Both countries lag behind the best performing high income countries in terms of the value of their ports infrastructure stock (relative to what would be expected given each country's characteristics), suggesting a need for greater investment in future than would be achieved under current trends.

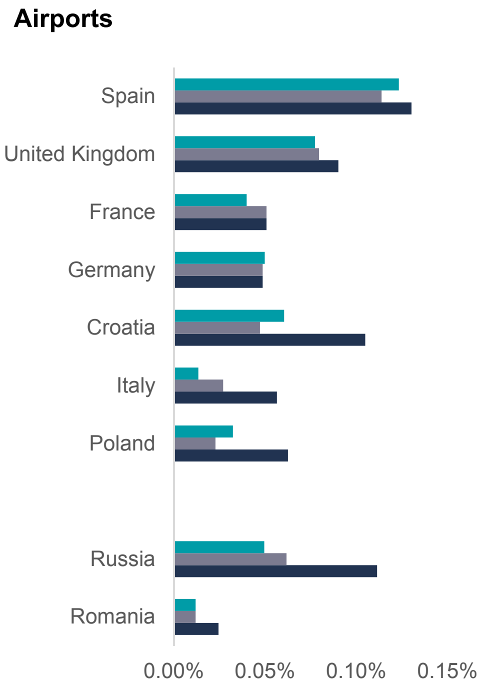
[51] Another possibility is that the low WEF score reflects negative perceptions of the Italian rail network amongst Italian survey respondents. If such perceptions are not a true reflection of the quality of service available on the Italian rail network, then there may be a tendency for the quality adjustment within our model to over-estimate the spending requirement.

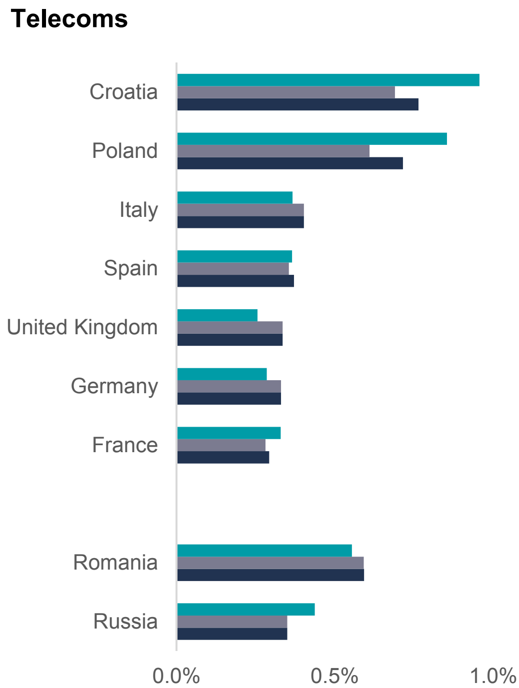
Fig. 73. Europe infrastructure spending needs by country and sector, 2007 to 2040, percent of GDP




Rail
Italy
United Kingdom
Spain
France
Germany
Croatia
Poland
Russia
Romania
0.0%
0.5%
1.0%
1.5%


2007-2015
2016-2040 Current trends
2016-2040 Investment need
Water
Poland
Croatia
Spain
United Kingdom
France
Italy
Germany
Romania
Russia
0.0%
0.2%
0.4%
0.6%
0.8%


Airports
Spain
United Kingdom
France
Germany
Croatia
Italy
Poland
Russia
Romania
0.00%
0.05%
0.10%
0.15%


Telecoms
Croatia
Poland
Italy
Spain
United Kingdom
Germany
France
Romania
Russia
0.0%
0.5%
1.0%

OCEANIA

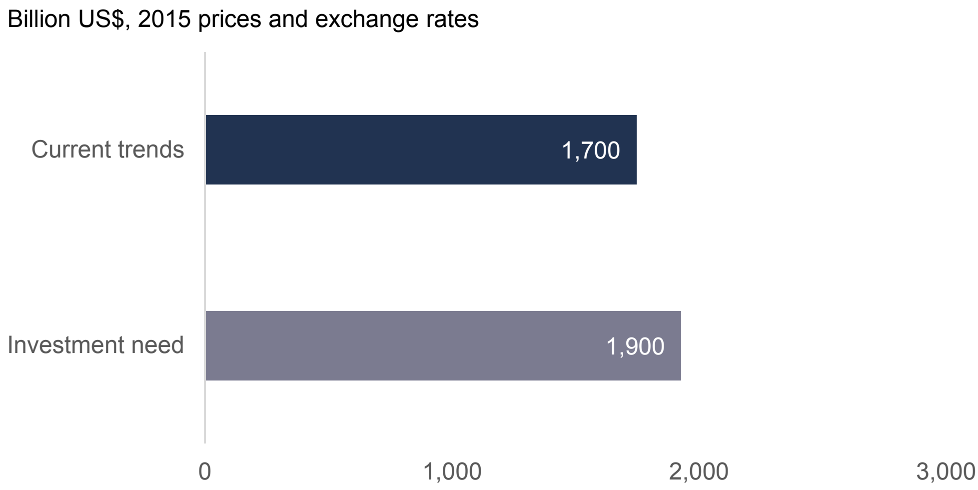
9. Regional infrastructure needs: **Oceania**

9.1 REGIONAL SPENDING NEEDS

The geography of Oceania means that spending needs tend to be relatively high by developed economy standards: its constituent countries are island nations with a strong need for international air and port connectivity, and have low population densities. The latter means that networks for road, rail and utilities need to cover long distances, and will therefore be more costly than in countries where the population is more concentrated.

Our analysis suggests that if the countries of Oceania continue to spend in line with current trends the region will invest $1.7 trillion between 2016 and 2040, or $70 billion per year. The region has invested very strongly in recent years, and the forecast investment need is just 10 percent higher than the current trends forecast, reflecting that a relatively small uplift is required to align spending with the best performing high income countries (after controlling for countries' characteristics).

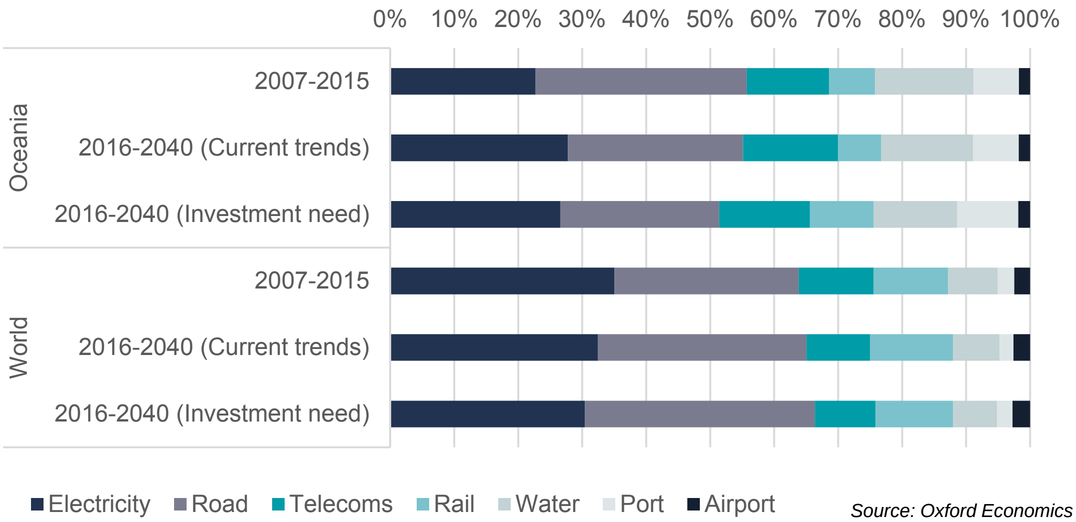
Fig. 74. *Oceania total infrastructure spending needs, 2016-2040*



Source: Oxford Economics

In the recent past, an above average proportion of Oceania's infrastructure investment has gone to the water and ports sectors. The latter is likely to be linked to strong growth in Australia's status as a source of raw materials for emerging Asian economies, in particular. Meanwhile, low population densities mean that Australia and New Zealand are better suited to road and air transport, rather than rail transport: the latter has accounted for seven percent of infrastructure investment since 2007, compared to the world average of 12 percent.

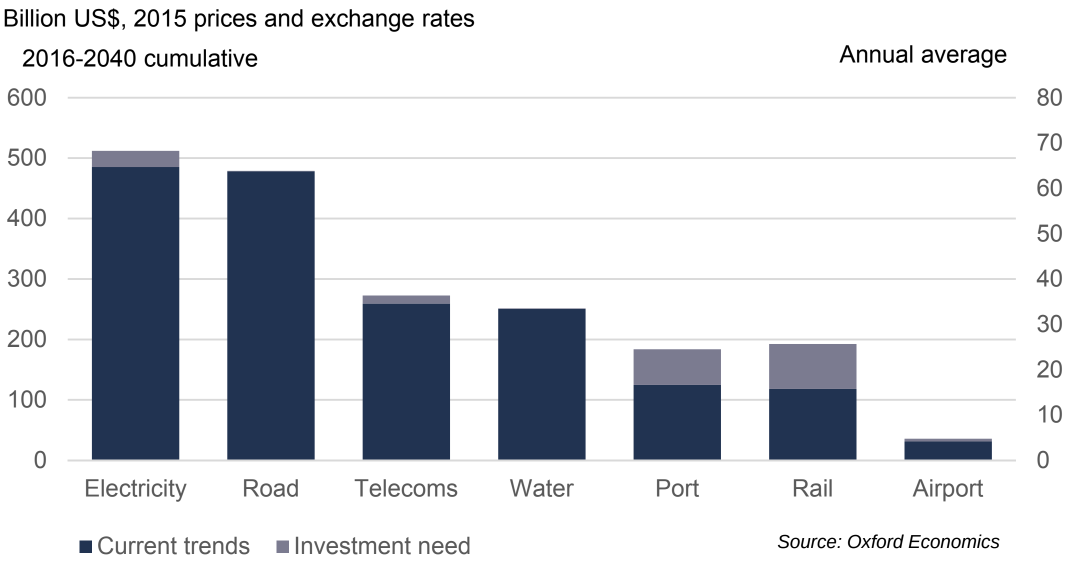
Fig. 75. Oceania sectoral pattern of infrastructure investment, 2007-2040



Source: Oxford Economics

In dollar terms, the electricity and road sectors are each expected to invest more than $450 billion between 2016 and 2040 under current trends, more than half of the total value of investment. Our analysis suggests that the investment gap is likely to be proportionately greatest in the port and rail sectors. In contrast, the investment need forecast for the water and roads sectors is only fractionally higher than what is likely to be delivered under current trends.

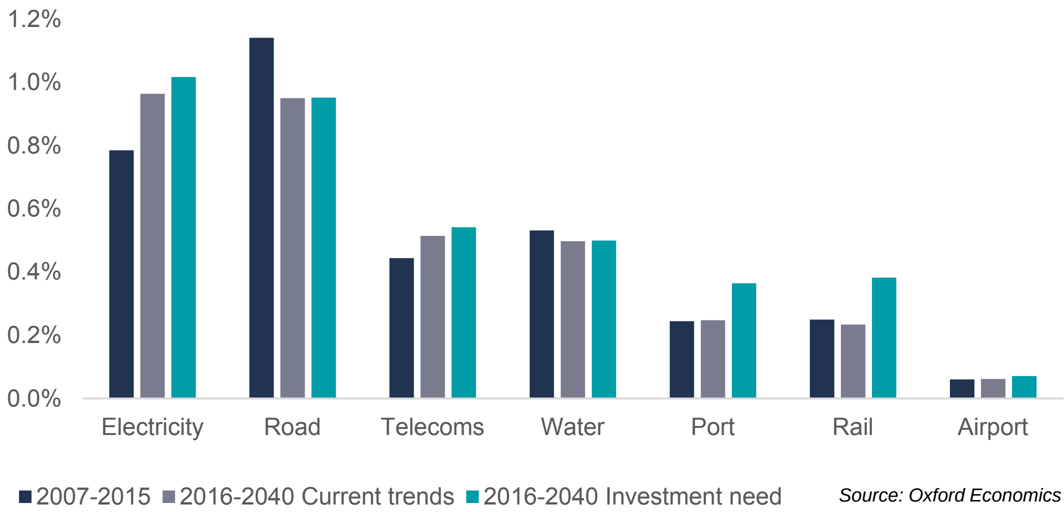
Fig. 76. Oceania infrastructure spending needs by sector, 2016-2040: cumulative (left scale) and annual average (right scale)



Source: Oxford Economics

At a total of 3.5 percent of GDP under current trends, and 3.8 percent of GDP under the investment need scenario, infrastructure investment is expected to remain relatively high in future years as the region accommodates strong rates of economic and demographic growth. However, this level of investment appears feasible given that the region has dedicated 3.5 percent of GDP to infrastructure since 2007.

Fig. 77. *Oceania infrastructure spending needs by sector, 2007-2040: percent of GDP*

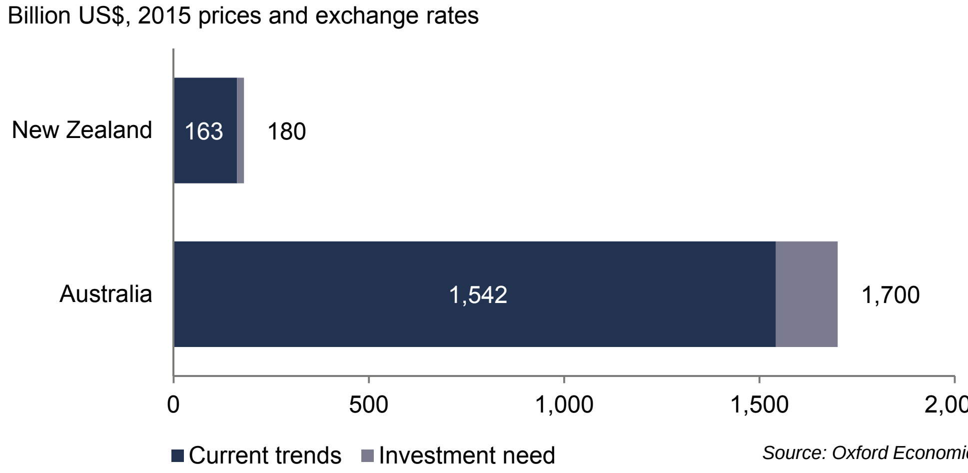


Source: Oxford Economics

9.2 COUNTRY SPENDING NEEDS

Our study incorporates the two largest economies in Oceania: Australia and New Zealand. These countries together account for 98 percent of regional GDP, though only 73 percent of population. The regional infrastructure market is dominated by Australia, which accounts for 88 percent of the estimated future investment, compared to nine percent for New Zealand. Nonetheless, the extent of the gap between the two scenarios for Australia and New Zealand is very similar: this amounts to 10 percent for Australia and 11 per cent for New Zealand.

Fig. 78. Oceania infrastructure spending needs, 2016-2040 cumulative



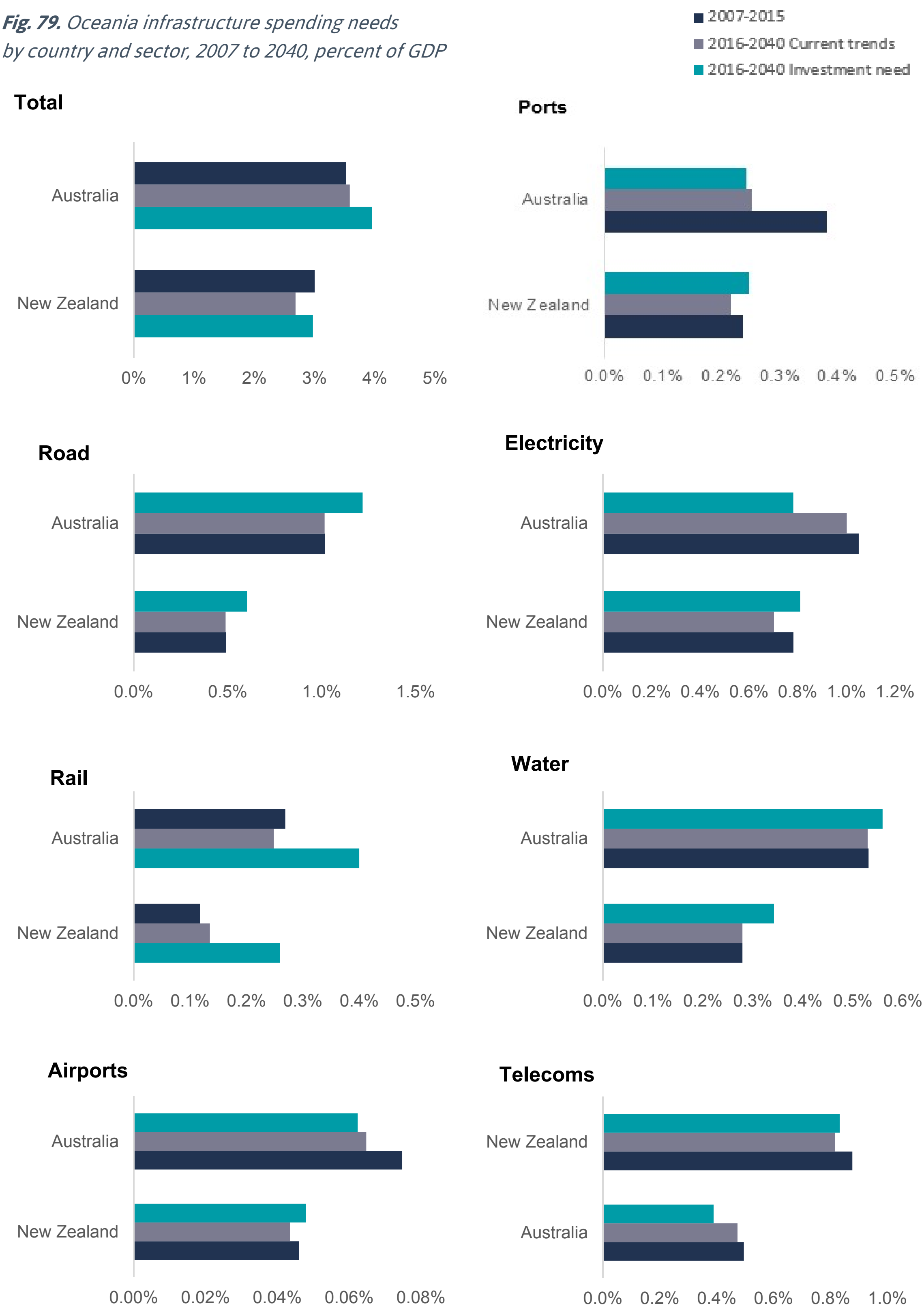
Source: Oxford Economics

As a proportion of GDP Australia is estimated to need to dedicate around one percentage point more to infrastructure in future than New Zealand under both of our scenarios, reflecting stronger expected rates of economic and demographic growth in the former: population is forecast to increase by over 40 percent in Australia between 2015 and 2040, more than twice the growth expected for New Zealand.

One sector where our forecasts do suggest a noticeable gap between the investment needed to match the best performing peer countries and that which would be delivered under current trends is **rail**. The geography of Australia and New Zealand is not well suited to rail travel, and the amount of rail infrastructure in these countries is noticeably lower than in many developed European and Asian countries, leaving clear scope to improve provision. Our modelling initially suggested that Australia would need to invest, arguably, implausibly large sums in rail infrastructure to bring provision up to the level of the best performing developed countries. However, the WEF measure suggests that the quality of rail infrastructure in Australia is relatively high given the amounts invested. This has the effect of moderating our forecast somewhat, though the rail infrastructure investment need forecast still represents a sizeable uplift compared to current trends.

In contrast, the quality adjustment step increases the investment need for Australia's **electricity** sector. In this case, the WEF quality measure is slightly below that achieved by other countries with similarly high levels of historic investment. As such, the need forecast is adjusted upwards to reflect that a higher level of investment will be required to achieve a given level of quality.

Fig. 79. Oceania infrastructure spending needs by country and sector, 2007 to 2040, percent of GDP



10. COUNTRY PROFILES

IN THIS SECTION, WE PRESENT A SUMMARY OF KEY FINDINGS FOR EACH OF THE 50 COUNTRIES IN OUR STUDY. COUNTRIES ARE PRESENTED IN ALPHABETICAL ORDER, STARTING OVERLEAF.

Angola

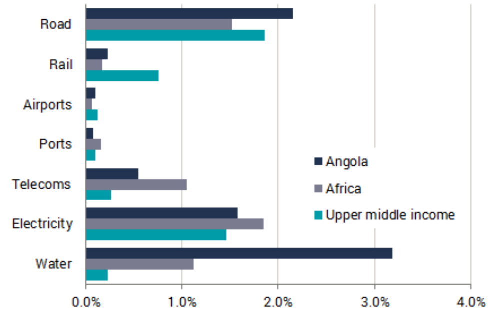
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	103	321	4.7%
GDP per head ($US)*	4,101	6,216	1.7%
Population (000s)	25,022	51,581	2.9%
Urban population (% of total)**	44.2%	68.5%	1.8%
Population density (persons per km2	20	41	2.9%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

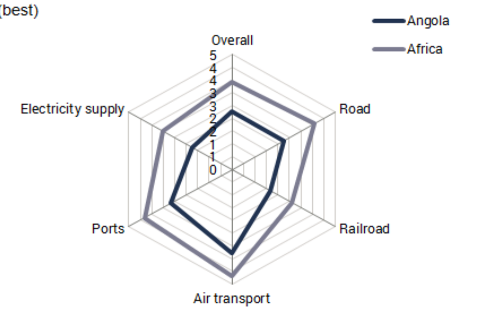
Percent of GDP



Source: Oxford Economics

Infrastructure quality

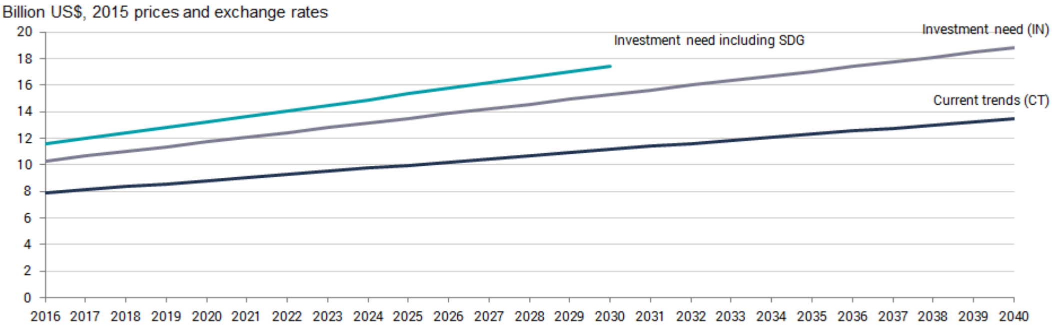
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

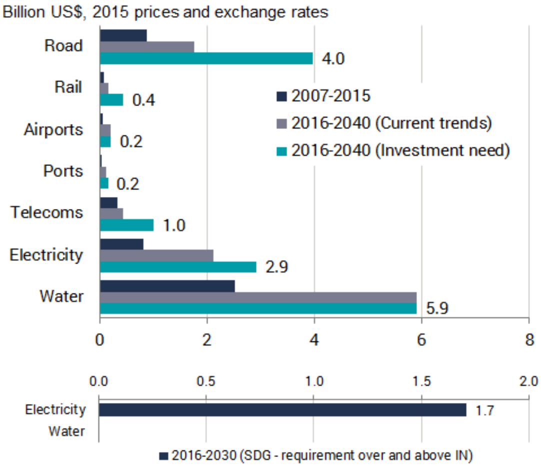
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

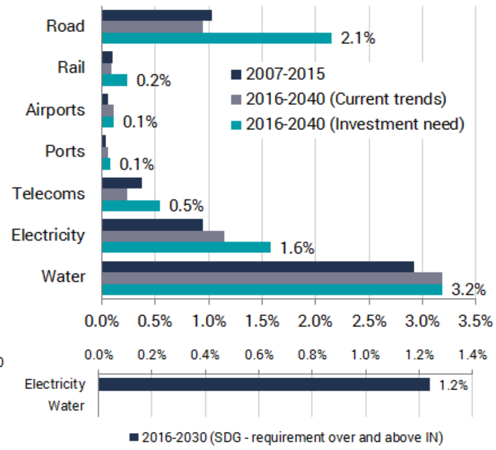
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	44	4	5	3	11	53	147	267
2016-2040 (Investment need)	99	11	5	4	25	73	147	364
2016-2040 (Gap between IN and CT)	55	7	0	1	14	20	0	97
2016-2030 (SDG - requirement over and above IN						26	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Argentina

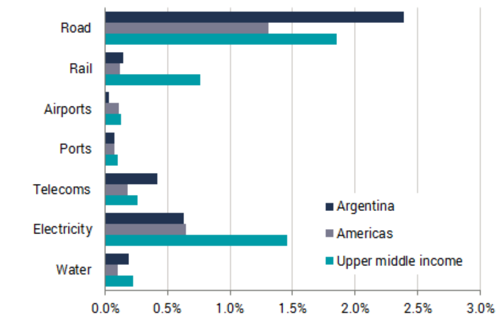
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	633	1,035	2.0%
GDP per head ($US)*	14,563	19,634	1.2%
Population (000s)	43,470	52,737	0.8%
Urban population (% of total)**	91.8%	95.7%	0.2%
Population density (persons per km2	16	19	0.8%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

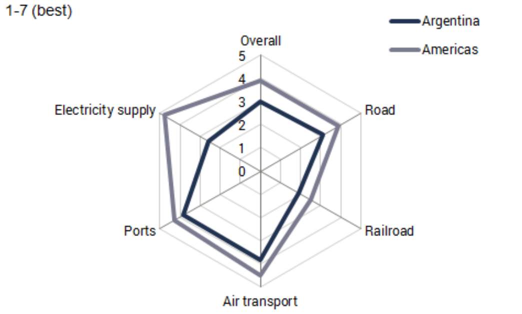
Percent of GDP



Source: Oxford Economics

Infrastructure quality

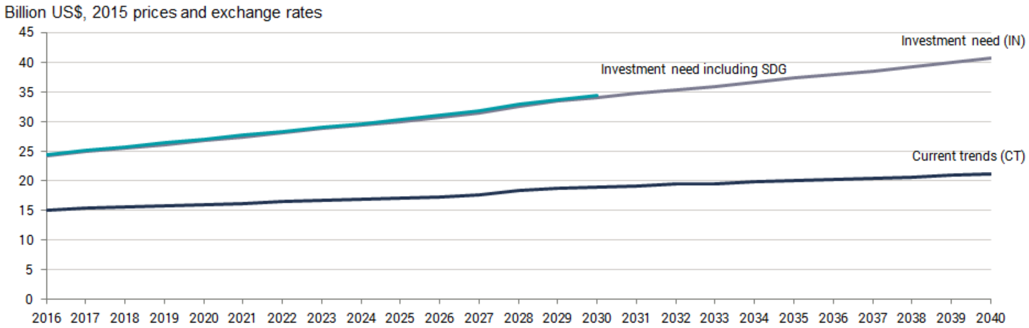
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

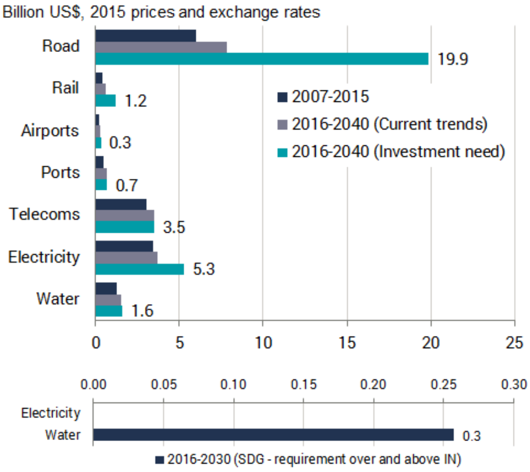
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

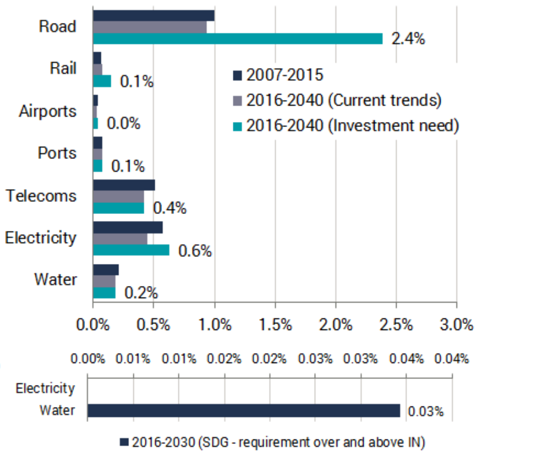
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	196	15	7	17	88	93	38	452
2016-2040 (Investment need)	497	30	8	17	88	132	39	810
2016-2040 (Gap between IN and CT)	302	15	1	0	0	39	1	358
2016-2030 (SDG - requirement over and above IN						0	4	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Australia

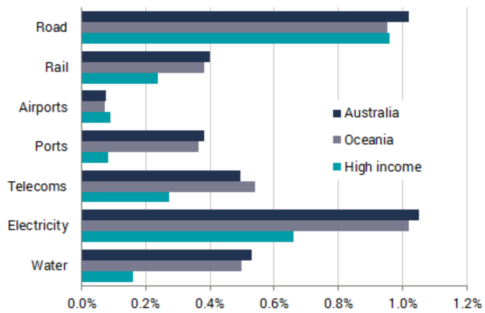
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,229	2,298	2.5%
GDP per head ($US)*	51,562	68,294	1.1%
Population (000s)	23,831	33,647	1.4%
Urban population (% of total)**	89.4%	95.7%	0.3%
Population density (persons per km2	3	4	1.4%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

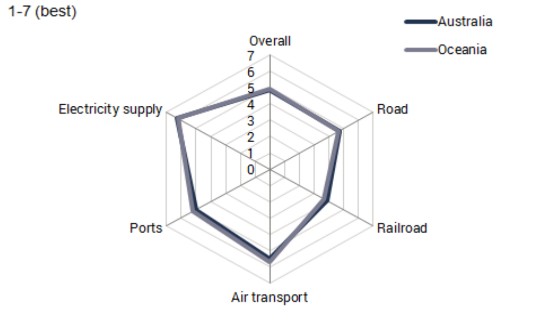
Percent of GDP



Source: Oxford Economics

Infrastructure quality

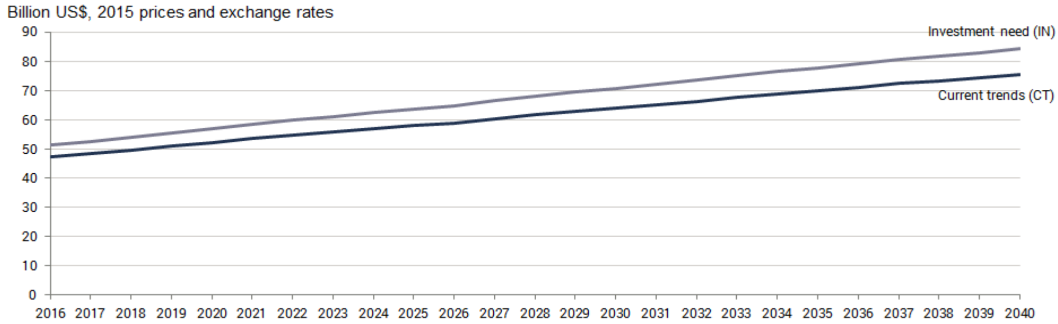
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

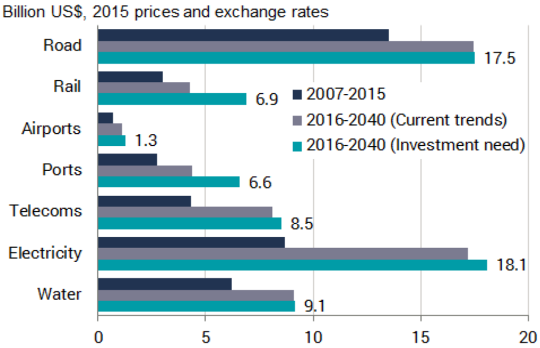
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

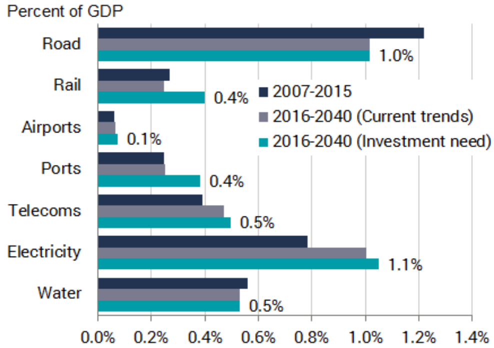
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	437	107	28	109	203	431	228	1,542
2016-2040 (Investment need)	438	172	32	165	213	452	228	1,700
2016-2040 (Gap between IN and CT)	1	65	4	56	10	21	1	158
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Azerbaijan

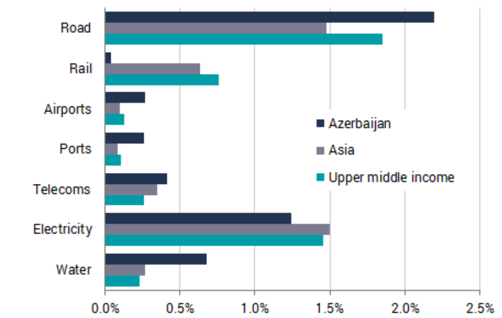
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	53	116	3.2%
GDP per head ($US)*	5,439	10,600	2.7%
Population (000s)	9,754	10,961	0.5%
Urban population (% of total)**	54.2%	56.4%	0.2%
Population density (persons per km2	118	133	0.5%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

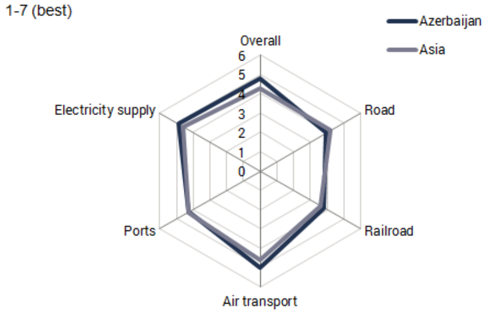
Percent of GDP



Source: Oxford Economics

Infrastructure quality

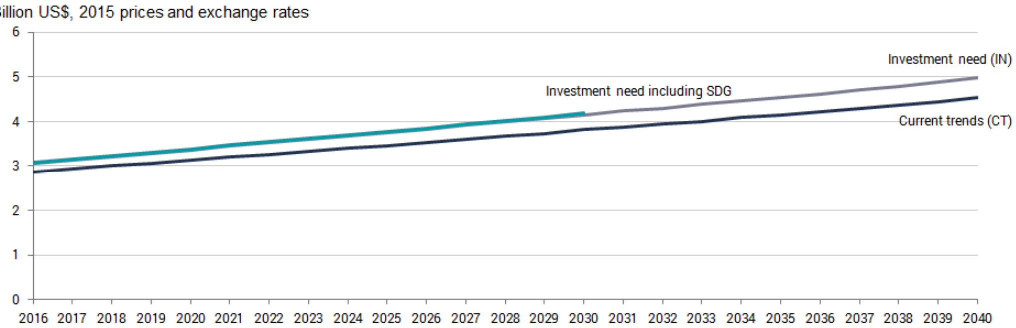
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

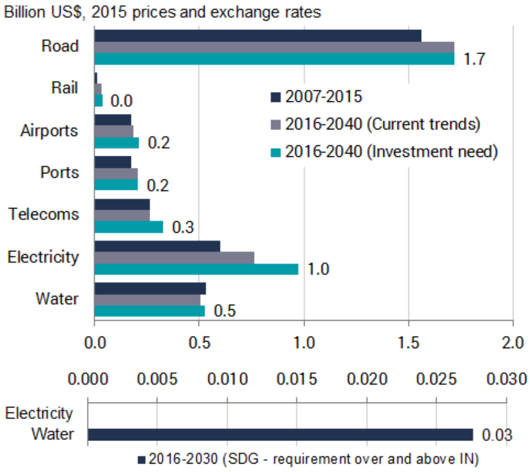
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

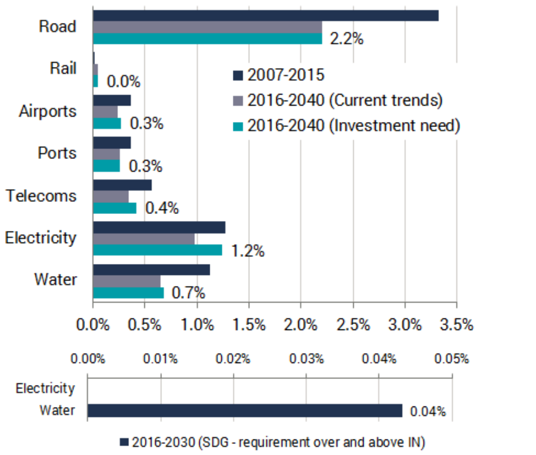
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	43	1	5	5	7	19	13	92
2016-2040 (Investment need)	43	1	5	5	8	24	13	100
2016-2040 (Gap between IN and CT)	0	0	1	0	2	5	1	8
2016-2030 (SDG - requirement over and above IN						0	0.4	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

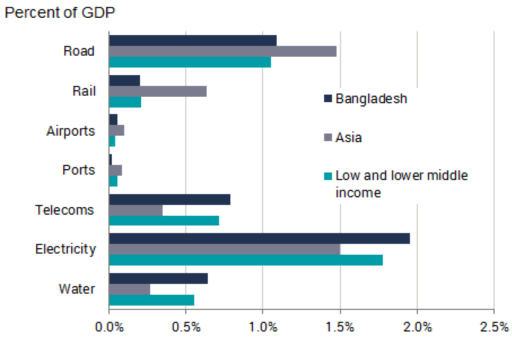
Bangladesh

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	222	879	5.7%
GDP per head ($US)*	1,381	4,459	4.8%
Population (000s)	160,996	197,134	0.8%
Urban population (% of total)**	34.3%	47.6%	1.3%
Population density (persons per km2	1,237	1,514	0.8%

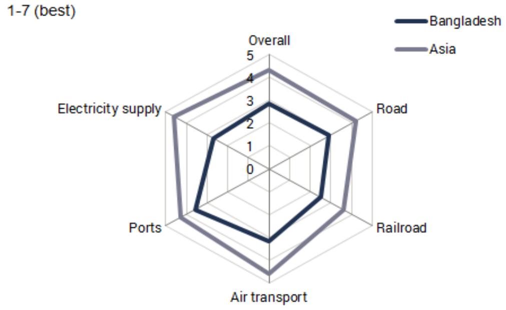
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



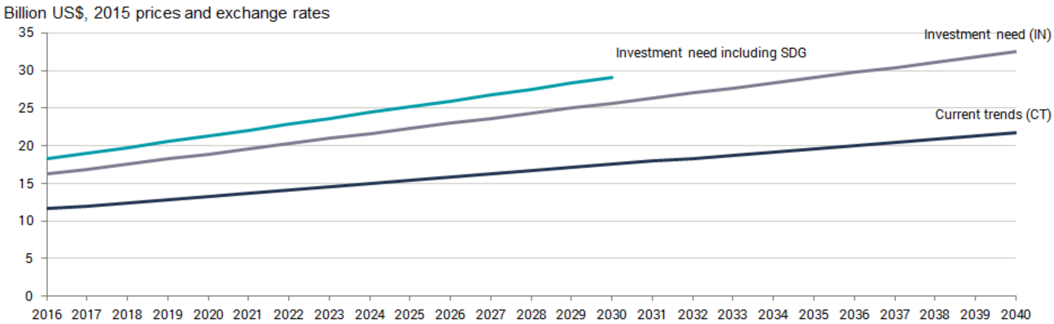
Source: Oxford Economics

Infrastructure quality



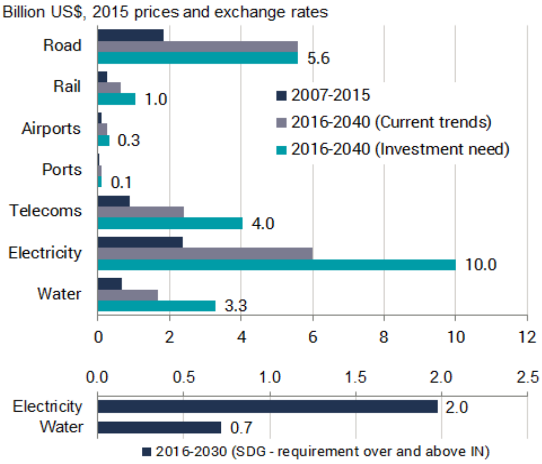
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

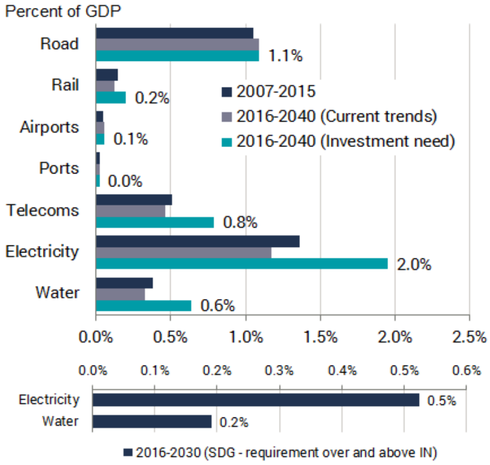


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	139	16	7	3	60	150	42	417
2016-2040 (Investment need)	139	26	8	3	101	250	82	608
2016-2040 (Gap between IN and CT)	0	10	1	0	41	100	40	192
2016-2030 (SDG - requirement over and above IN						30	11	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Brazil

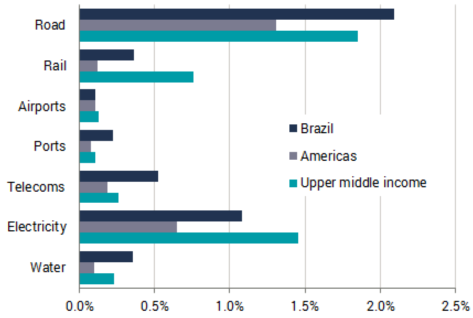
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,820	2,797	1.7%
GDP per head ($US)*	8,746	11,850	1.2%
Population (000s)	208,064	236,073	0.5%
Urban population (% of total)**	85.8%	92.5%	0.3%
Population density (persons per km2	25	28	0.5%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

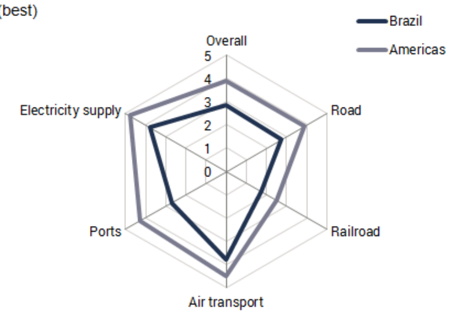
Percent of GDP



Source: Oxford Economics

Infrastructure quality

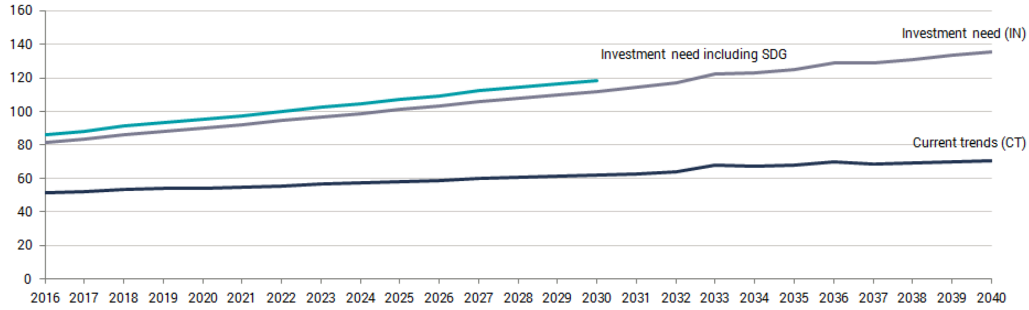
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

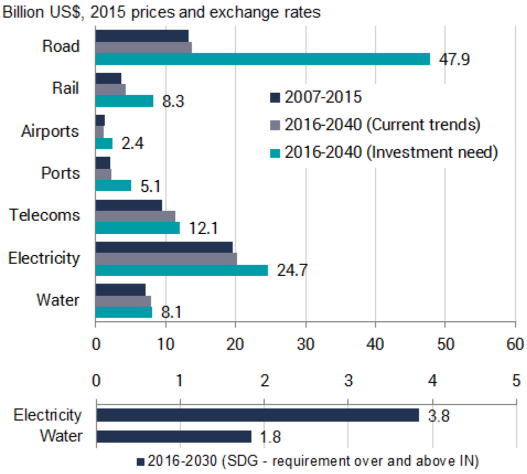
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

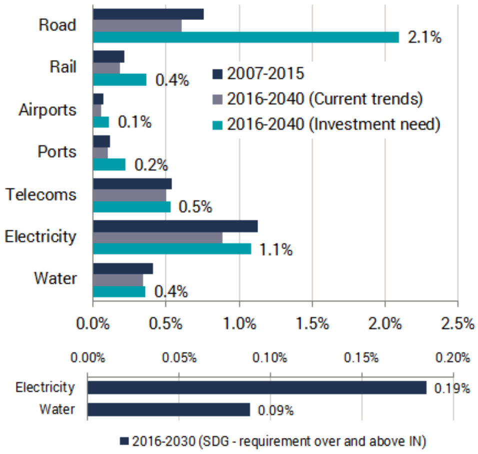
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	345	106	30	56	284	507	196	1,524
2016-2040 (Investment need)	1,197	207	61	127	301	616	203	2,713
2016-2040 (Gap between IN and CT)	852	102	31	71	17	109	7	1,189
2016-2030 (SDG - requirement over and above IN						58	28	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

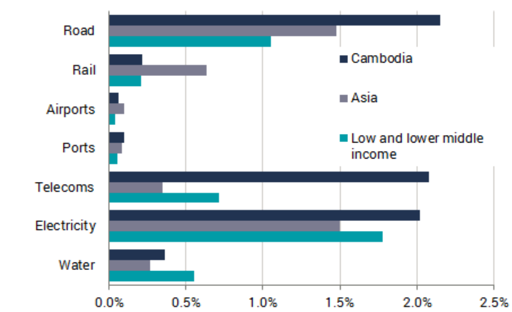
Cambodia

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	18	99	7.0%
GDP per head ($US)*	1,160	4,736	5.8%
Population (000s)	15,578	20,939	1.2%
Urban population (% of total)**	21.6%	38.8%	2.4%
Population density (persons per km2	88	119	1.2%

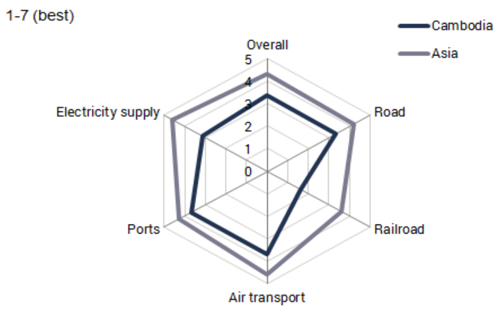
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



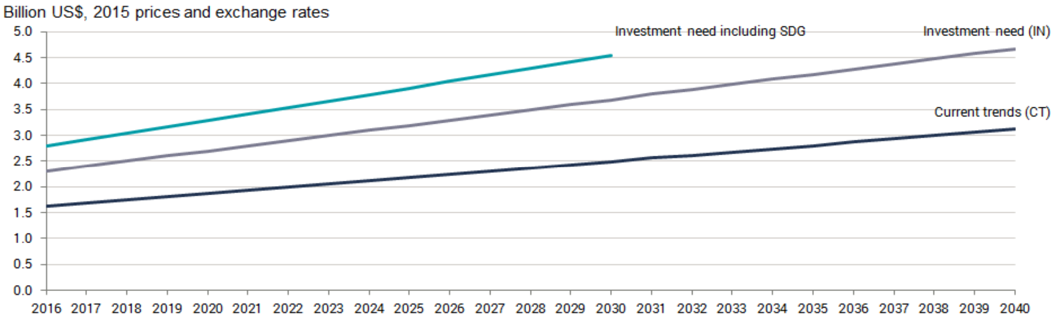
Source: Oxford Economics

Infrastructure quality



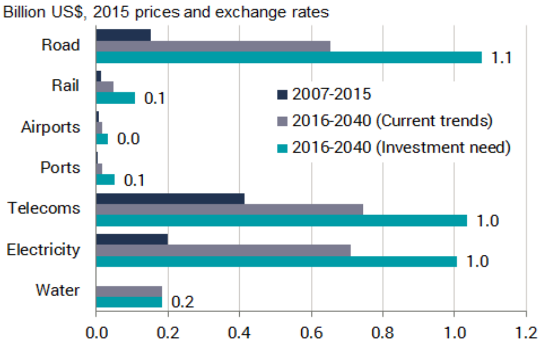
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

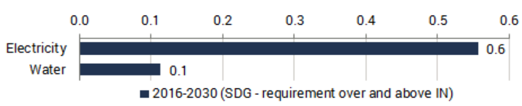
Total infrastructure investment 2016-40



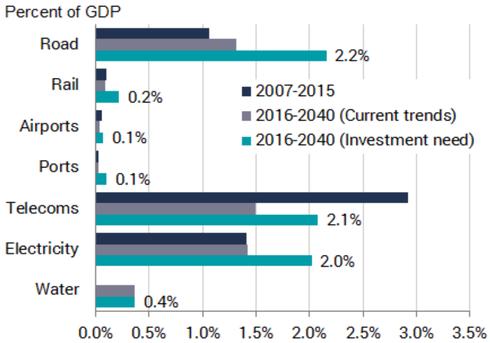
Source: Oxford Economics

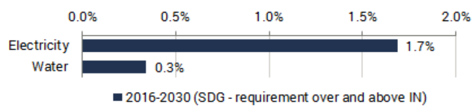
Average annual investment





Infrastructure investment as a percentage of GDP





Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	16	1	0	0	19	18	5	59
2016-2040 (Investment need)	27	3	1	1	26	25	5	87
2016-2040 (Gap between IN and CT)	11	2	0	1	7	7	0	28
2016-2030 (SDG - requirement over and above IN						8	2	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Canada

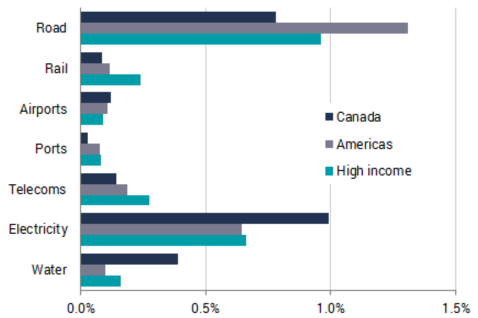
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,555	2,268	1.5%
GDP per head ($US)*	43,408	51,304	0.7%
Population (000s)	35,821	44,201	0.8%
Urban population (% of total)**	81.8%	84.3%	0.1%
Population density (persons per km2	4	5	0.8%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

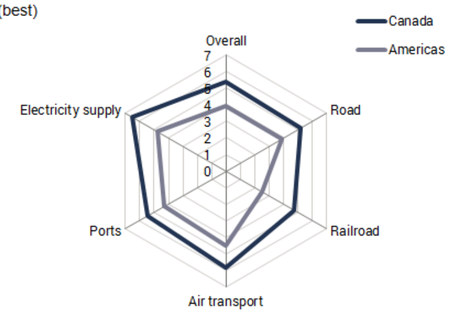
Percent of GDP



Source: Oxford Economics

Infrastructure quality

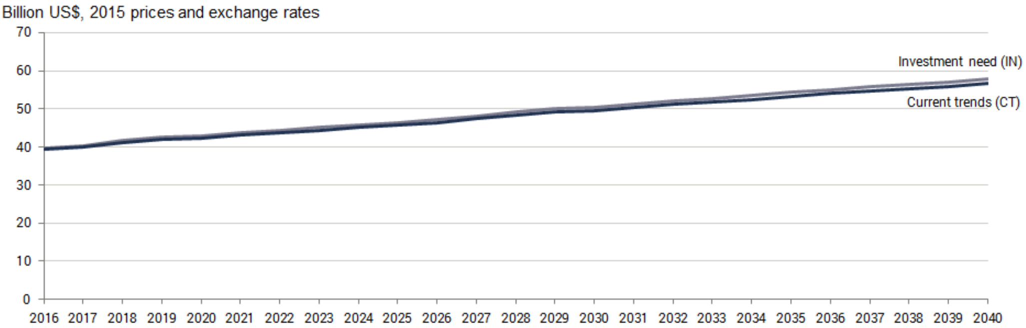
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

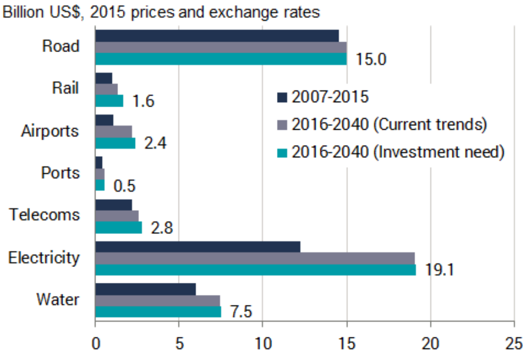
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

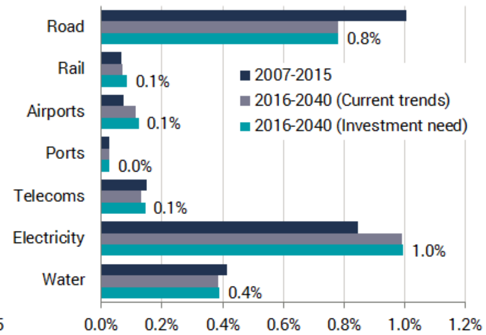
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	375	34	55	13	64	476	186	1,204
2016-2040 (Investment need)	375	41	59	13	70	478	188	1,224
2016-2040 (Gap between IN and CT)	0	7	5	0	6	1	2	20
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Chile

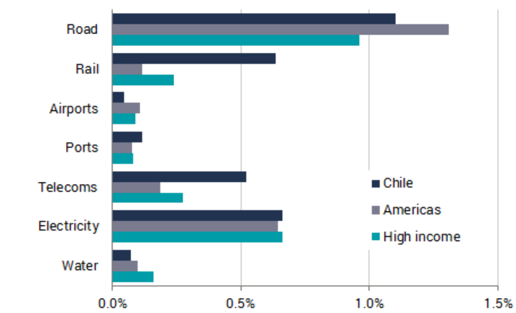
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	241	430	2.3%
GDP per head ($US)*	13,428	20,345	1.7%
Population (000s)	17,971	21,150	0.7%
Urban population (% of total)**	89.8%	98.7%	0.4%
Population density (persons per km2	24	28	0.7%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

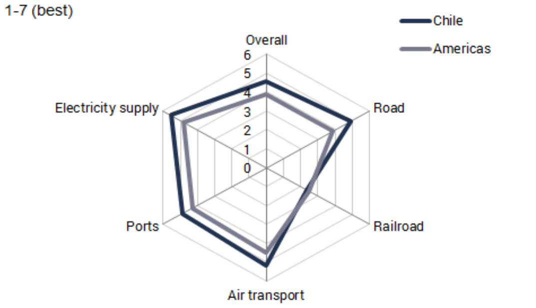
Percent of GDP



Source: Oxford Economics

Infrastructure quality

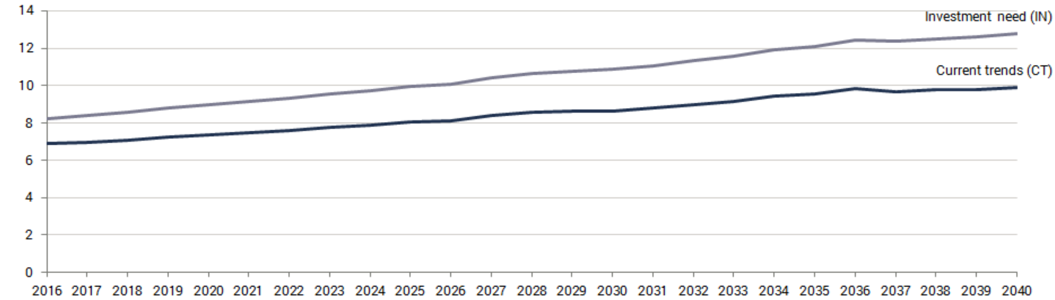
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

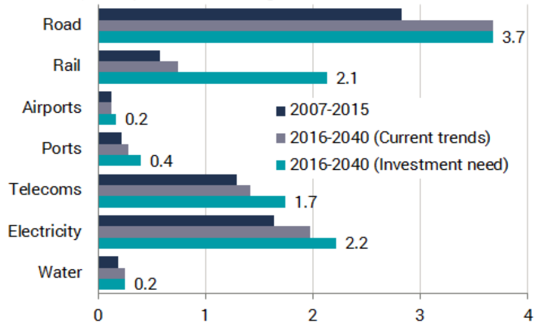
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

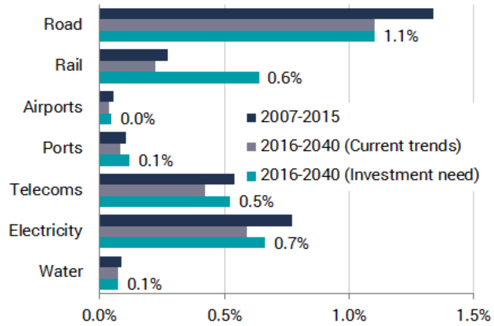
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	92	19	3	7	35	49	6	212
2016-2040 (Investment need)	92	53	4	10	44	55	6	264
2016-2040 (Gap between IN and CT)	0	35	1	3	8	6	0	53
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

China

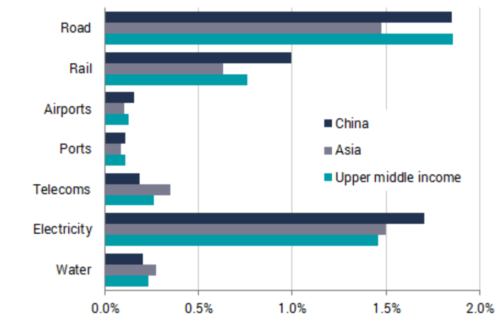
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	10,960	33,363	4.6%
GDP per head ($US)*	7,960	23,928	4.5%
Population (000s)	1,376,822	1,394,288	0.1%
Urban population (% of total)**	55.6%	81.4%	1.5%
Population density (persons per km2	147	149	0.1%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

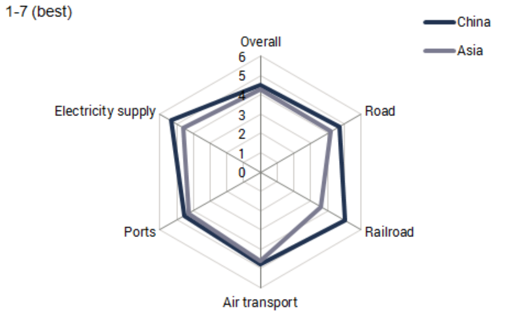
Infrastructure investment need, 2016-2040

Percent of GDP



Source: Oxford Economics

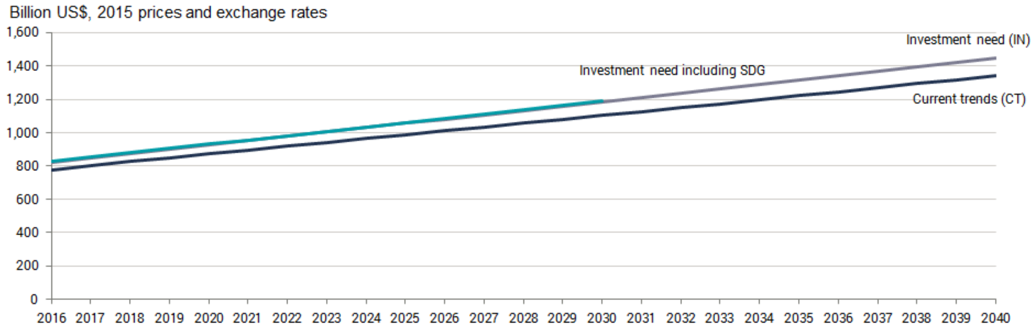
Infrastructure quality



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

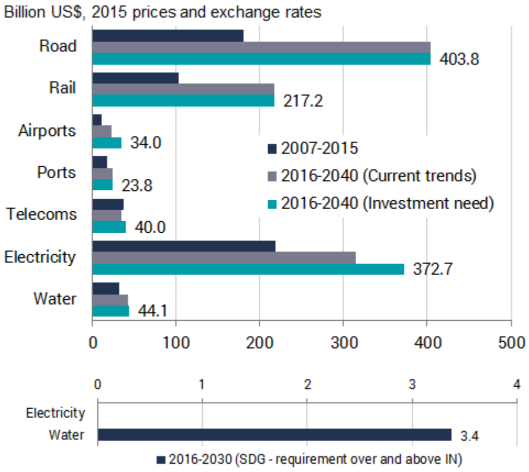
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

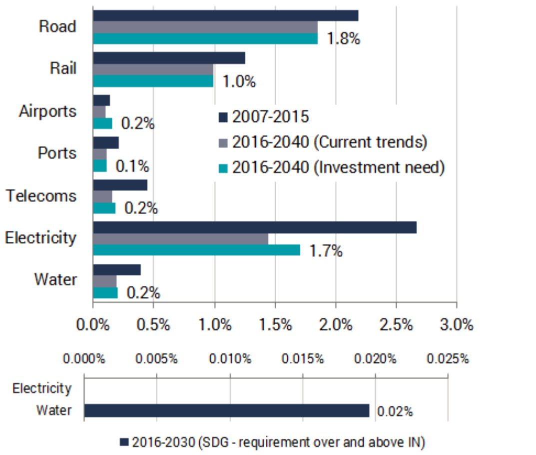
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	10,096	5,430	570	596	849	7,866	1,062	26,468
2016-2040 (Investment need)	10,096	5,430	850	596	1,001	9,317	1,104	28,393
2016-2040 (Gap between IN and CT)	0	0	280	0	152	1,451	42	1,925
2016-2030 (SDG - requirement over and above IN						0	51	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Colombia

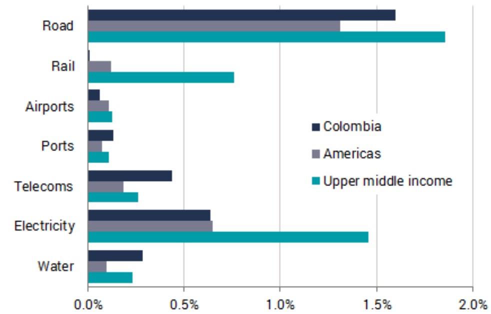
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	292	574	2.7%
GDP per head ($US)*	6,056	10,498	2.2%
Population (000s)	48,229	54,723	0.5%
Urban population (% of total)**	76.4%	85.2%	0.4%
Population density (persons per km2	43	49	0.5%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

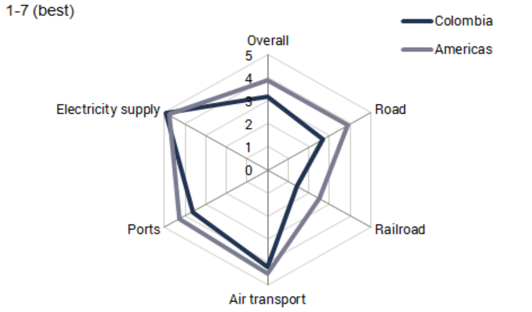
Percent of GDP



Source: Oxford Economics

Infrastructure quality

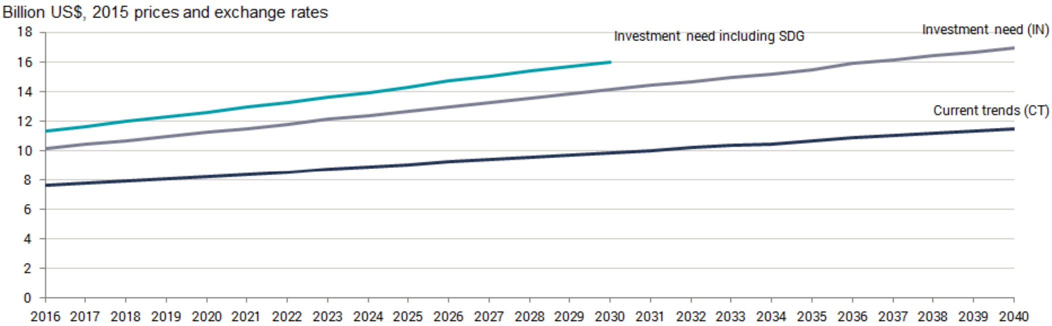
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

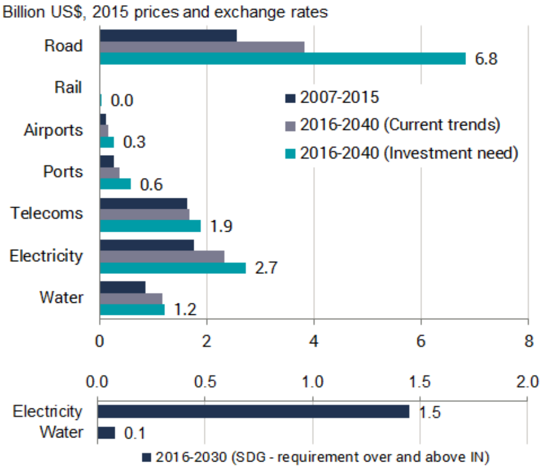
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

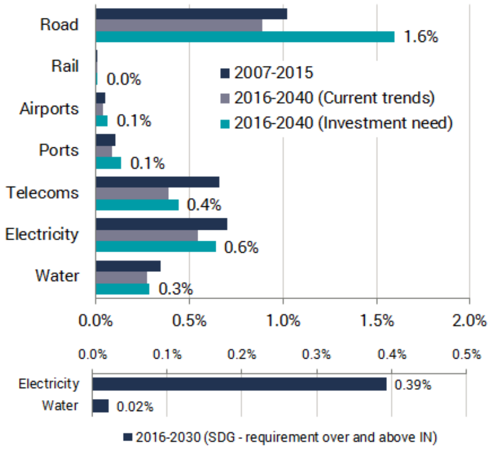
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	95	0	4	9	42	58	29	238
2016-2040 (Investment need)	171	1	7	15	47	68	30	339
2016-2040 (Gap between IN and CT)	75	0	2	5	5	10	1	100
2016-2030 (SDG - requirement over and above IN						22	1	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Croatia

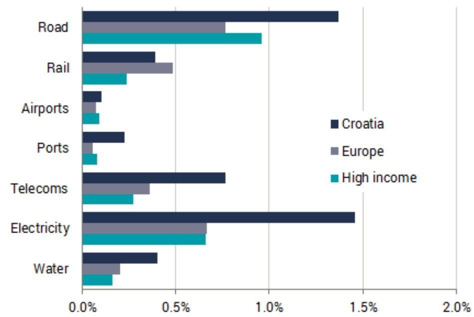
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	49	76	1.8%
GDP per head ($US)*	11,524	19,308	2.1%
Population (000s)	4,222	3,921	-0.3%
Urban population (% of total)**	58.8%	64.4%	0.4%
Population density (persons per km2	75	70	-0.3%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

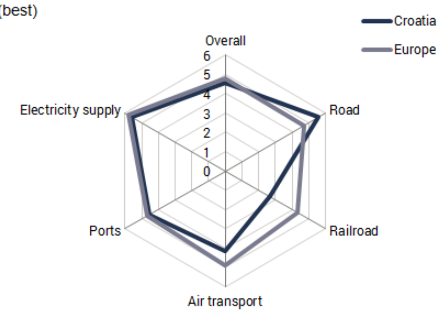
Percent of GDP



Source: Oxford Economics

Infrastructure quality

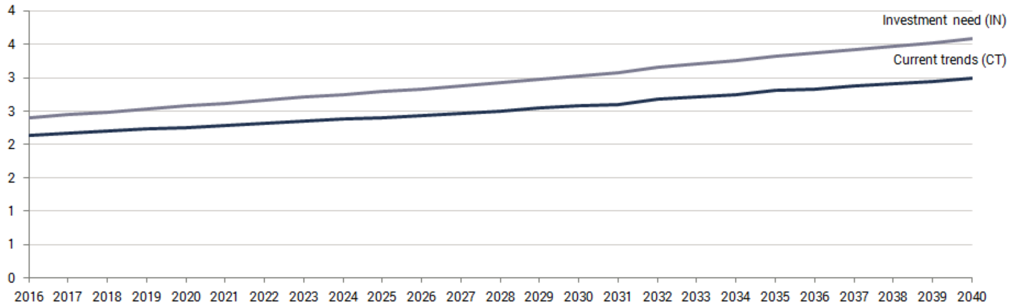
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

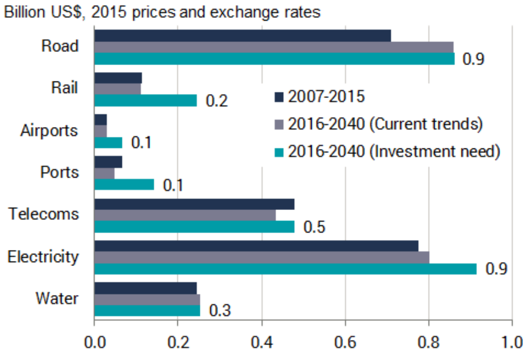
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

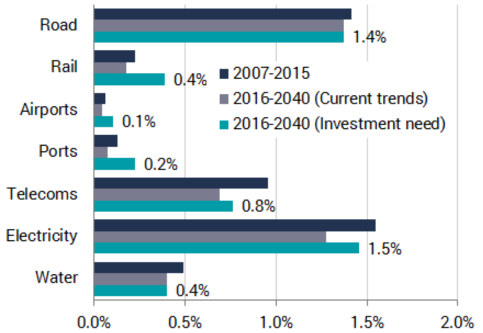
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	22	3	1	1	11	20	6	63
2016-2040 (Investment need)	22	6	2	4	12	23	6	74
2016-2040 (Gap between IN and CT)	0	3	1	2	1	3	0	11
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Ecuador

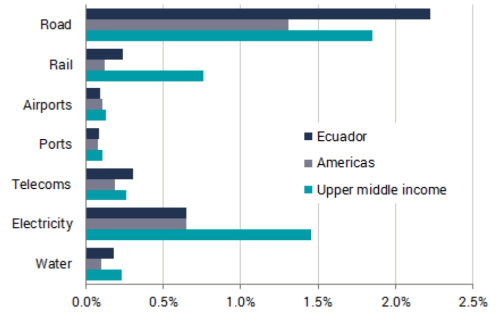
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	100	207	2.9%
GDP per head ($US)*	6,205	9,639	1.8%
Population (000s)	16,144	21,484	1.1%
Urban population (% of total)**	65.0%	81.6%	0.9%
Population density (persons per km2	65	87	1.1%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

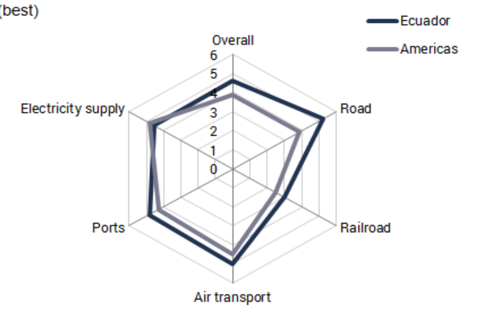
Percent of GDP



Source: Oxford Economics

Infrastructure quality

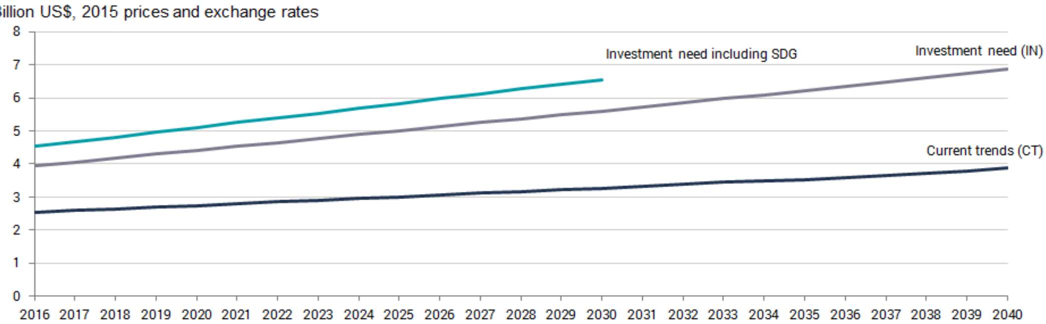
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

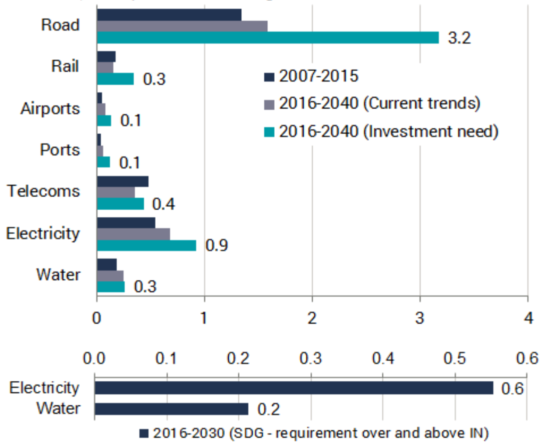
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

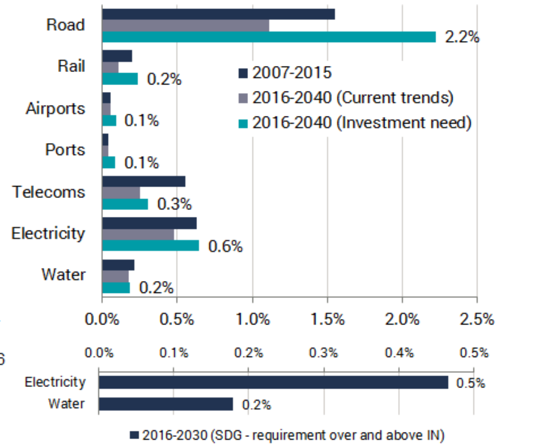
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	40	4	2	2	9	17	6	79
2016-2040 (Investment need)	79	8	3	3	11	23	7	135
2016-2040 (Gap between IN and CT)	40	5	1	2	2	6	0	55
2016-2030 (SDG - requirement over and above IN						8	3	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Egypt

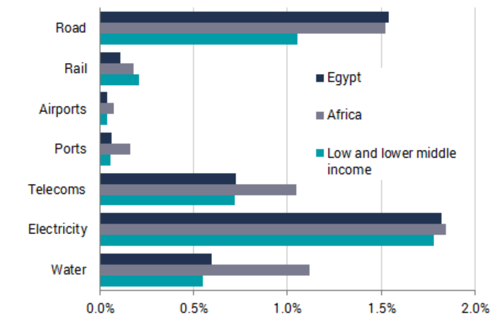
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	318	842	4.0%
GDP per head ($US)*	3,472	6,263	2.4%
Population (000s)	91,508	134,428	1.6%
Urban population (% of total)**	43.1%	45.7%	0.2%
Population density (persons per km2	92	135	1.6%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

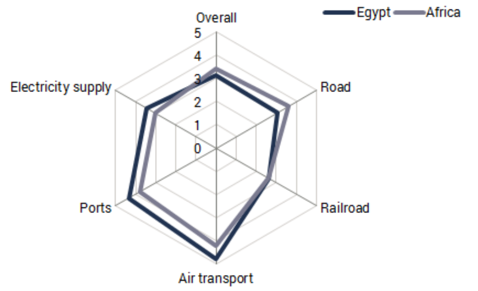
Percent of GDP



Source: Oxford Economics

Infrastructure quality

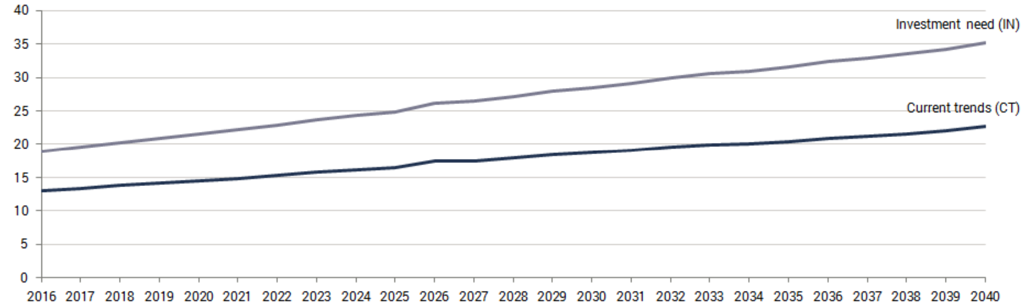
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

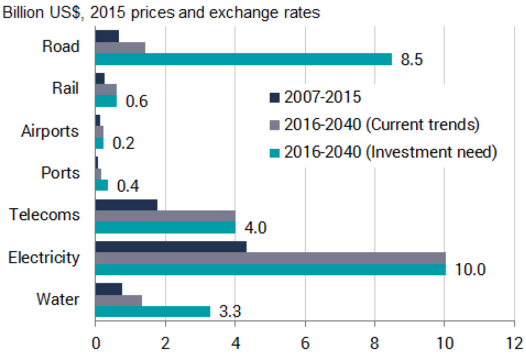
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

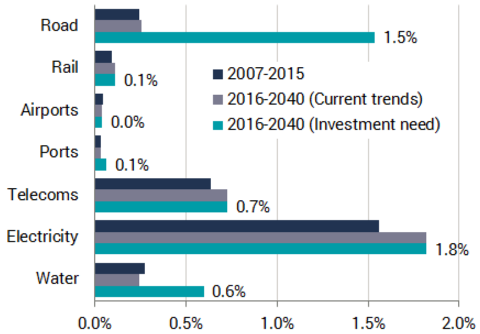
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	35	15	5	4	100	251	33	445
2016-2040 (Investment need)	212	15	5	9	100	251	82	675
2016-2040 (Gap between IN and CT)	177	0	0	5	0	0	49	230
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Ethiopia

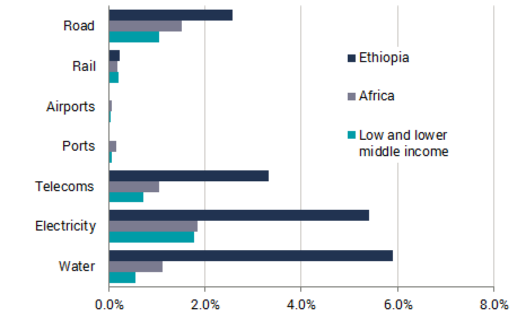
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	60	238	5.7%
GDP per head ($US)*	601	1,446	3.6%
Population (000s)	99,391	164,270	2.0%
Urban population (% of total)**	19.3%	30.1%	1.8%
Population density (persons per km2	99	164	2.0%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

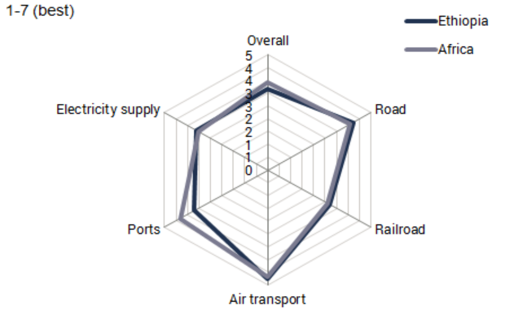
Percent of GDP



Source: Oxford Economics

Infrastructure quality

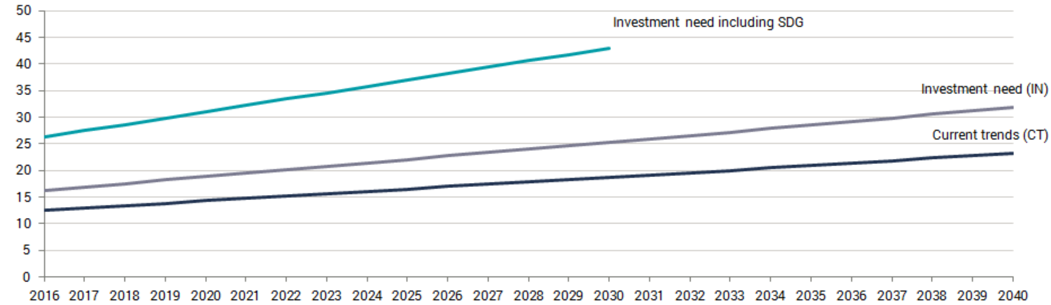
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

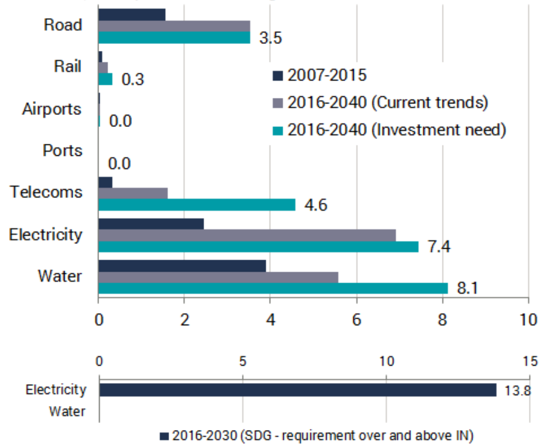
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

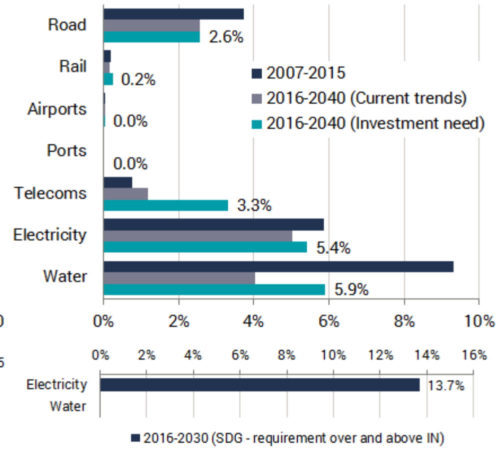
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	88	5	1	0	40	173	139	447
2016-2040 (Investment need)	88	8	1	0	115	186	203	601
2016-2040 (Gap between IN and CT)	0	3	0	0	74	13	64	154
2016-2030 (SDG - requirement over and above IN						208	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

France

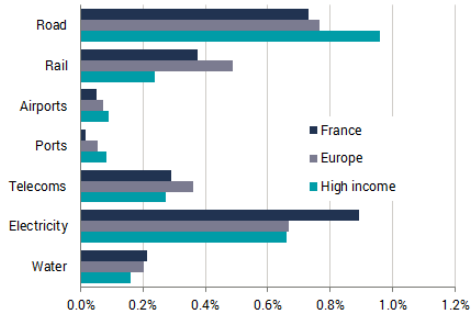
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	2,420	3,155	1.1%
GDP per head ($US)*	36,333	43,768	0.7%
Population (000s)	66,608	72,084	0.3%
Urban population (% of total)**	79.4%	84.8%	0.3%
Population density (persons per km2	122	132	0.3%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

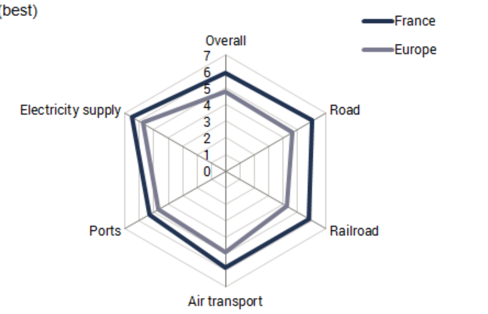
Percent of GDP



Source: Oxford Economics

Infrastructure quality

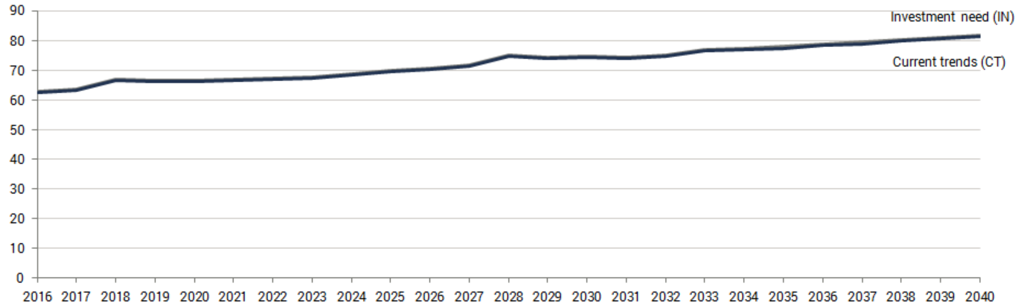
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

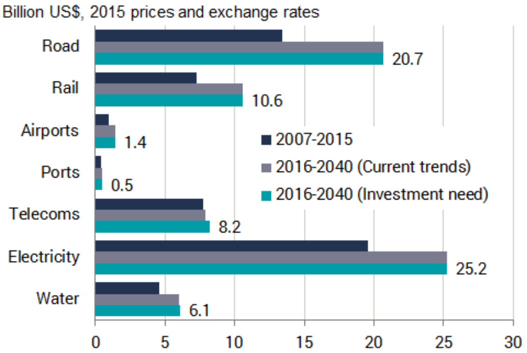
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

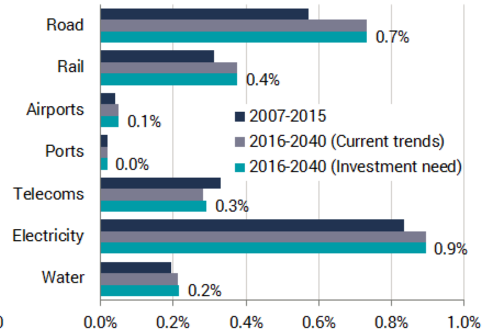
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	516	265	36	13	198	631	150	1,808
2016-2040 (Investment need)	516	265	36	13	206	631	152	1,818
2016-2040 (Gap between IN and CT)	0	0	0	0	8	0	2	10
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Germany

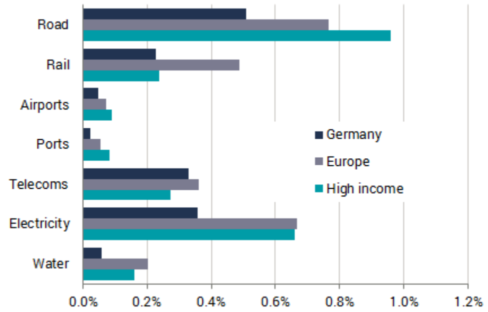
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	3,362	3,942	0.6%
GDP per head ($US)*	41,127	49,645	0.8%
Population (000s)	81,744	79,397	-0.1%
Urban population (% of total)**	74.8%	76.2%	0.1%
Population density (persons per km2	235	228	-0.1%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

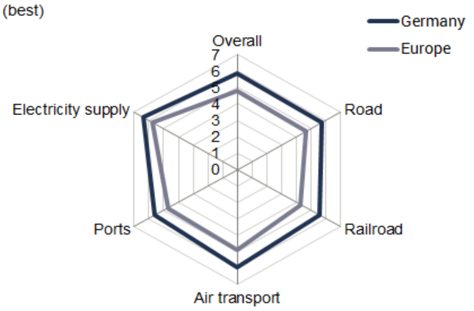
Percent of GDP



Source: Oxford Economics

Infrastructure quality

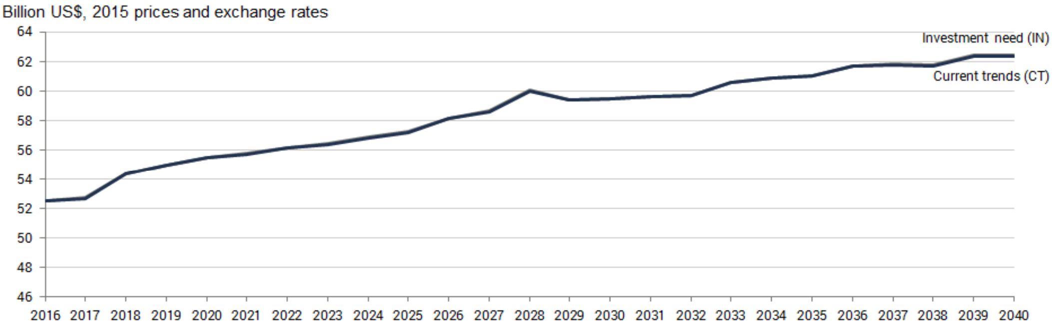
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

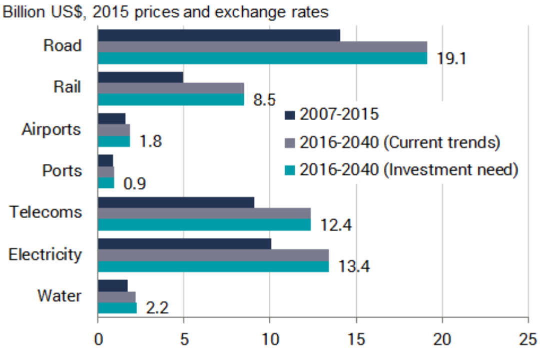
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

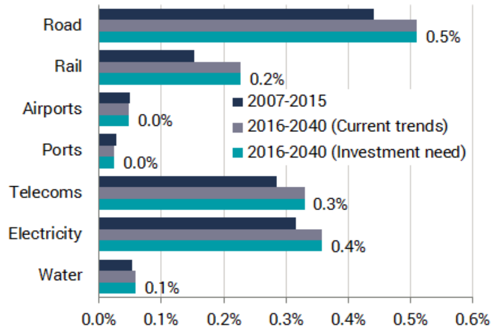
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	478	213	46	23	309	335	55	1,460
2016-2040 (Investment need)	478	213	46	23	309	335	56	1,460
2016-2040 (Gap between IN and CT)	0	0	0	0	0	0	1	1
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

India

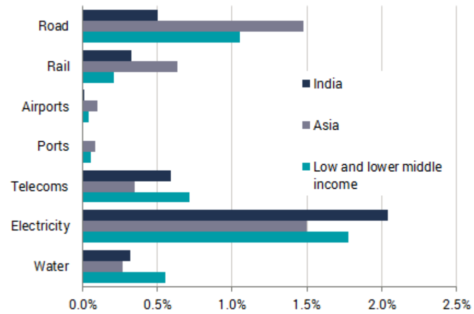
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	2,063	7,865	5.5%
GDP per head ($US)*	1,571	4,811	4.6%
Population (000s)	1,313,030	1,634,820	0.9%
Urban population (% of total)**	32.8%	42.0%	1.0%
Population density (persons per km2	442	550	0.9%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

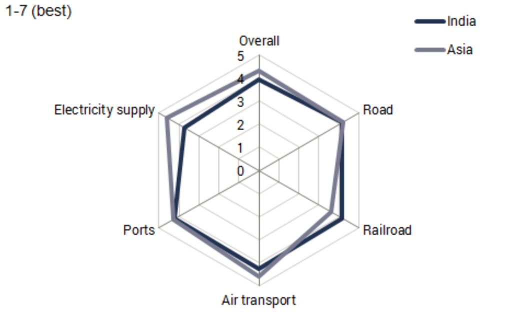
Percent of GDP



Source: Oxford Economics

Infrastructure quality

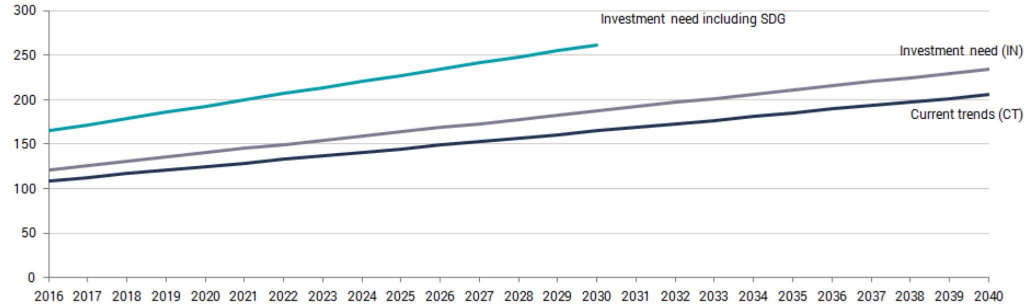
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

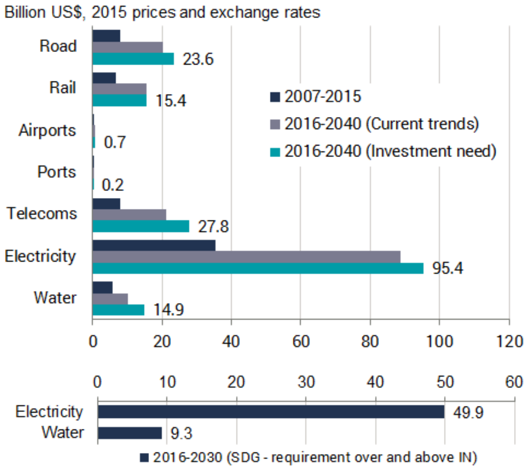
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

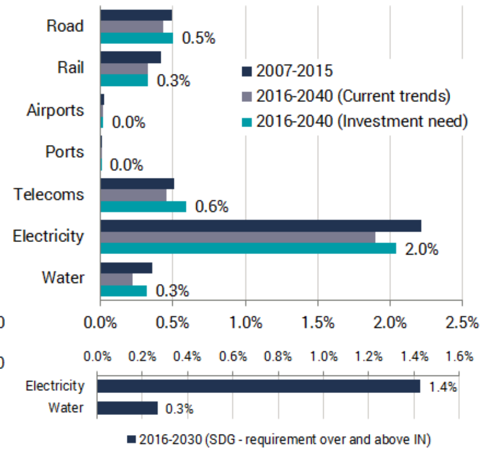
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	510	385	18	5	529	2,222	256	3,926
2016-2040 (Investment need)	589	385	18	5	696	2,385	373	4,452
2016-2040 (Gap between IN and CT)	79	0	0	0	167	163	117	526
2016-2030 (SDG - requirement over and above IN						748	140	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Indonesia

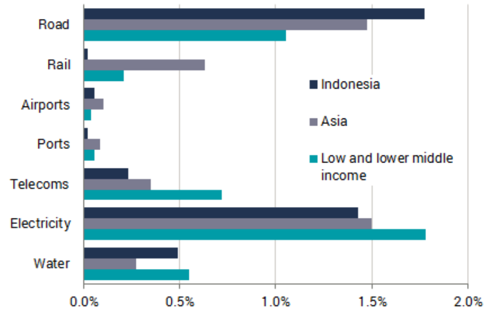
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	861	2,706	4.7%
GDP per head ($US)*	3,338	8,656	3.9%
Population (000s)	257,939	312,604	0.8%
Urban population (% of total)**	53.7%	87.7%	2.0%
Population density (persons per km2	142	173	0.8%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

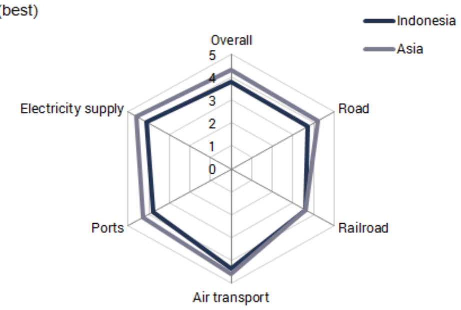
Percent of GDP



Source: Oxford Economics

Infrastructure quality

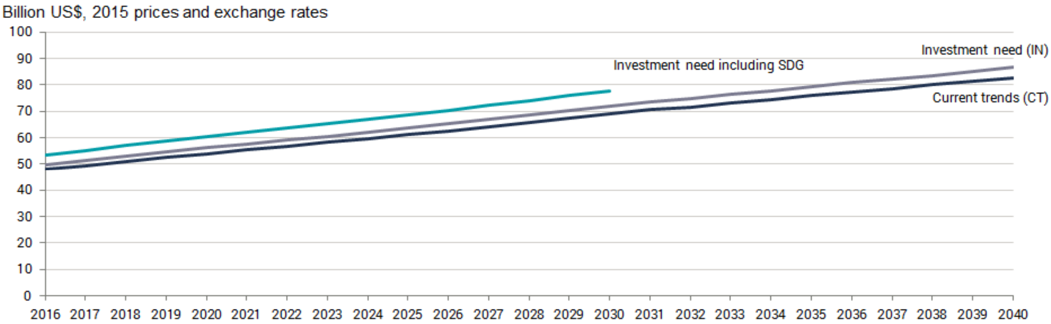
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

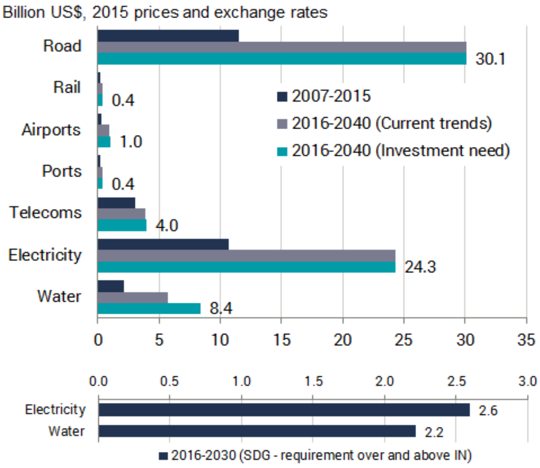
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

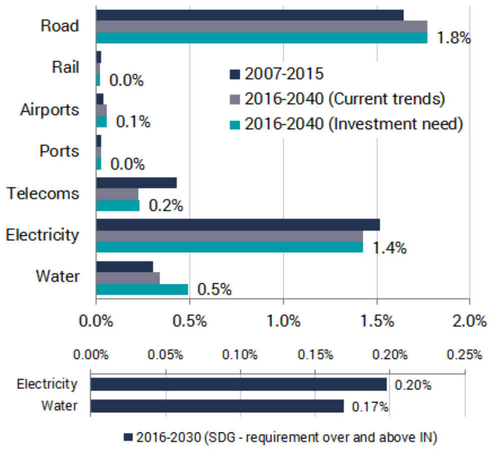
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	752	9	23	11	96	607	144	1,642
2016-2040 (Investment need)	752	9	25	11	99	607	209	1,712
2016-2040 (Gap between IN and CT)	0	0	2	0	3	0	65	70
2016-2030 (SDG - requirement over and above IN						39	33	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Italy

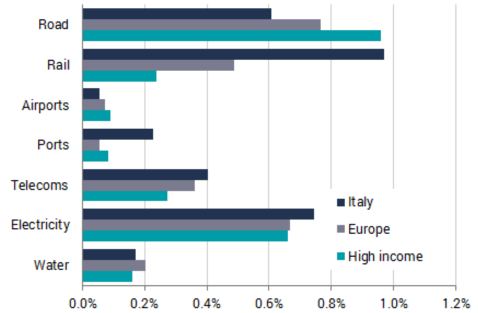
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,821	2,159	0.7%
GDP per head ($US)*	29,910	35,420	0.7%
Population (000s)	60,894	60,964	0.0%
Urban population (% of total)**	68.9%	71.6%	0.2%
Population density (persons per km2	207	207	0.0%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

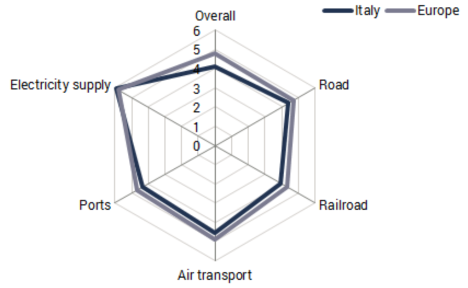
Percent of GDP



Source: Oxford Economics

Infrastructure quality

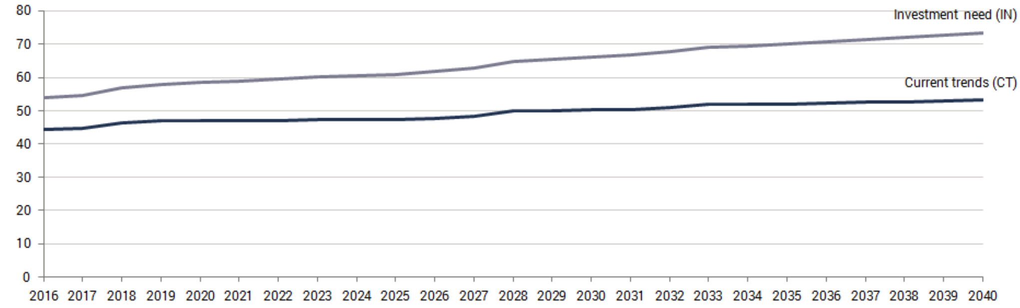
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

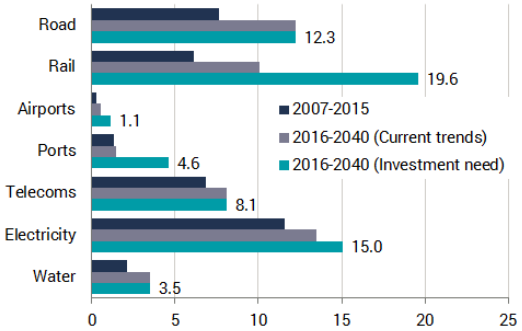
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

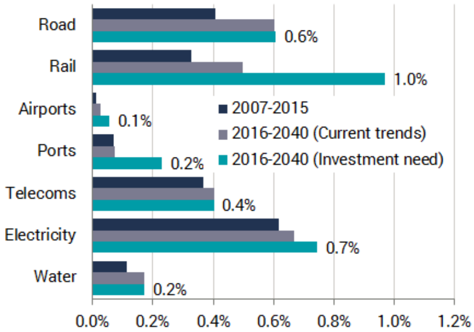
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	305	251	14	37	203	337	87	1,234
2016-2040 (Investment need)	306	490	29	116	203	376	87	1,607
2016-2040 (Gap between IN and CT)	1	239	15	79	0	39	0	373
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

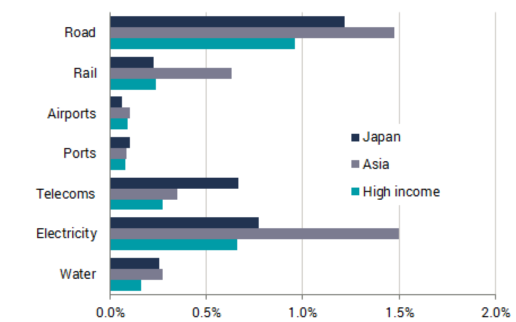
Japan

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	4,384	4,673	0.3%
GDP per head ($US)*	34,648	41,096	0.7%
Population (000s)	126,544	113,706	-0.4%
Urban population (% of total)**	93.5%	97.1%	0.2%
Population density (persons per km2	347	312	-0.4%

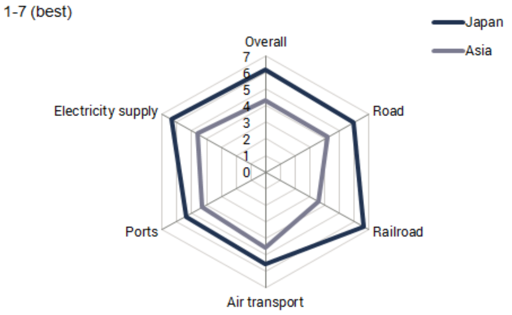
*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



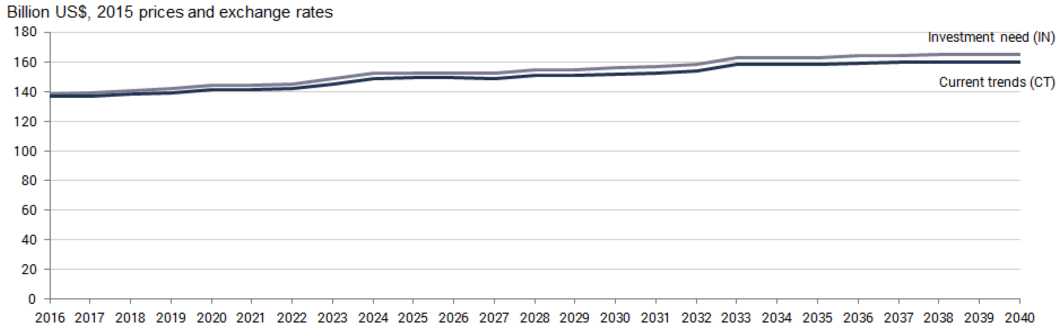
Source: Oxford Economics

Infrastructure quality



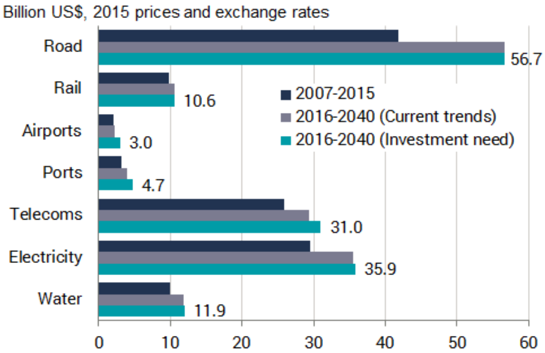
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

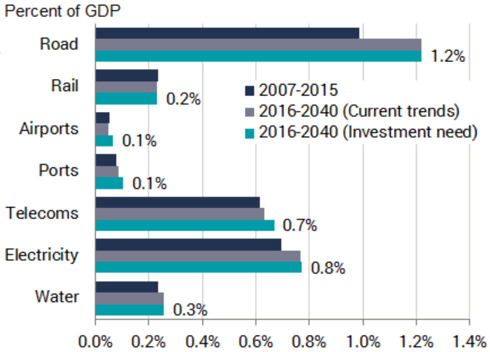


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	1,417	266	55	98	734	890	295	3,755
2016-2040 (Investment need)	1,417	266	75	118	775	897	299	3,846
2016-2040 (Gap between IN and CT)	0	0	20	20	42	7	3	91
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Jordan

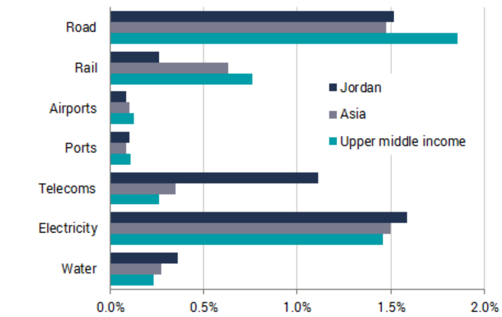
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	38	97	3.9%
GDP per head ($US)*	4,940	9,249	2.5%
Population (000s)	7,595	10,492	1.3%
Urban population (% of total)**	83.1%	85.1%	0.1%
Population density (persons per km2	86	118	1.3%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

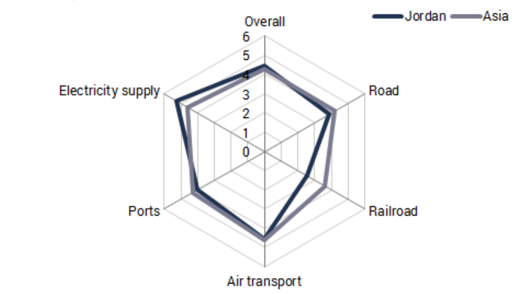
Percent of GDP



Source: Oxford Economics

Infrastructure quality

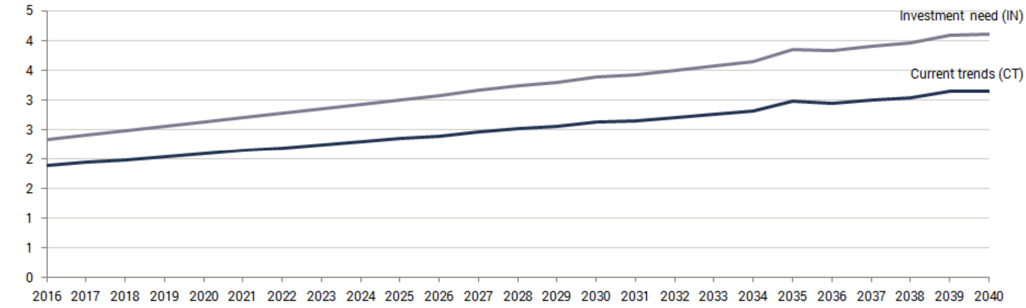
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

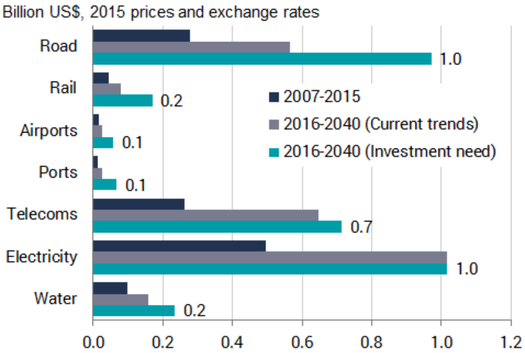
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

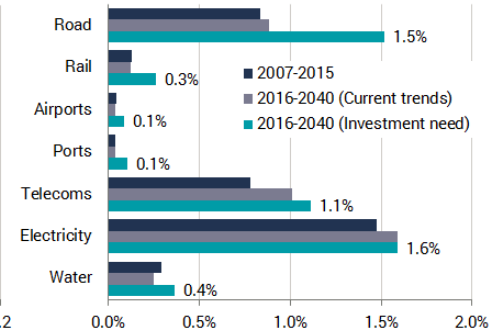
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	14	2	1	1	16	25	4	63
2016-2040 (Investment need)	24	4	1	2	18	25	6	81
2016-2040 (Gap between IN and CT)	10	2	1	1	2	0	2	18
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Kazakhstan

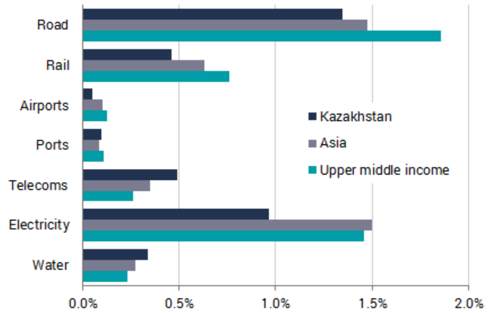
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	177	501	4.3%
GDP per head ($US)*	10,025	23,557	3.5%
Population (000s)	17,625	21,265	0.8%
Urban population (% of total)**	53.8%	60.3%	0.5%
Population density (persons per km2	7	8	0.8%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population

Infrastructure investment need, 2016-2040

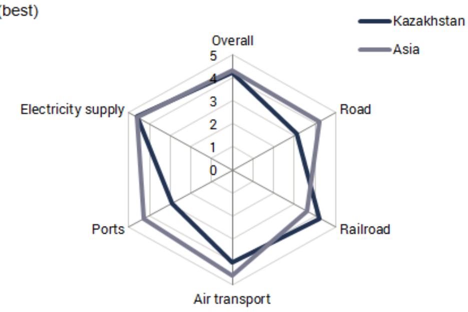
Percent of GDP



Source: Oxford Economics

Infrastructure quality

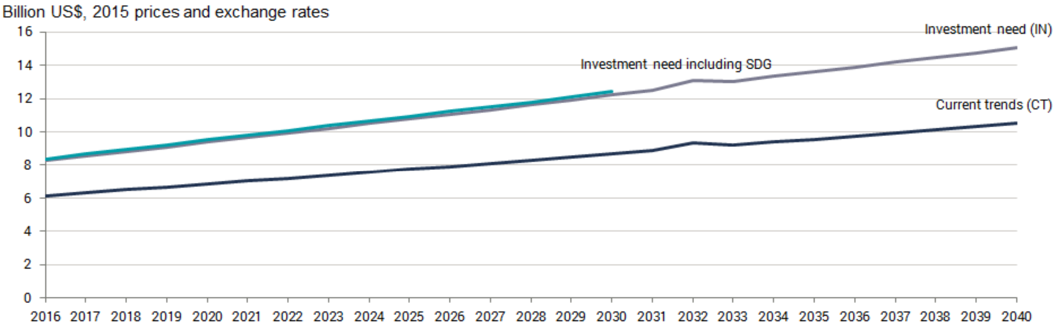
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

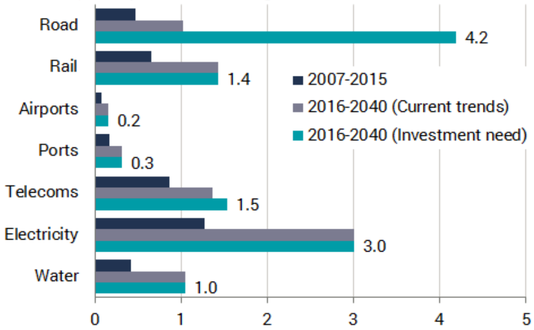
Billion US$, 2015 prices and exchange rates

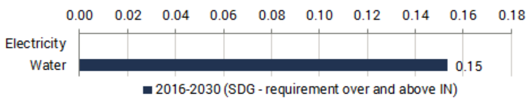


Source: Oxford Economics

Average annual investment

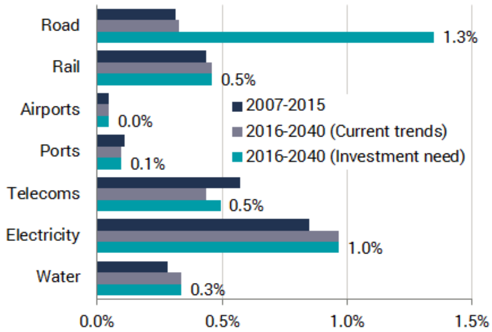
Billion US$, 2015 prices and exchange rates

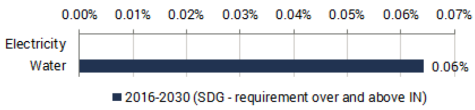




Infrastructure investment as a percentage of GDP

Percent of GDP





Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	26	36	4	8	34	75	26	208
2016-2040 (Investment need)	105	36	4	8	38	75	26	292
2016-2040 (Gap between IN and CT)	79	0	0	0	4	0	0	84
2016-2030 (SDG - requirement over and above IN						0	2	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Kenya

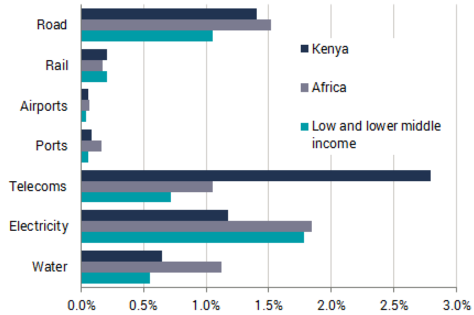
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	63	243	5.5%
GDP per head ($US)*	1,377	3,034	3.2%
Population (000s)	46,050	80,091	2.2%
Urban population (% of total)**	25.5%	33.8%	1.1%
Population density (persons per km2	81	141	2.2%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

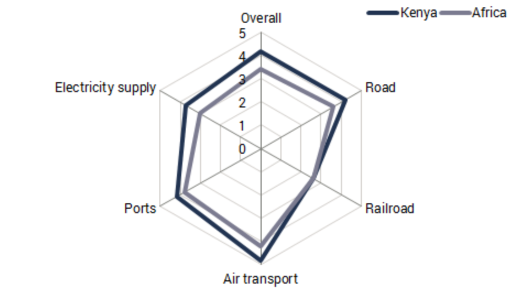
Percent of GDP



Source: Oxford Economics

Infrastructure quality

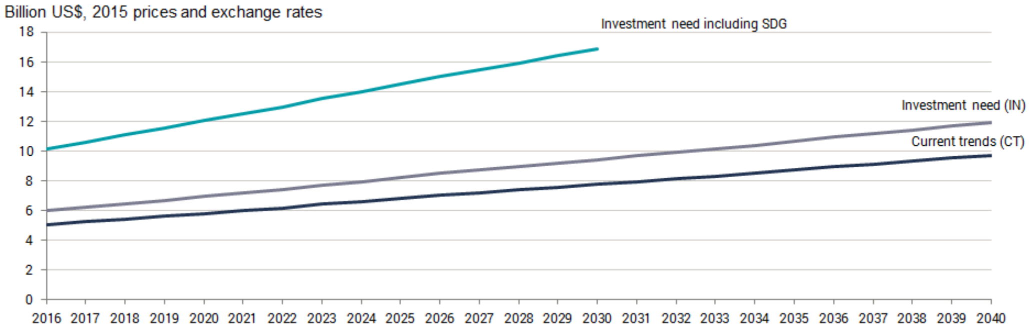
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

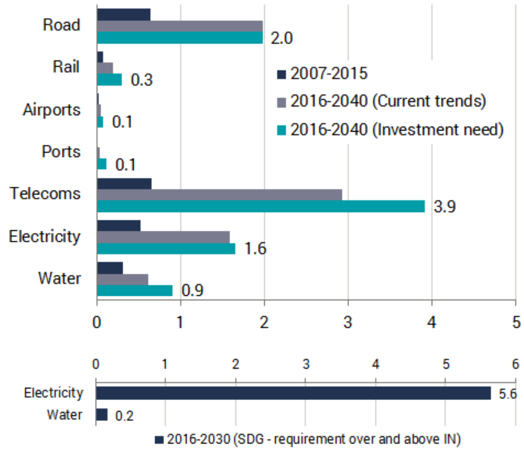
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

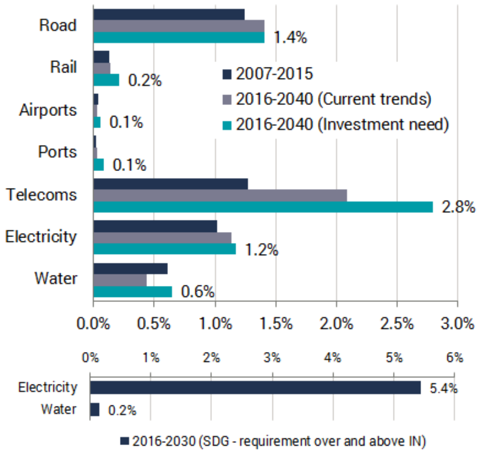
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	49	5	1	1	73	40	15	184
2016-2040 (Investment need)	49	7	2	3	98	41	23	223
2016-2040 (Gap between IN and CT)	0	3	1	2	25	1	7	39
2016-2030 (SDG - requirement over and above IN						85	2	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Malaysia

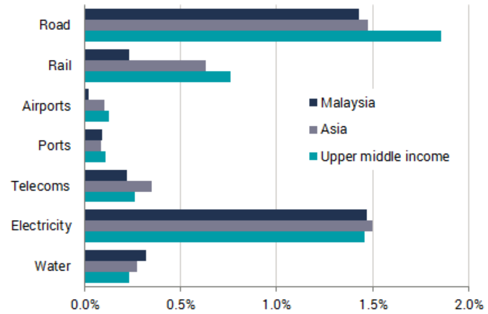
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	297	680	3.4%
GDP per head ($US)*	9,777	17,488	2.4%
Population (000s)	30,384	38,881	1.0%
Urban population (% of total)**	74.1%	86.3%	0.6%
Population density (persons per km2	92	118	1.0%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

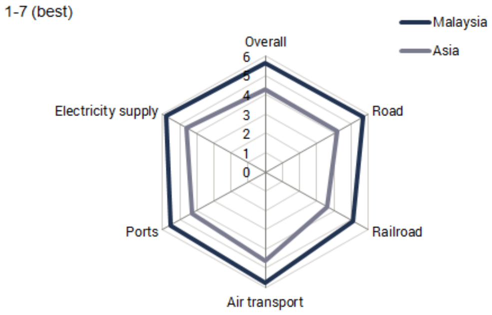
Infrastructure investment need, 2016-2040

Percent of GDP



Source: Oxford Economics

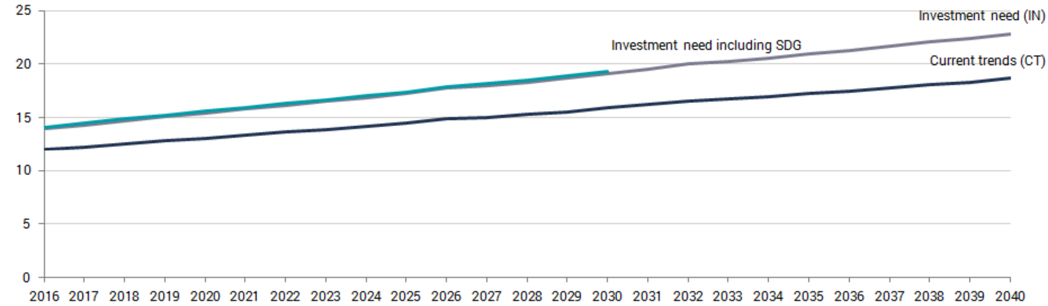
Infrastructure quality



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

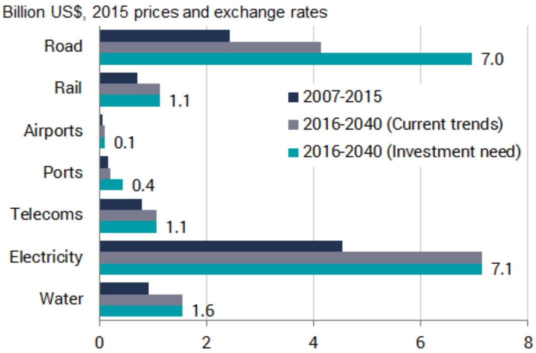
Billion US$, 2015 prices and exchange rates

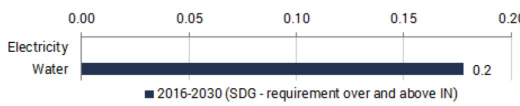


Source: Oxford Economics

Average annual investment

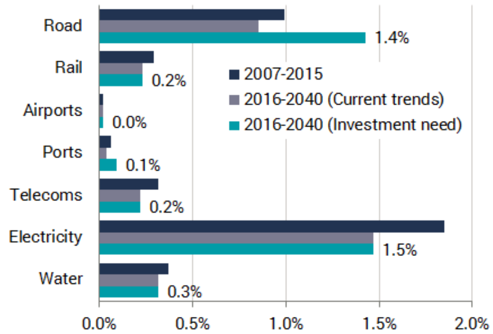
Billion US$, 2015 prices and exchange rates

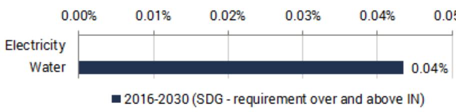




Infrastructure investment as a percentage of GDP

Percent of GDP





Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	104	28	2	5	27	179	39	383
2016-2040 (Investment need)	174	28	2	11	27	179	39	460
2016-2040 (Gap between IN and CT)	70	0	0	6	0	0	0	77
2016-2030 (SDG - requirement over and above IN						0	3	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Mexico

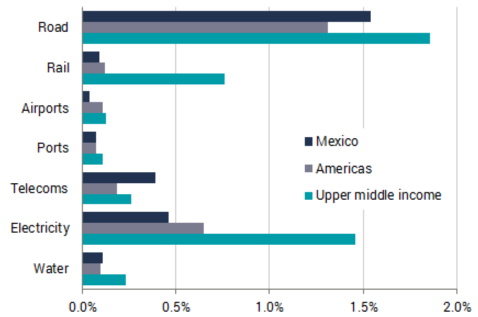
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,151	2,036	2.3%
GDP per head ($US)*	9,045	12,899	1.4%
Population (000s)	127,220	157,859	0.9%
Urban population (% of total)**	79.4%	88.1%	0.4%
Population density (persons per km2	65	81	0.9%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

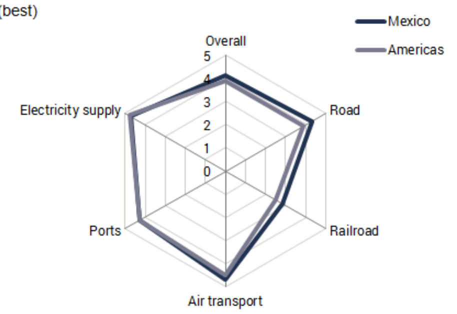
Percent of GDP



Source: Oxford Economics

Infrastructure quality

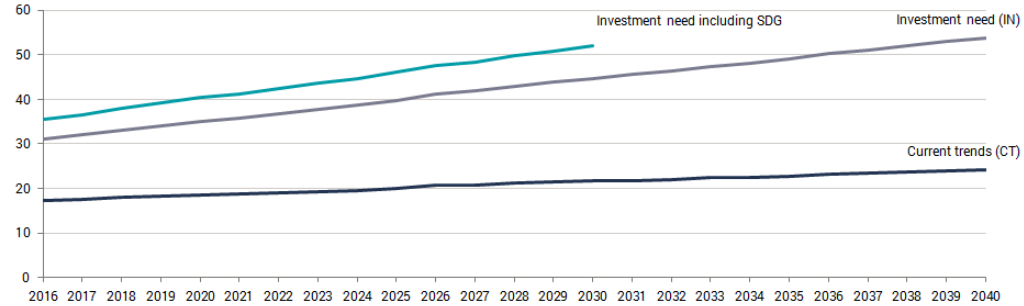
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

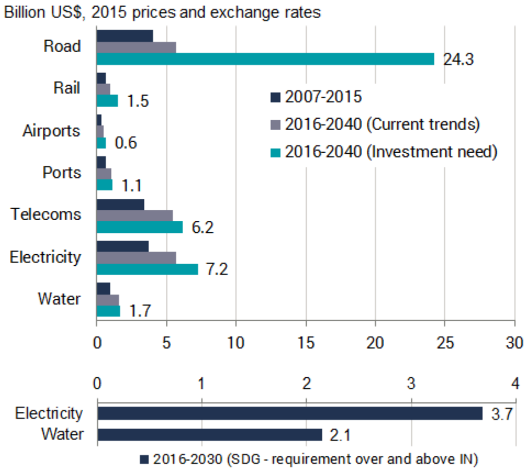
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

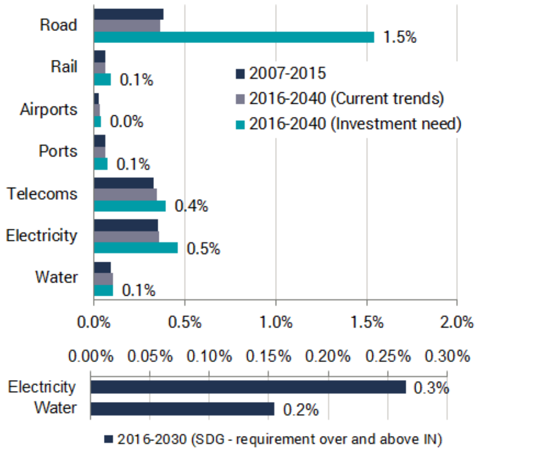
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	142	24	12	26	136	142	41	522
2016-2040 (Investment need)	607	37	16	29	155	181	42	1,066
2016-2040 (Gap between IN and CT)	464	14	3	3	19	39	2	544
2016-2030 (SDG - requirement over and above IN						55	32	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Morocco

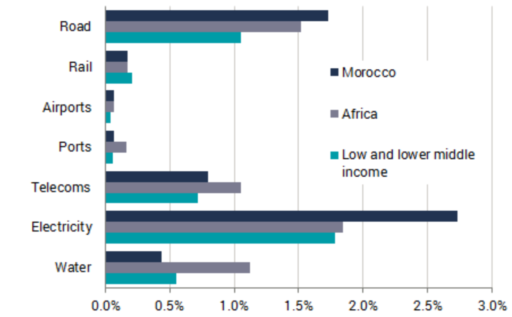
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	100	243	3.6%
GDP per head ($US)*	2,919	5,761	2.8%
Population (000s)	34,378	42,148	0.8%
Urban population (% of total)**	60.2%	70.3%	0.6%
Population density (persons per km2	77	94	0.8%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

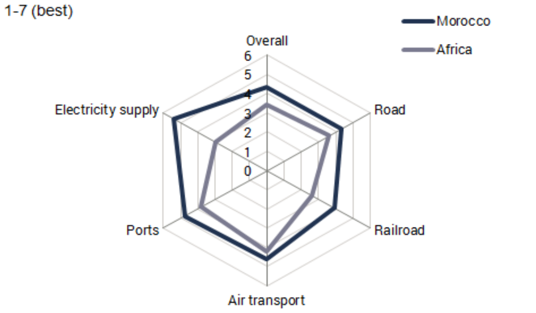
Percent of GDP



Source: Oxford Economics

Infrastructure quality

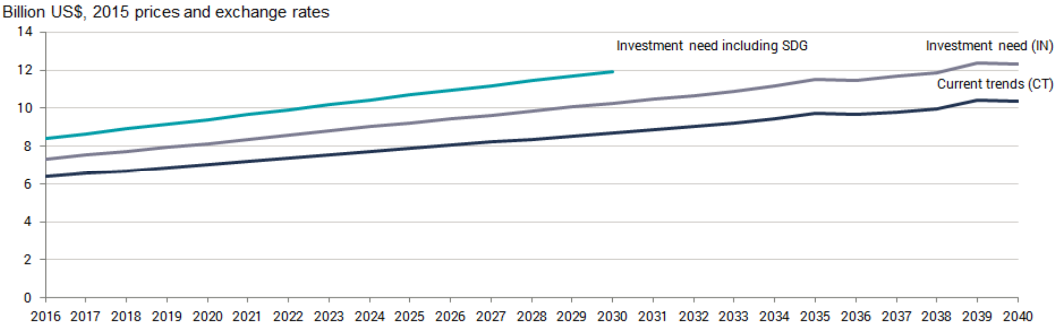
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

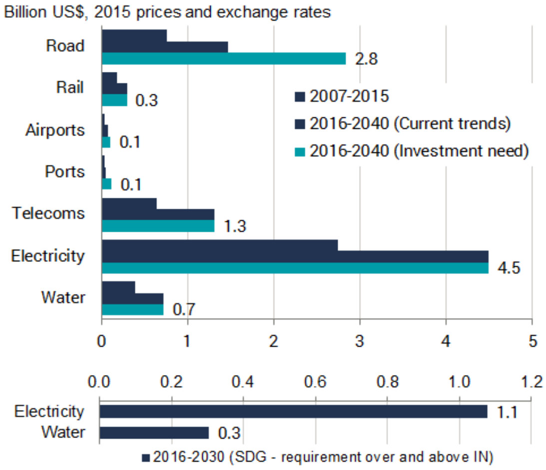
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

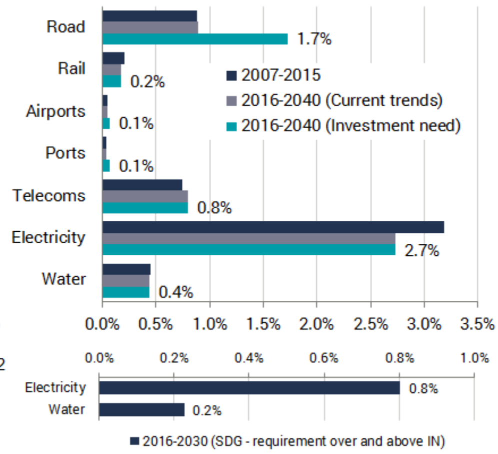
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	37	7	2	1	33	112	18	210
2016-2040 (Investment need)	71	7	3	3	33	112	18	246
2016-2040 (Gap between IN and CT)	34	0	1	2	0	0	0	37
2016-2030 (SDG - requirement over and above IN						16	5	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Myanmar

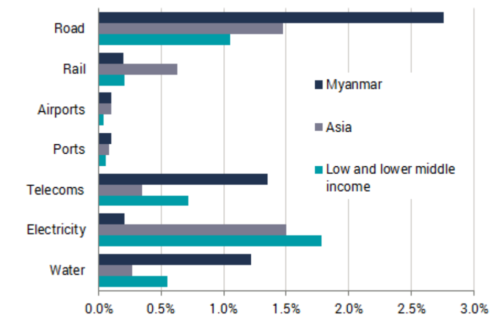
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	62	262	5.9%
GDP per head ($US)*	1,152	4,178	5.3%
Population (000s)	53,897	62,804	0.6%
Urban population (% of total)**	34.2%	50.4%	1.6%
Population density (persons per km2	83	96	0.6%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

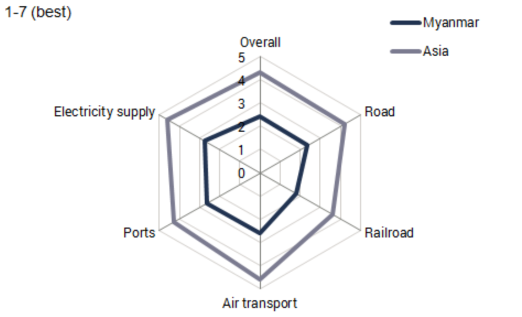
Percent of GDP



Source: Oxford Economics

Infrastructure quality

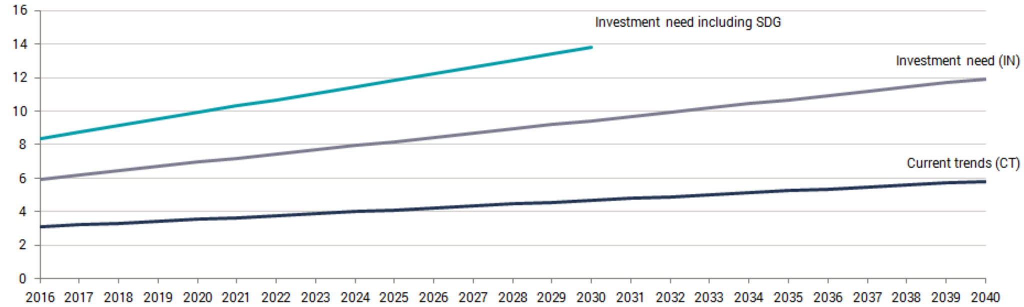
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

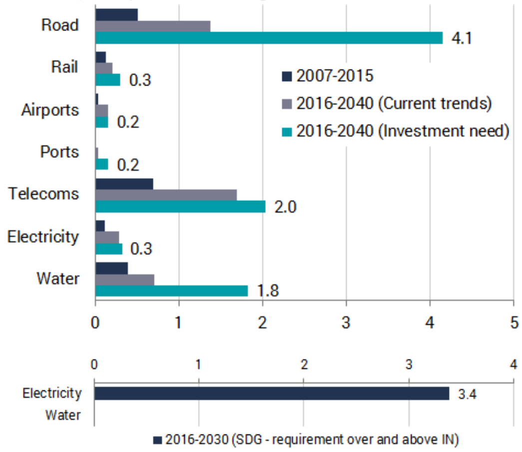
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

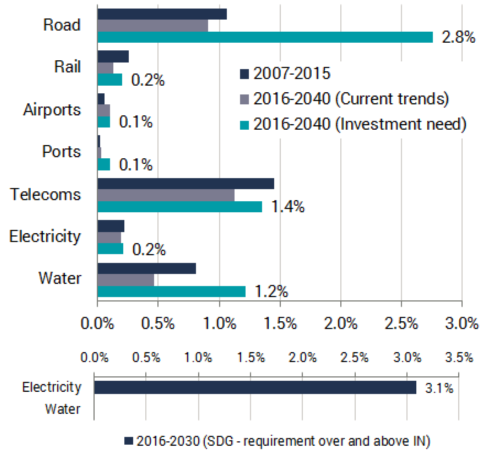
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	34	5	4	1	42	7	18	111
2016-2040 (Investment need)	104	8	4	4	51	8	46	224
2016-2040 (Gap between IN and CT)	69	3	0	3	9	1	28	112
2016-2030 (SDG - requirement over and above IN						51	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

New Zealand

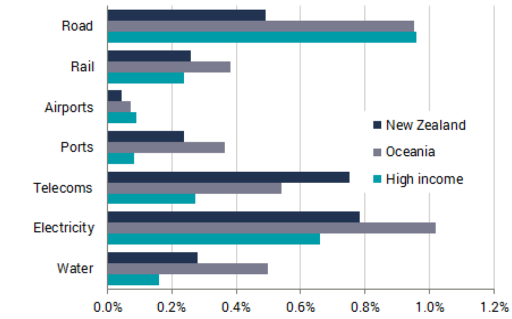
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	173	309	2.3%
GDP per head ($US)*	38,192	57,308	1.6%
Population (000s)	4,534	5,398	0.7%
Urban population (% of total)**	86.4%	87.8%	0.1%
Population density (persons per km2	17	21	0.7%

**2015 prices and exchange rates; ** Av. annual growth shows average average annual change in urban share of population*

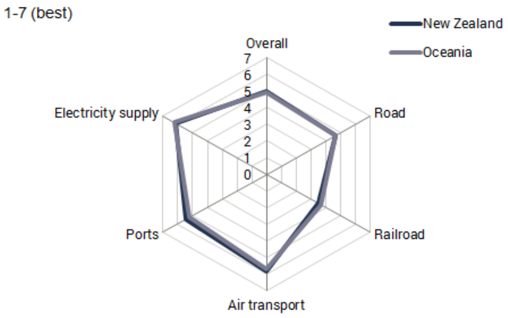
Infrastructure investment need, 2016-2040

Percent of GDP



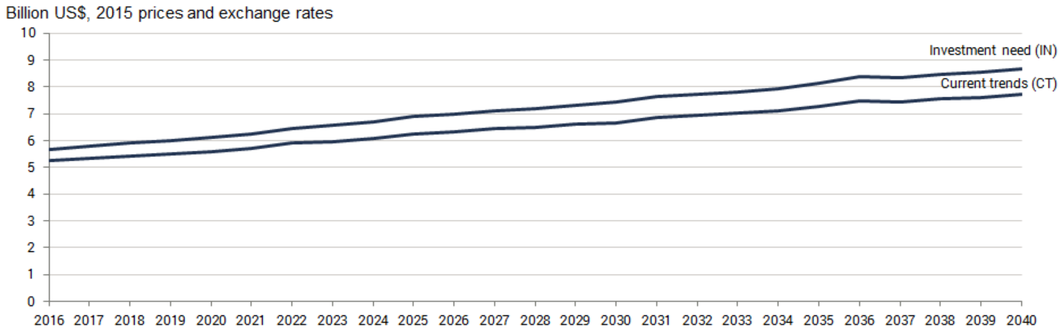
Source: Oxford Economics

Infrastructure quality



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

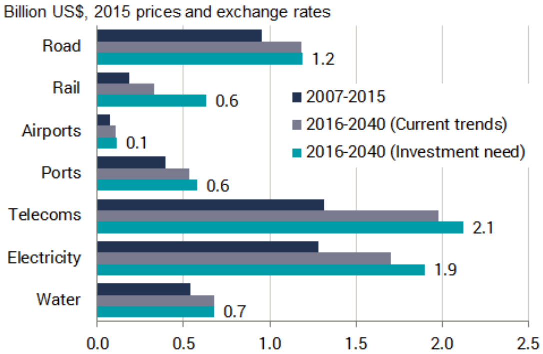
Total infrastructure investment 2016-40



Source: Oxford Economics

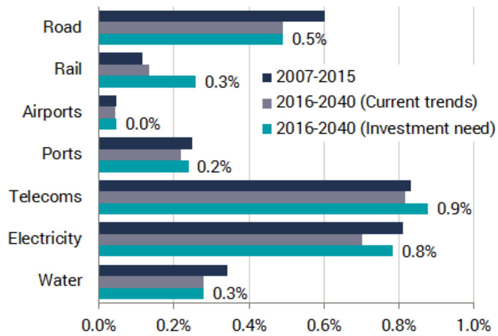
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	30	8	3	13	49	43	17	163
2016-2040 (Investment need)	30	16	3	14	53	47	17	180
2016-2040 (Gap between IN and CT)	0	8	0	1	4	5	0	17
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Nigeria

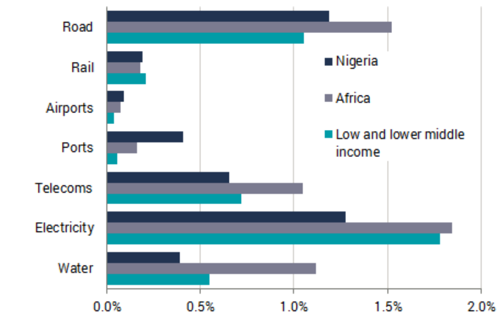
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	495	1,359	4.1%
GDP per head ($US)*	2,714	4,152	1.7%
Population (000s)	182,202	327,406	2.4%
Urban population (% of total)**	47.8%	69.5%	1.5%
Population density (persons per km2	200	359	2.4%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

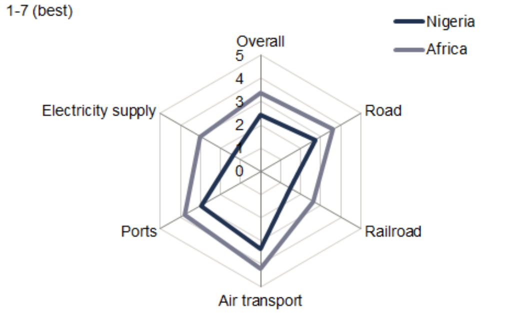
Percent of GDP



Source: Oxford Economics

Infrastructure quality

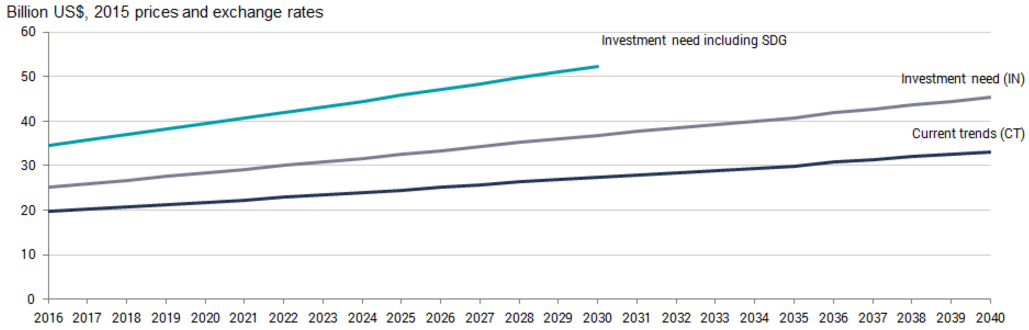
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

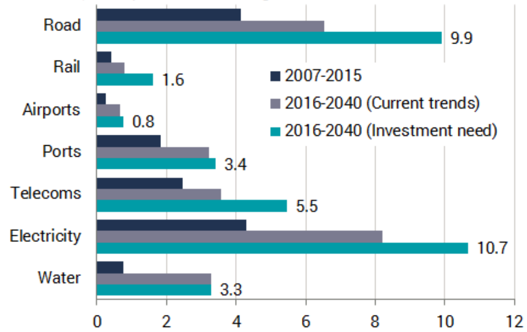
Billion US$, 2015 prices and exchange rates

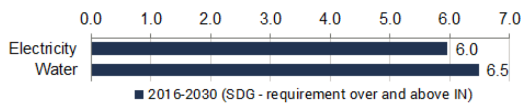


Source: Oxford Economics

Average annual investment

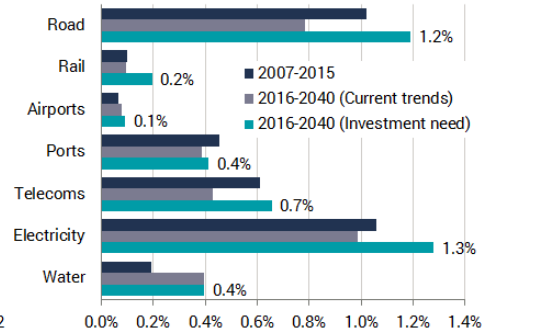
Billion US$, 2015 prices and exchange rates

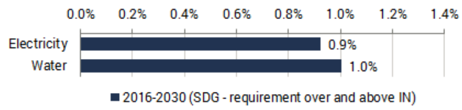




Infrastructure investment as a percentage of GDP

Percent of GDP





Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	164	20	16	80	89	205	82	657
2016-2040 (Investment need)	248	40	19	86	137	267	82	878
2016-2040 (Gap between IN and CT)	84	21	3	5	47	61	0	221
2016-2030 (SDG - requirement over and above IN						89	97	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

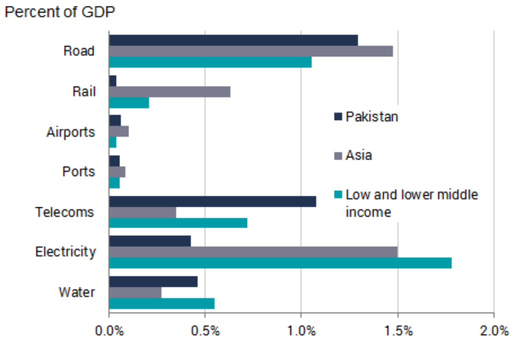
Pakistan

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	268	950	5.2%
GDP per head ($US)*	1,416	3,404	3.6%
Population (000s)	188,925	278,987	1.6%
Urban population (% of total)**	38.8%	49.3%	1.0%
Population density (persons per km2	245	362	1.6%

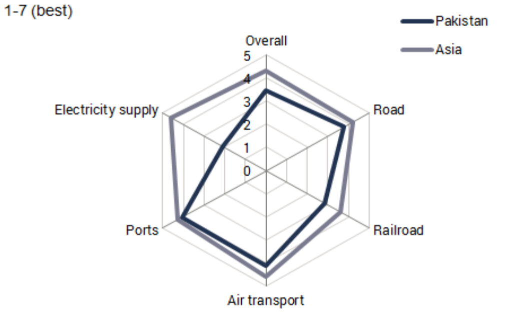
*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population

Infrastructure investment need, 2016-2040



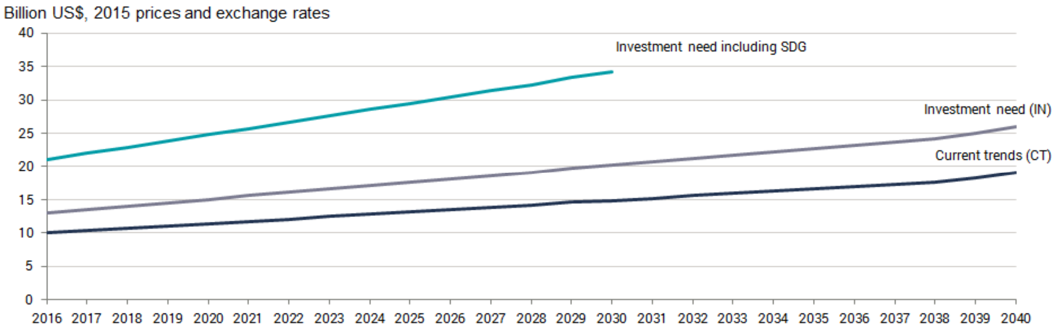
Source: Oxford Economics

Infrastructure quality



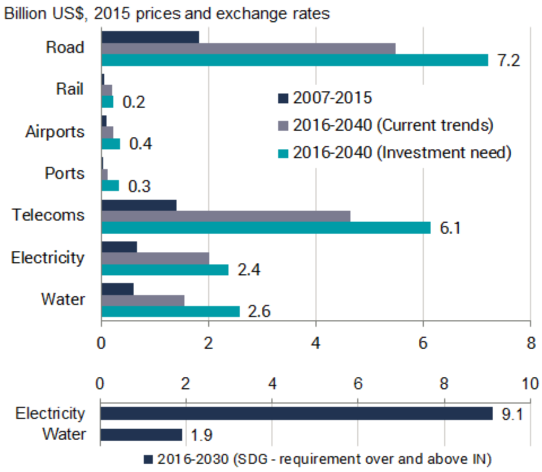
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

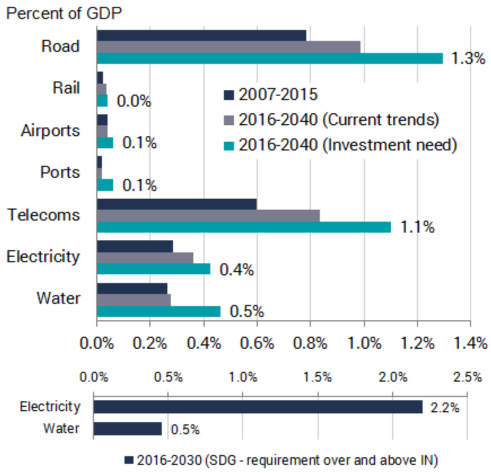


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	137	5	6	3	116	50	39	355
2016-2040 (Investment need)	180	5	9	8	153	59	64	480
2016-2040 (Gap between IN and CT)	43	0	3	6	37	9	26	124
2016-2030 (SDG - requirement over and above IN						137	28	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

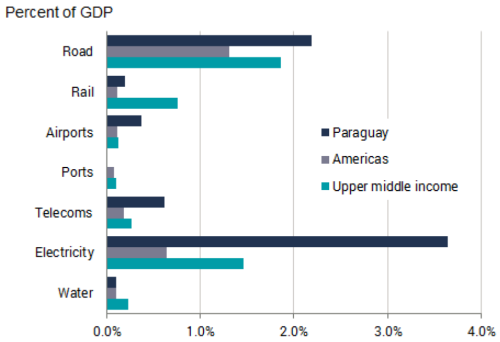
Paraguay

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	28	57	2.9%
GDP per head ($US)*	4,174	6,698	1.9%
Population (000s)	6,639	8,458	1.0%
Urban population (% of total)**	59.7%	76.8%	1.0%
Population density (persons per km2	17	21	1.0%

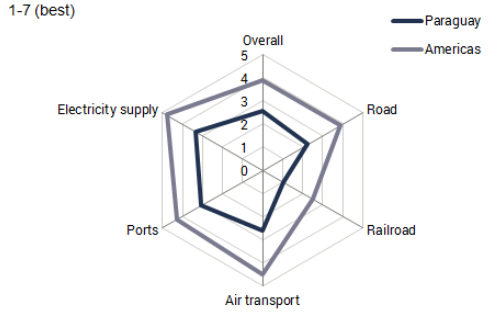
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



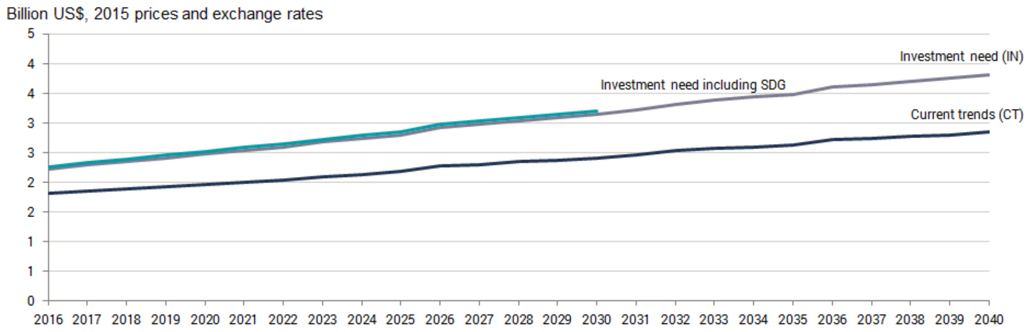
Source: Oxford Economics

Infrastructure quality



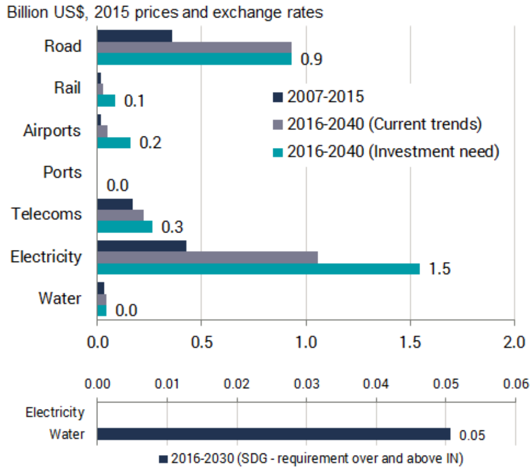
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

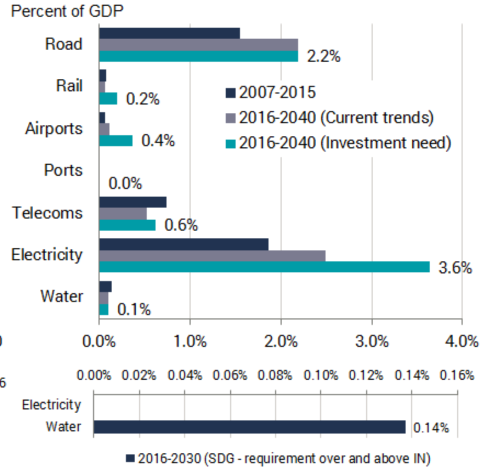


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	23	1	1	0	6	26	1	58
2016-2040 (Investment need)	23	2	4	0	7	39	1	76
2016-2040 (Gap between IN and CT)	0	1	3	0	1	12	0	17
2016-2030 (SDG - requirement over and above IN						0	1	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Peru

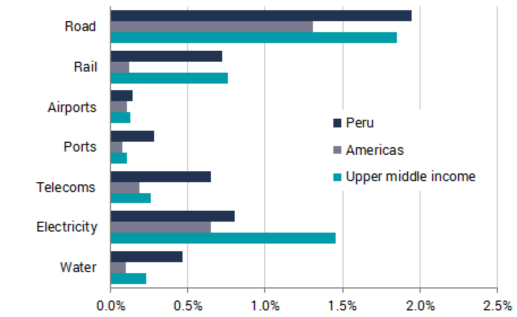
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	192	460	3.6%
GDP per head ($US)*	6,122	11,562	2.6%
Population (000s)	31,377	39,754	1.0%
Urban population (% of total)**	78.2%	82.1%	0.2%
Population density (persons per km2	25	31	1.0%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

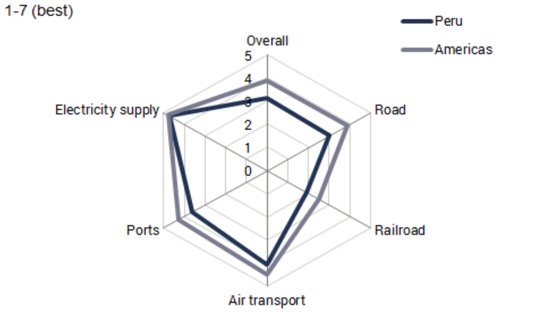
Percent of GDP



Source: Oxford Economics

Infrastructure quality

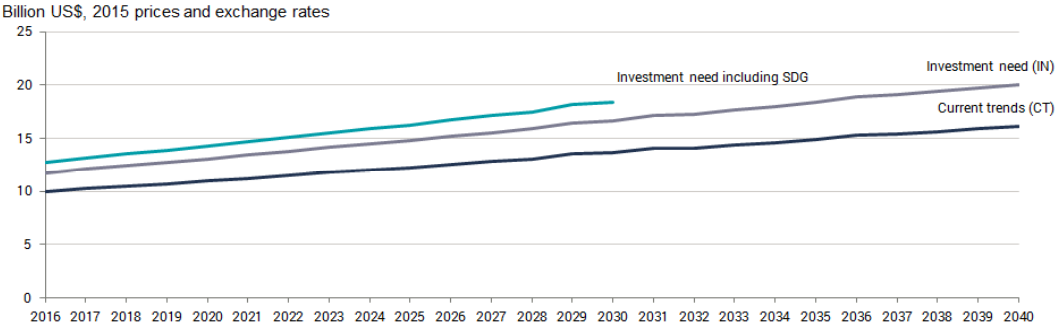
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

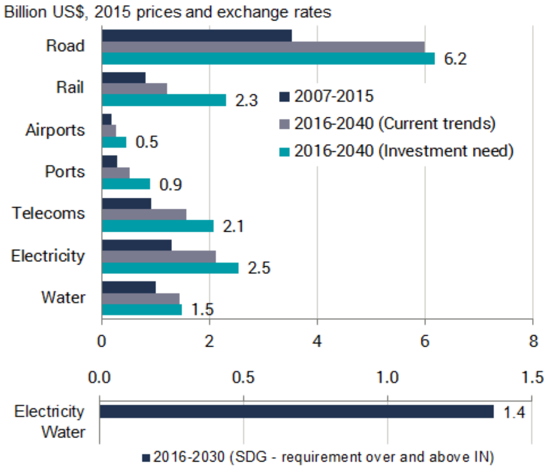
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

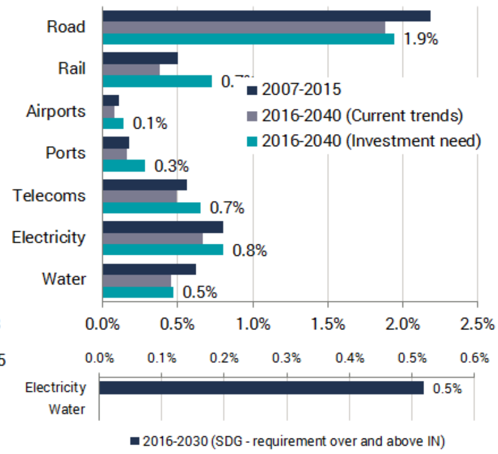
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	150	30	7	13	39	53	36	327
2016-2040 (Investment need)	154	58	11	22	52	64	37	399
2016-2040 (Gap between IN and CT)	5	27	5	10	13	11	1	71
2016-2030 (SDG - requirement over and above IN						21	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

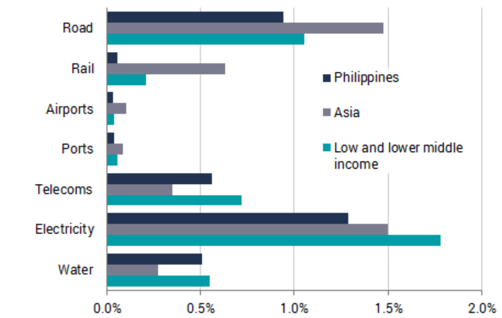
Philippines

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	292	925	4.7%
GDP per head ($US)*	2,896	6,746	3.4%
Population (000s)	100,893	137,174	1.2%
Urban population (% of total)**	44.4%	66.9%	1.7%
Population density (persons per km2	338	460	1.2%

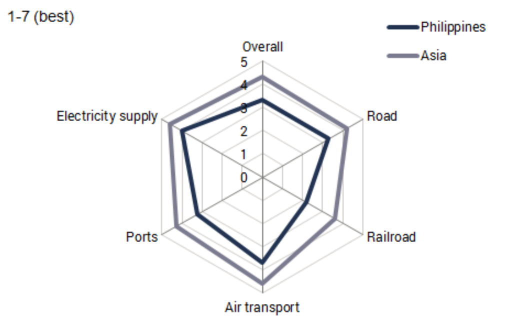
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



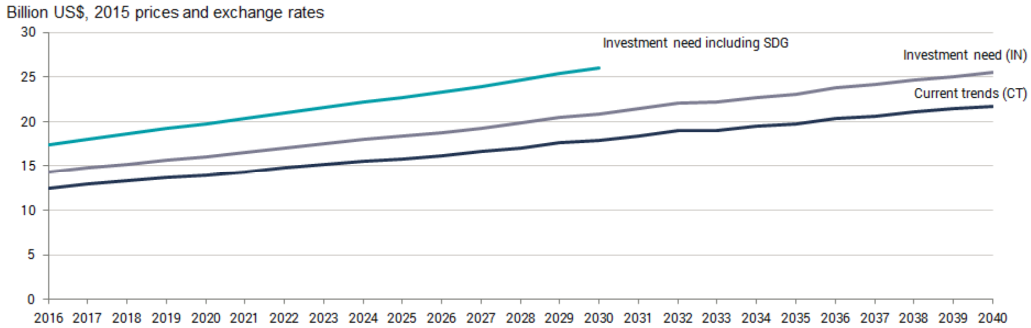
Source: Oxford Economics

Infrastructure quality



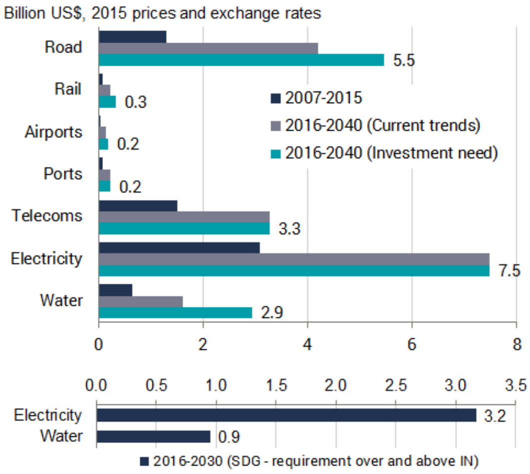
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

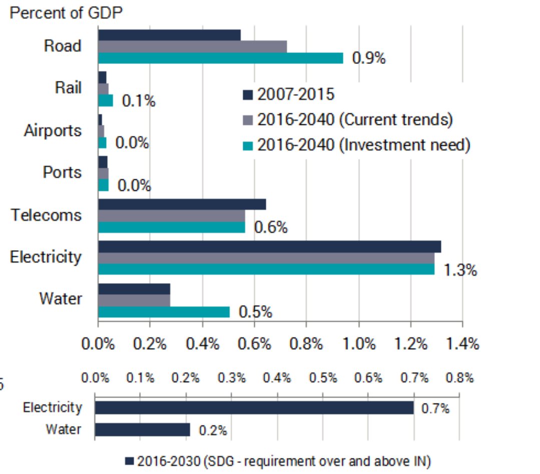


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	105	6	3	6	82	187	40	429
2016-2040 (Investment need)	136	8	5	6	82	187	73	498
2016-2040 (Gap between IN and CT)	31	3	1	0	0	0	33	69
2016-2030 (SDG - requirement over and above IN						48	14	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

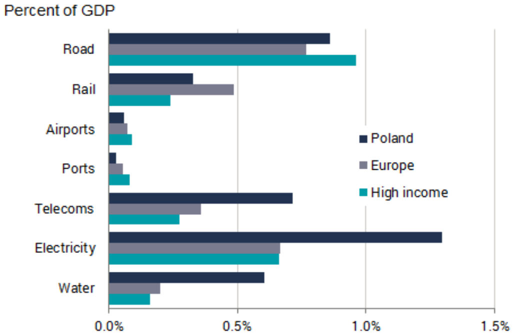
Poland

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	476	817	2.2%
GDP per head ($US)*	12,529	22,814	2.4%
Population (000s)	38,015	35,811	-0.2%
Urban population (% of total)**	60.6%	61.5%	0.1%
Population density (persons per km2	124	117	-0.2%

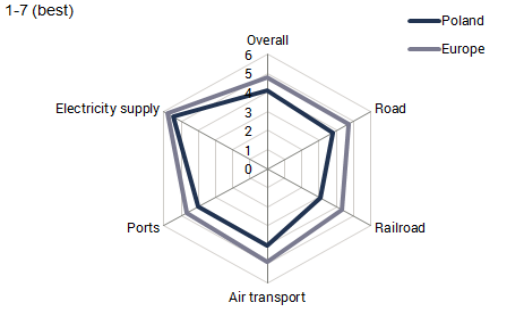
*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



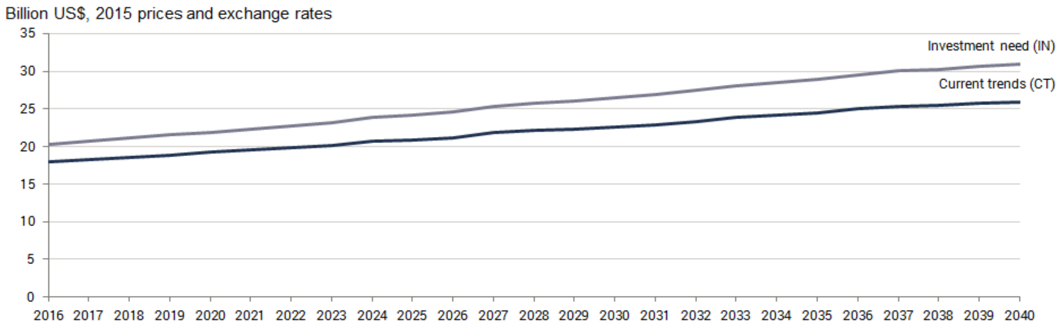
Source: Oxford Economics

Infrastructure quality



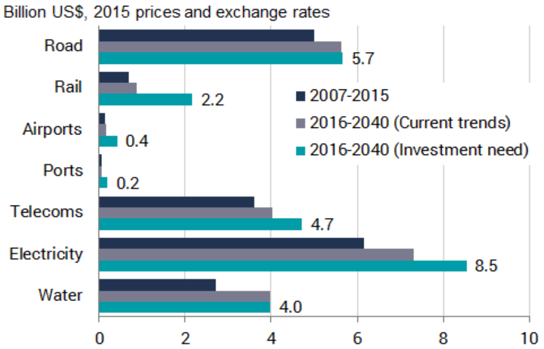
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

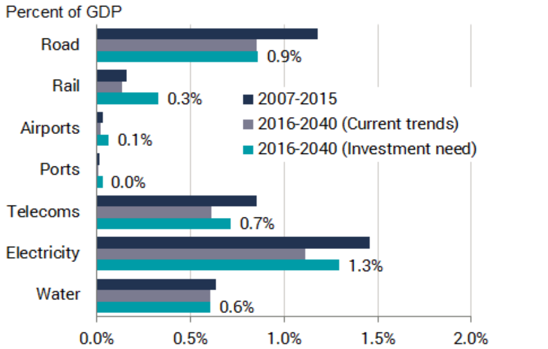


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	141	22	4	1	100	183	99	551
2016-2040 (Investment need)	142	54	10	5	118	213	99	642
2016-2040 (Gap between IN and CT)	1	32	7	4	17	30	0	91
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Romania

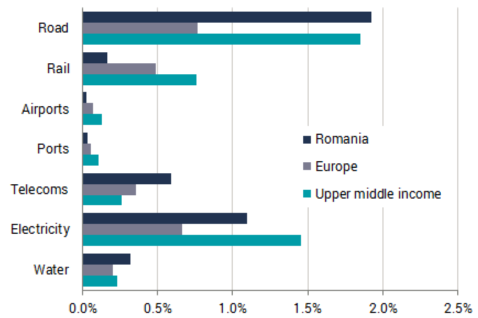
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	178	261	1.5%
GDP per head ($US)*	8,950	13,830	1.8%
Population (000s)	19,847	18,851	-0.2%
Urban population (% of total)**	54.6%	56.6%	0.1%
Population density (persons per km2	86	82	-0.2%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

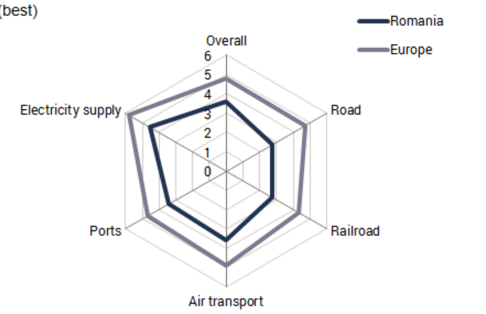
Percent of GDP



Source: Oxford Economics

Infrastructure quality

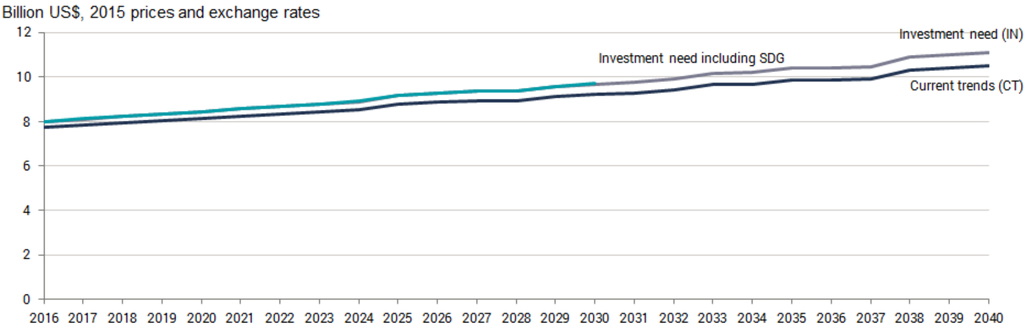
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

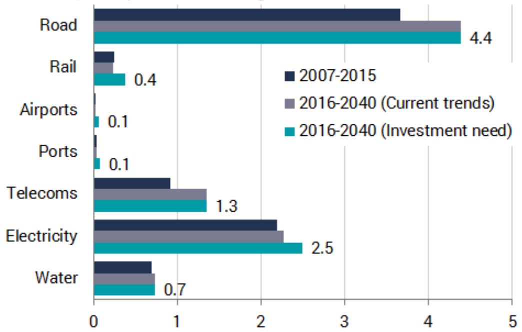
Billion US$, 2015 prices and exchange rates

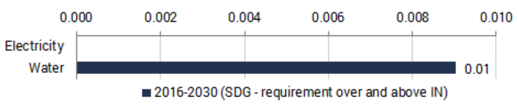


Source: Oxford Economics

Average annual investment

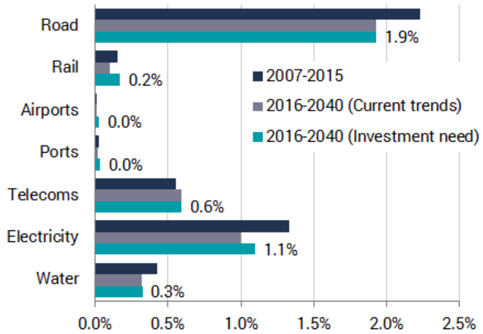
Billion US$, 2015 prices and exchange rates

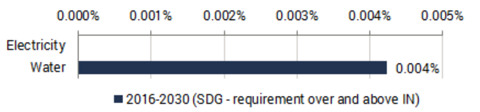




Infrastructure investment as a percentage of GDP

Percent of GDP





Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	110	6	1	1	34	57	18	226
2016-2040 (Investment need)	110	10	1	2	34	62	18	237
2016-2040 (Gap between IN and CT)	0	4	1	1	0	6	0	11
2016-2030 (SDG - requirement over and above IN						0	0.1	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Russia

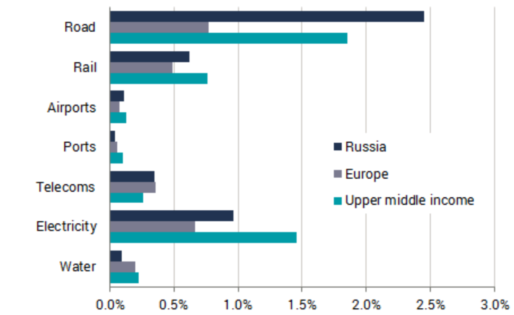
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,331	1,792	1.2%
GDP per head ($US)*	9,279	13,491	1.5%
Population (000s)	143,453	132,830	-0.3%
Urban population (% of total)**	74.0%	74.4%	0.0%
Population density (persons per km2	9	8	-0.3%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

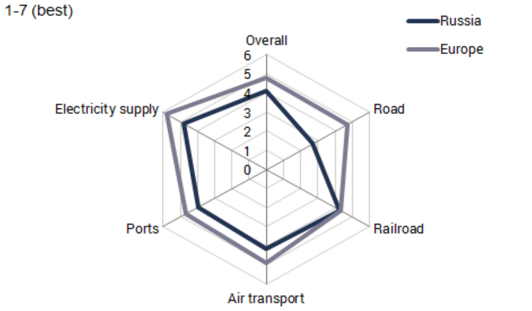
Percent of GDP



Source: Oxford Economics

Infrastructure quality

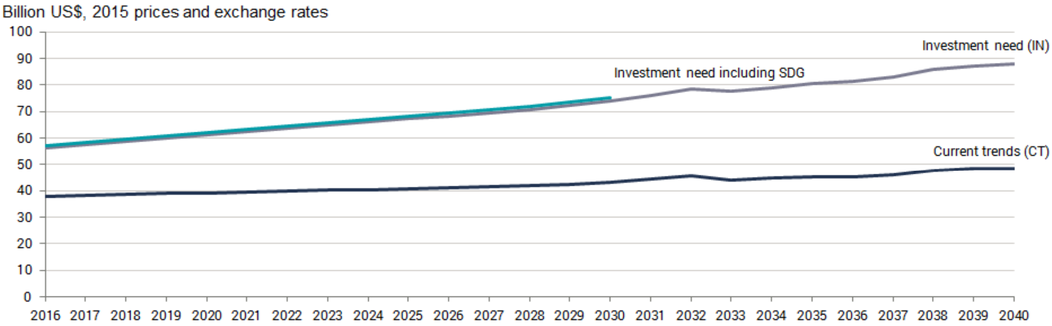
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

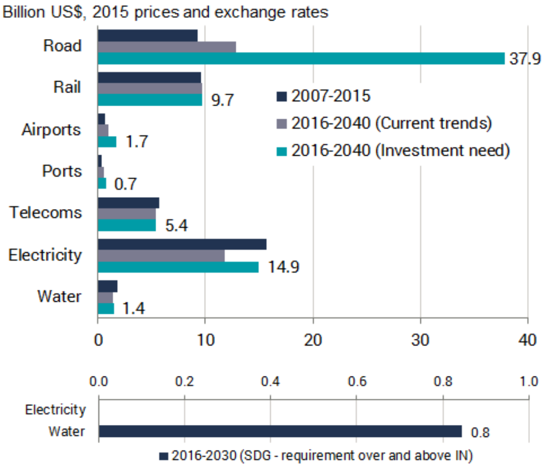
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

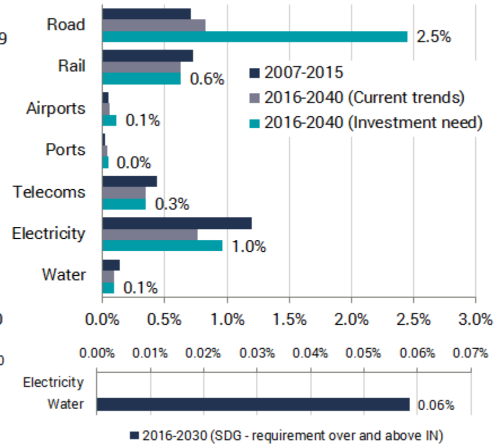
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	320	241	24	15	135	295	35	1,065
2016-2040 (Investment need)	947	241	43	17	135	373	36	1,792
2016-2040 (Gap between IN and CT)	626	0	19	3	0	77	1	727
2016-2030 (SDG - requirement over and above IN						0	13	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Saudi Arabia

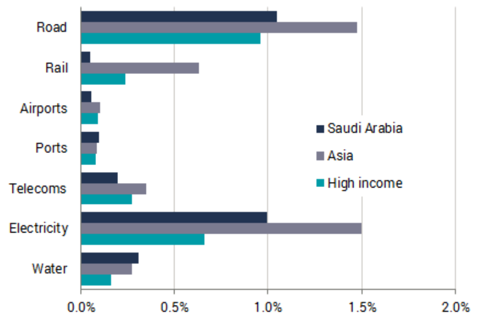
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	646	1,127	2.3%
GDP per head ($US)*	20,485	26,131	1.0%
Population (000s)	31,540	43,136	1.3%
Urban population (% of total)**	83.1%	93.7%	0.5%
Population density (persons per km2	15	20	1.3%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

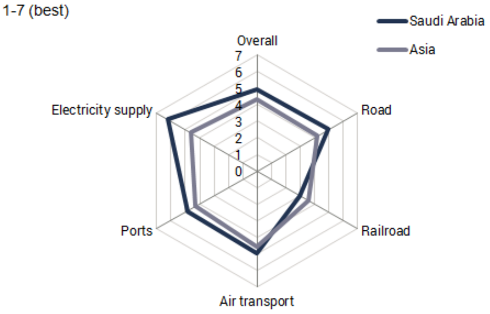
Percent of GDP



Source: Oxford Economics

Infrastructure quality

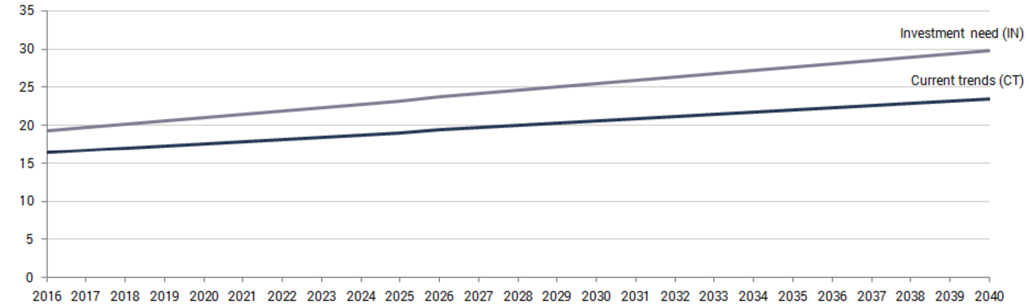
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

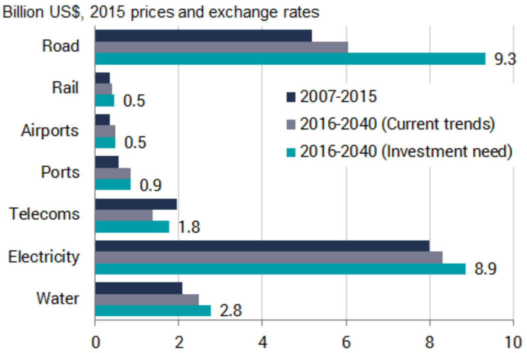
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

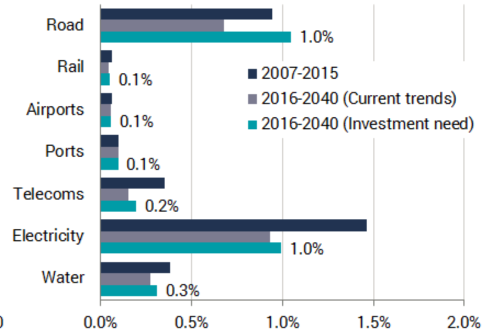
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	151	10	12	21	34	208	62	499
2016-2040 (Investment need)	233	11	12	21	44	222	69	613
2016-2040 (Gap between IN and CT)	82	2	0	0	10	14	8	115
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Senegal

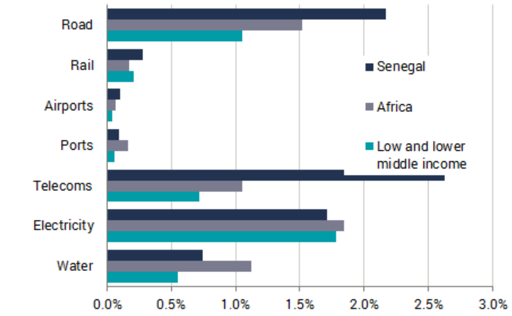
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	14	89	7.7%
GDP per head ($US)*	917	3,048	4.9%
Population (000s)	15,129	29,086	2.6%
Urban population (% of total)**	43.6%	51.0%	0.6%
Population density (persons per km2	79	151	2.6%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

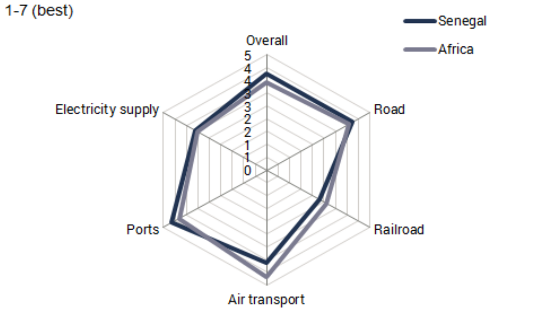
Percent of GDP



Source: Oxford Economics

Infrastructure quality

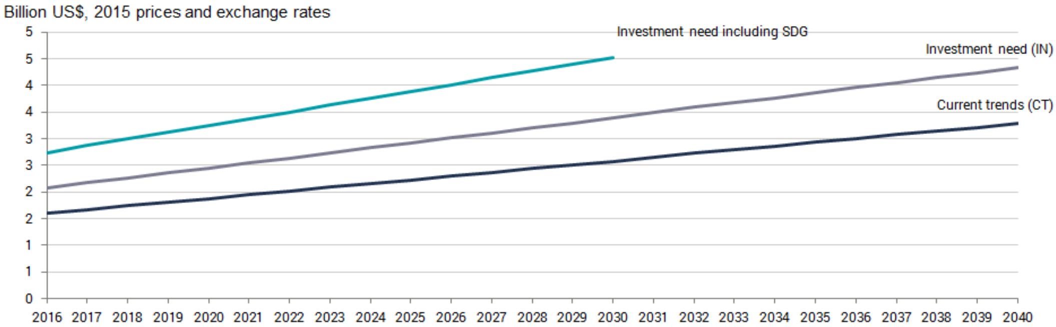
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

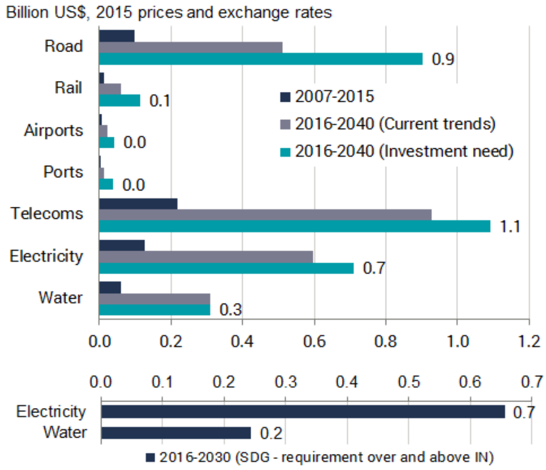
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

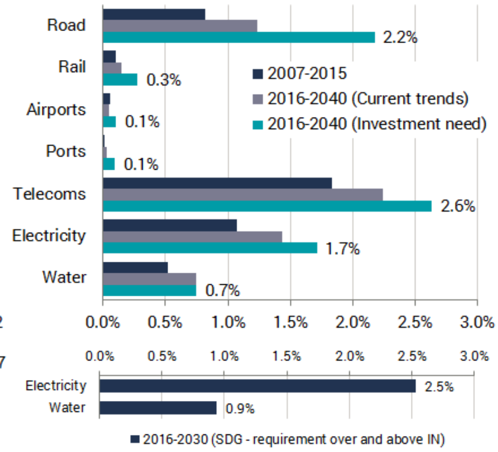
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	13	2	1	0	23	15	8	61
2016-2040 (Investment need)	23	3	1	1	27	18	8	80
2016-2040 (Gap between IN and CT)	10	1	1	1	4	3	0	19
2016-2030 (SDG - requirement over and above IN						10	4	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

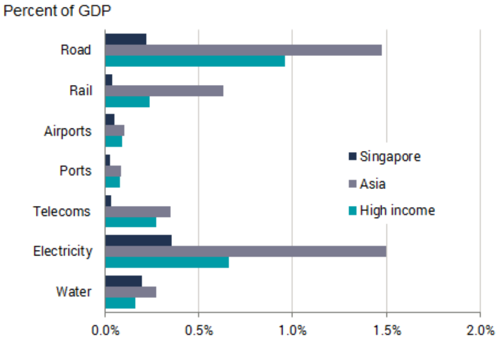
Singapore

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	293	504	2.2%
GDP per head ($US)*	52,796	72,614	1.3%
Population (000s)	5,546	6,938	0.9%
Urban population (% of total)**	100.0%	100.0%	0.0%
Population density (persons per km2	7,845	9,814	0.9%

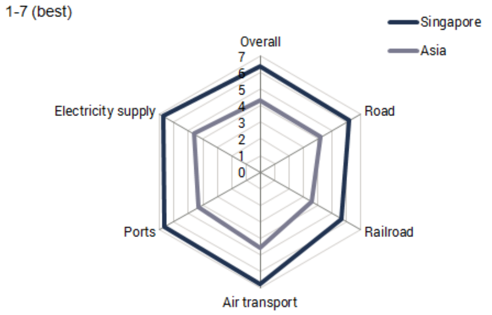
*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population

Infrastructure investment need, 2016-2040



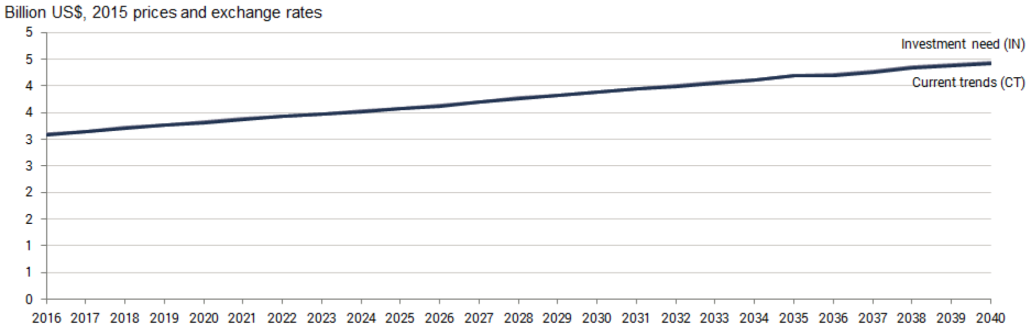
Source: Oxford Economics

Infrastructure quality



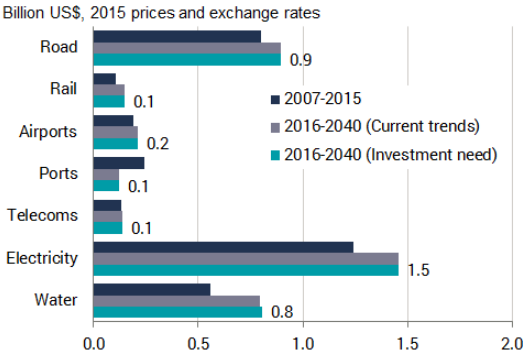
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

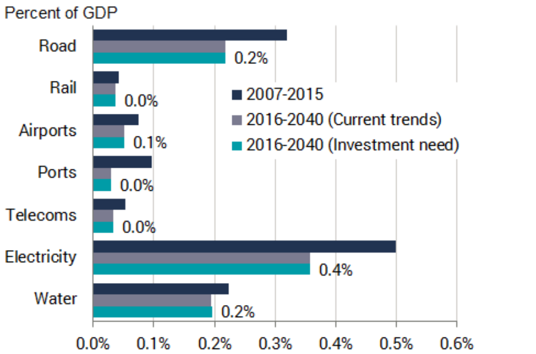


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	22	4	5	3	3	36	20	94
2016-2040 (Investment need)	22	4	5	3	3	36	20	94
2016-2040 (Gap between IN and CT)	0	0	0	0	0	0	0	0
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

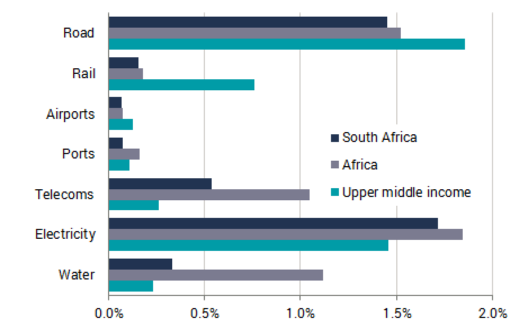
South Africa

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	316	504	1.9%
GDP per head ($US)*	5,794	8,001	1.3%
Population (000s)	54,552	63,036	0.6%
Urban population (% of total)**	64.8%	78.2%	0.8%
Population density (persons per km2	45	52	0.6%

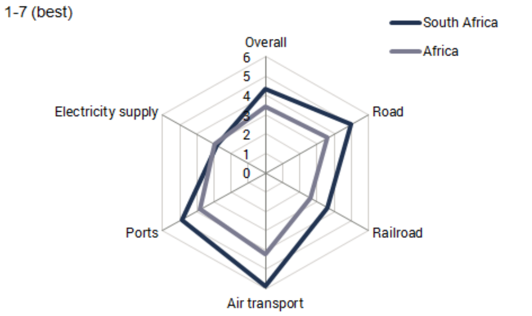
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



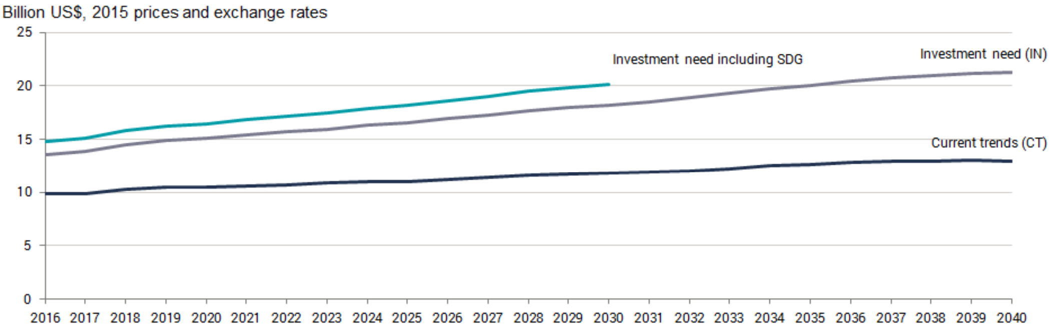
Source: Oxford Economics

Infrastructure quality



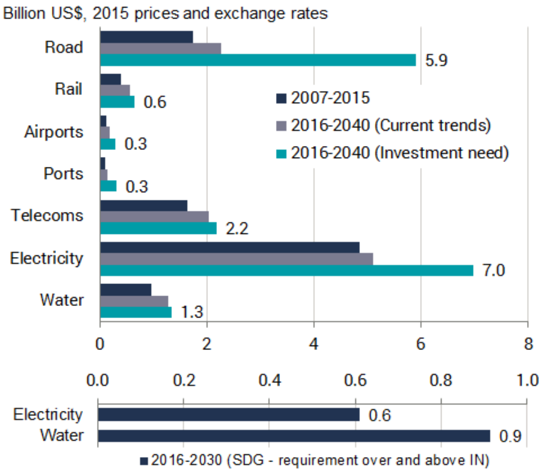
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

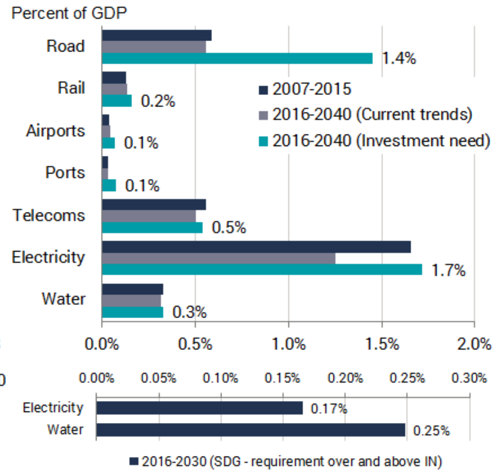


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	57	14	4	4	51	128	32	289
2016-2040 (Investment need)	148	16	7	8	55	175	34	441
2016-2040 (Gap between IN and CT)	91	2	3	4	4	47	1	152
2016-2030 (SDG - requirement over and above IN						9	14	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

South Korea

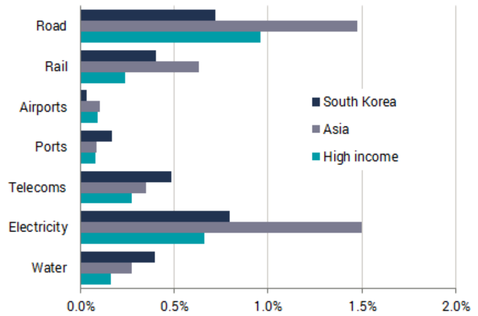
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,379	2,300	2.1%
GDP per head ($US)*	27,404	43,901	1.9%
Population (000s)	50,320	52,384	0.2%
Urban population (% of total)**	82.5%	90.0%	0.4%
Population density (persons per km2	516	537	0.2%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

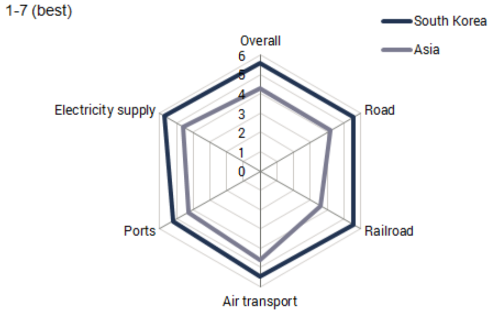
Percent of GDP



Source: Oxford Economics

Infrastructure quality

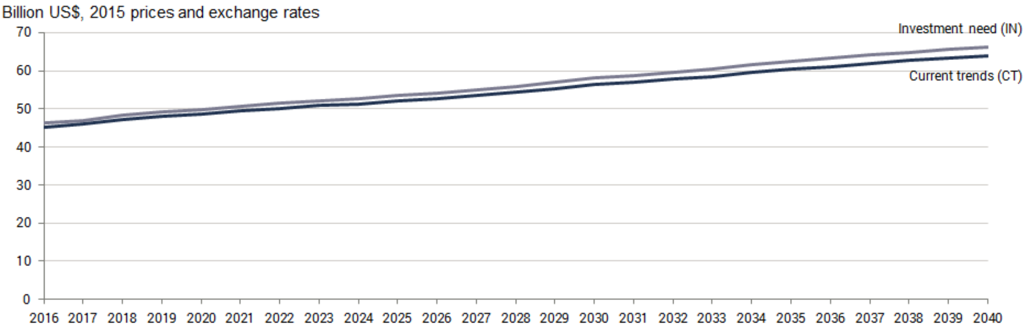
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

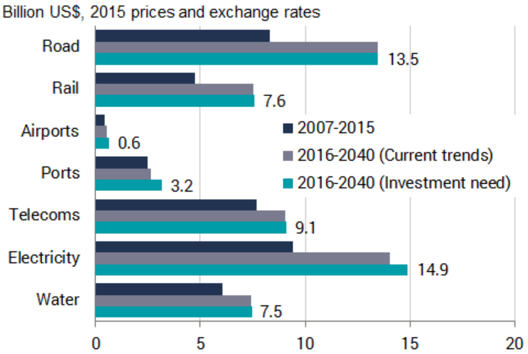
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

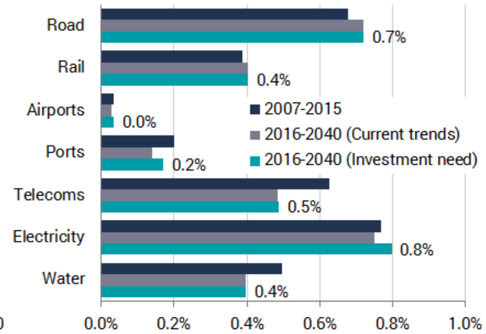
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	337	188	13	66	227	351	185	1,368
2016-2040 (Investment need)	337	189	16	79	228	373	186	1,409
2016-2040 (Gap between IN and CT)	0	1	2	13	1	22	1	41
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Spain

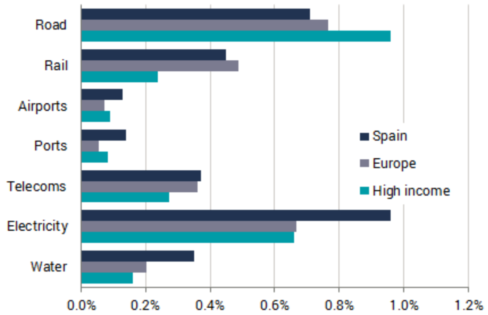
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	1,193	1,607	1.2%
GDP per head ($US)*	25,722	35,778	1.3%
Population (000s)	46,396	44,920	-0.1%
Urban population (% of total)**	79.6%	82.4%	0.1%
Population density (persons per km2	93	90	-0.1%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

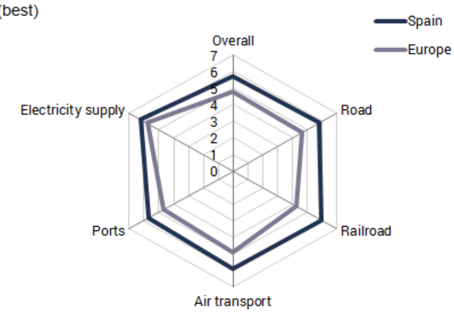
Percent of GDP



Source: Oxford Economics

Infrastructure quality

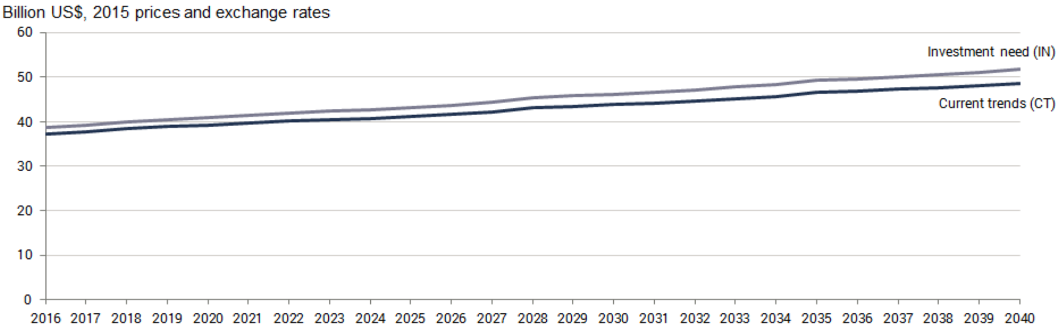
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

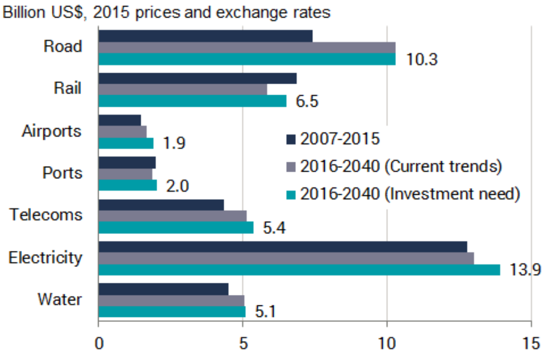
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

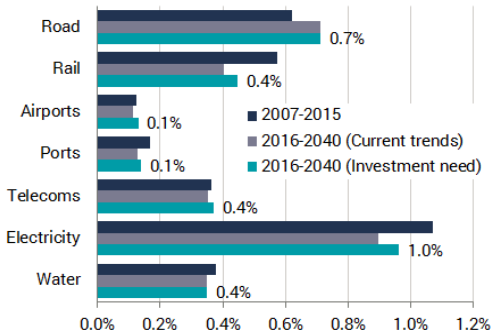
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	258	146	41	46	129	326	126	1,073
2016-2040 (Investment need)	258	163	47	51	135	349	127	1,129
2016-2040 (Gap between IN and CT)	0	16	6	4	6	23	1	57
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Tanzania

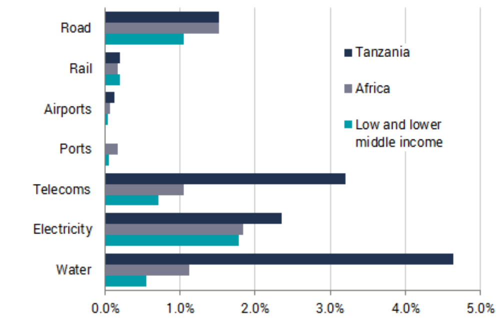
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	45	191	6.0%
GDP per head ($US)*	840	1,768	3.0%
Population (000s)	53,470	108,174	2.9%
Urban population (% of total)**	31.6%	55.1%	2.2%
Population density (persons per km2	60	122	2.9%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

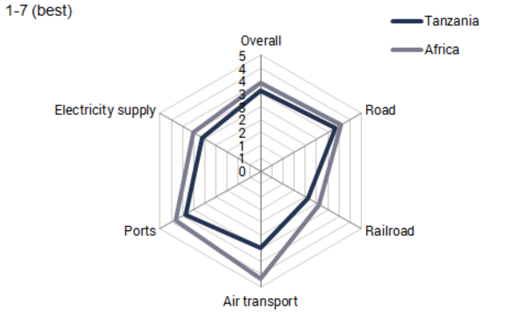
Percent of GDP



Source: Oxford Economics

Infrastructure quality

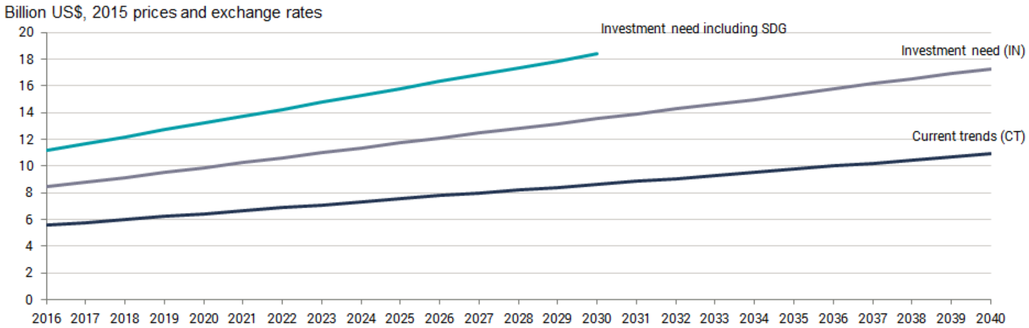
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

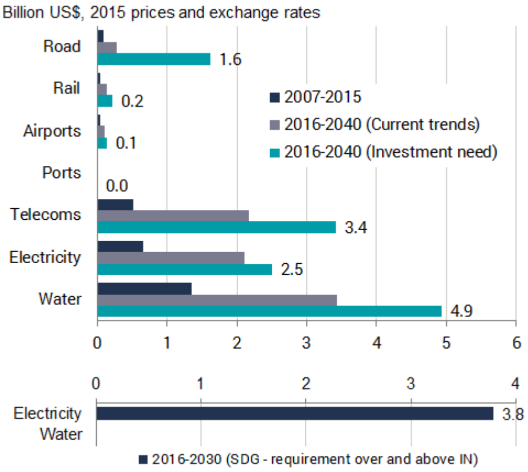
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

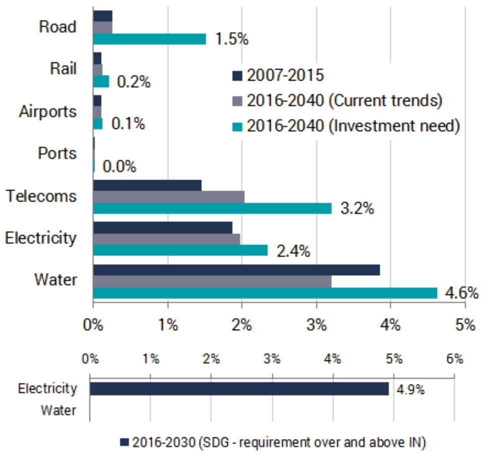
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	7	3	3	0	54	53	86	206
2016-2040 (Investment need)	40	6	3	0	85	63	124	321
2016-2040 (Gap between IN and CT)	34	2	1	0	31	10	38	115
2016-2030 (SDG - requirement over and above IN						57	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

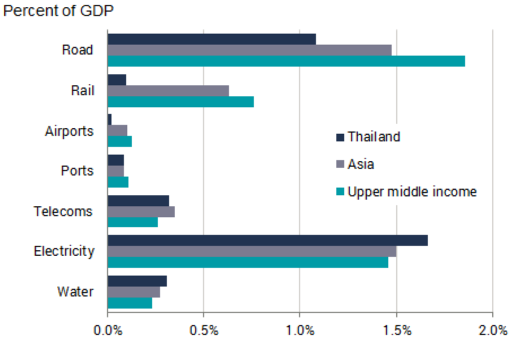
Thailand

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	396	679	2.2%
GDP per head ($US)*	5,819	10,258	2.3%
Population (000s)	67,982	66,152	-0.1%
Urban population (% of total)**	47.6%	55.8%	0.6%
Population density (persons per km2	133	129	-0.1%

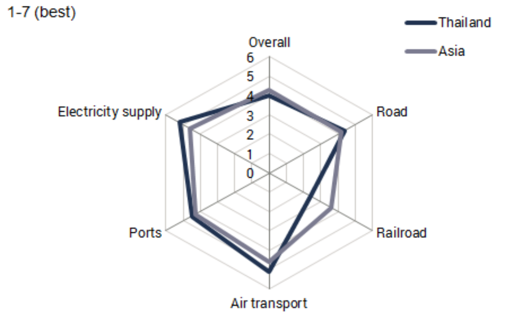
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



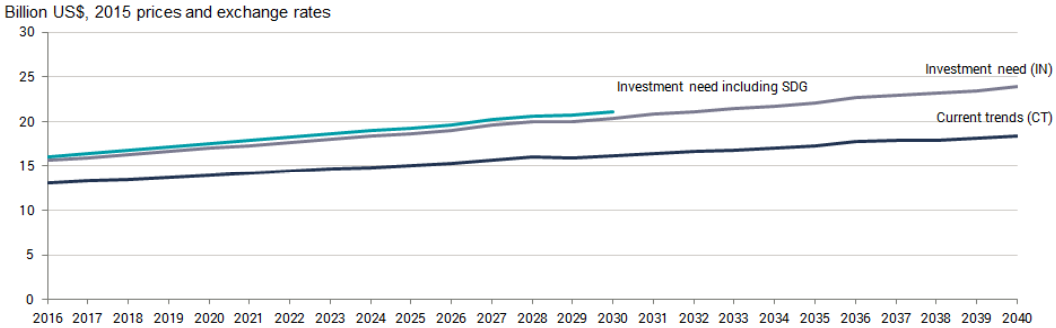
Source: Oxford Economics

Infrastructure quality



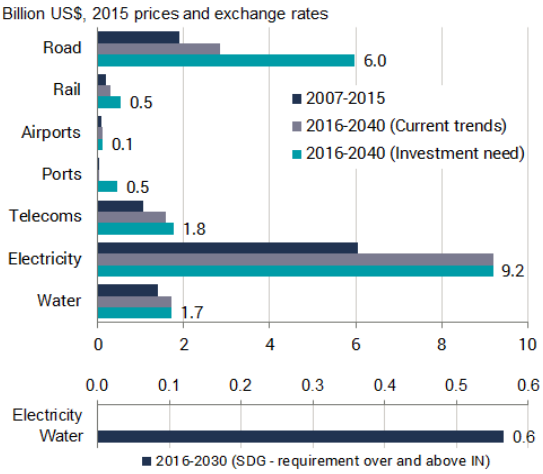
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

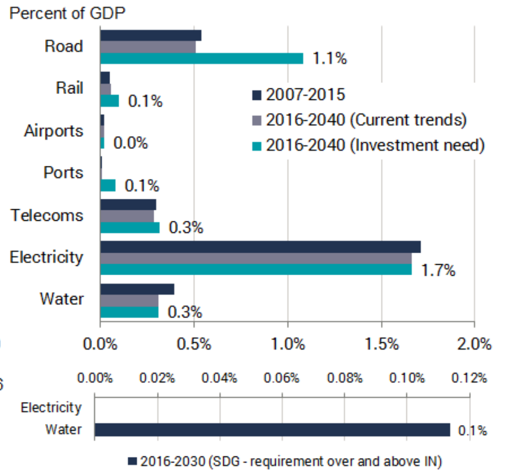


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	71	7	3	1	39	230	43	394
2016-2040 (Investment need)	149	14	3	12	44	230	43	494
2016-2040 (Gap between IN and CT)	79	6	0	11	5	0	0	100
2016-2030 (SDG - requirement over and above IN						0	8	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

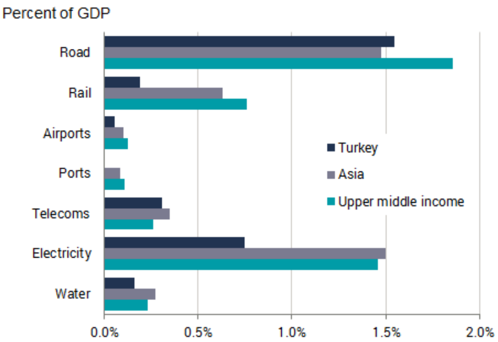
Turkey

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	858	1,829	3.1%
GDP per head ($US)*	10,887	19,711	2.4%
Population (000s)	78,781	92,795	0.7%
Urban population (% of total)**	73.9%	91.9%	0.9%
Population density (persons per km2	102	121	0.7%

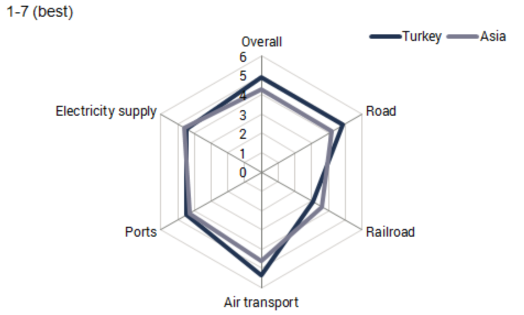
*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population

Infrastructure investment need, 2016-2040



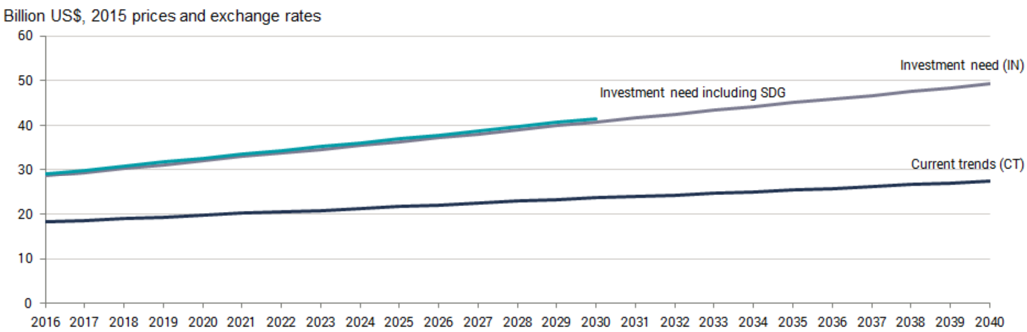
Source: Oxford Economics

Infrastructure quality



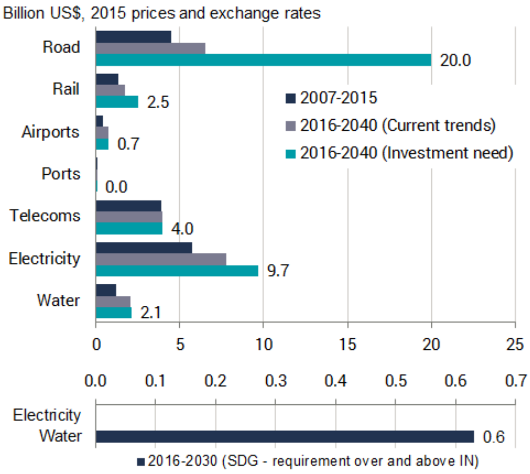
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

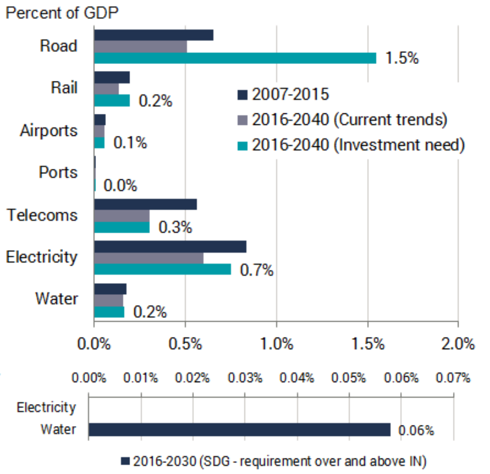


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	164	44	18	1	99	194	51	569
2016-2040 (Investment need)	499	63	18	1	99	242	53	975
2016-2040 (Gap between IN and CT)	335	19	1	0	0	48	2	405
2016-2030 (SDG - requirement over and above IN						0	9	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

United Kingdom

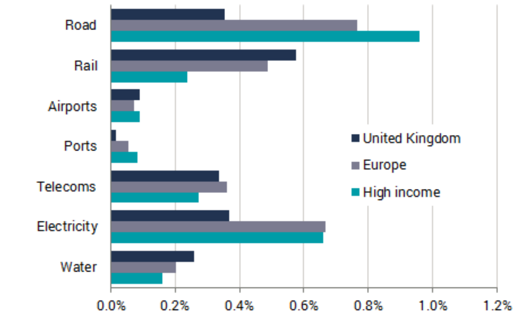
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	2,863	4,343	1.7%
GDP per head ($US)*	43,916	59,529	1.2%
Population (000s)	65,182	72,950	0.5%
Urban population (% of total)**	82.6%	85.3%	0.1%
Population density (persons per km2	269	302	0.5%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

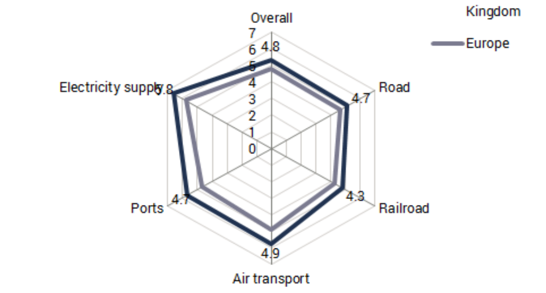
Percent of GDP



Source: Oxford Economics

Infrastructure quality

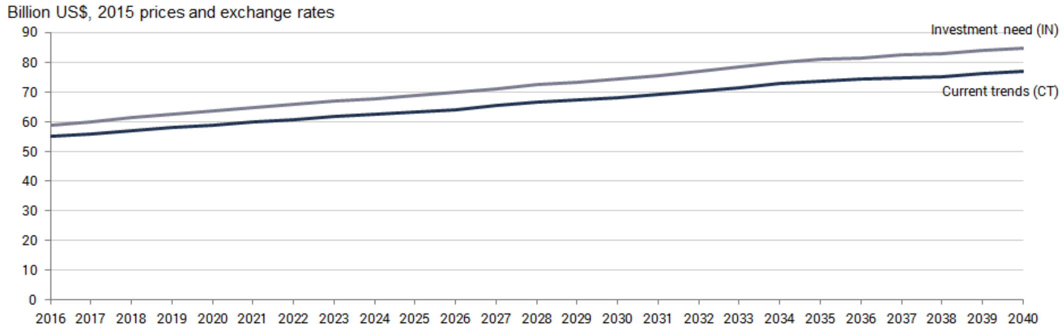
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

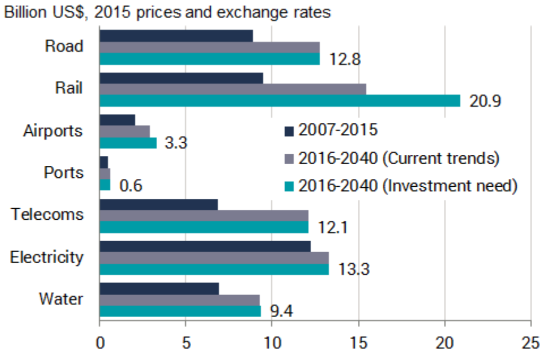
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

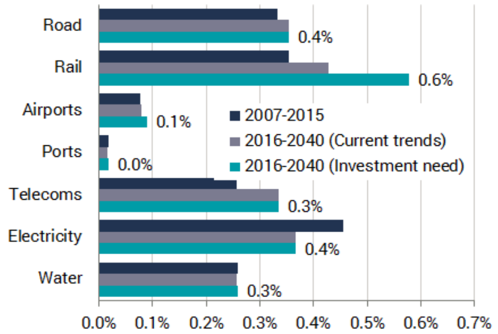
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	319	387	72	14	303	332	233	1,660
2016-2040 (Investment need)	320	523	82	16	303	332	234	1,809
2016-2040 (Gap between IN and CT)	0	136	10	1	0	0	1	148
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

United States

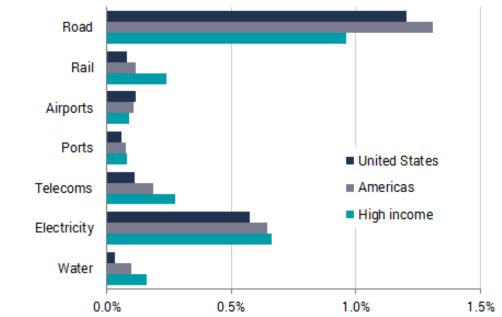
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	18,037	26,962	1.6%
GDP per head ($US)*	56,124	70,912	0.9%
Population (000s)	321,369	380,219	0.7%
Urban population (% of total)**	82.2%	91.3%	0.4%
Population density (persons per km2	35	42	0.7%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

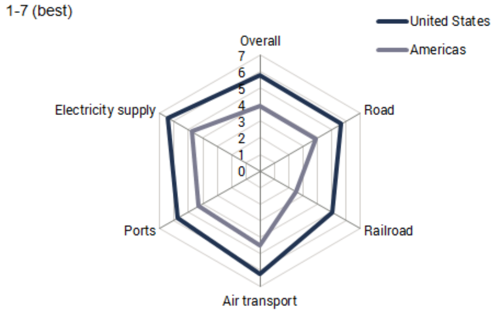
Percent of GDP



Source: Oxford Economics

Infrastructure quality

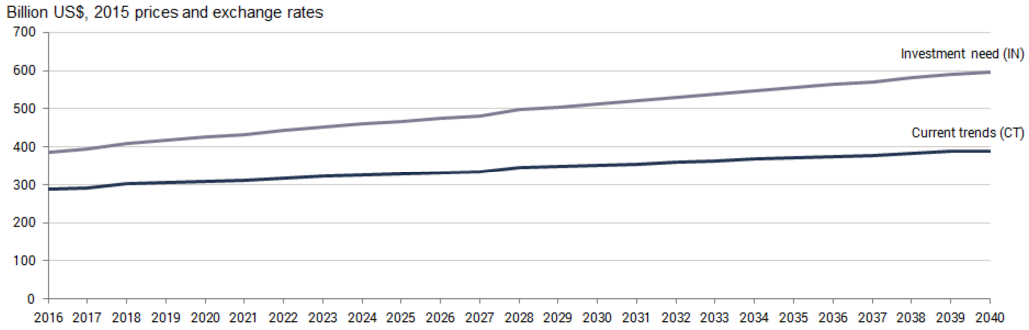
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

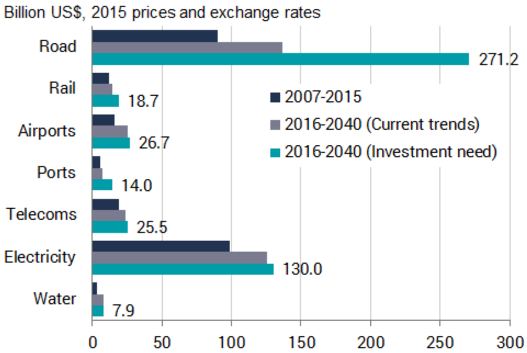
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

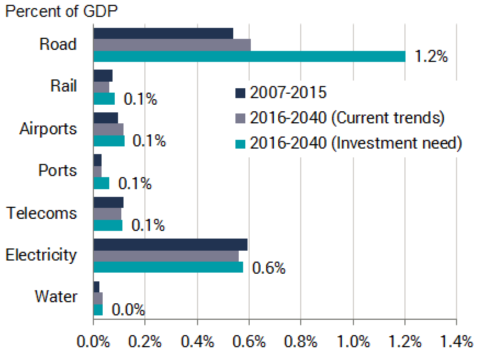
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	3,418	353	642	182	601	3,150	197	8,543
2016-2040 (Investment need)	6,779	469	667	350	636	3,251	198	12,351
2016-2040 (Gap between IN and CT)	3,361	116	26	168	35	100	2	3,808
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

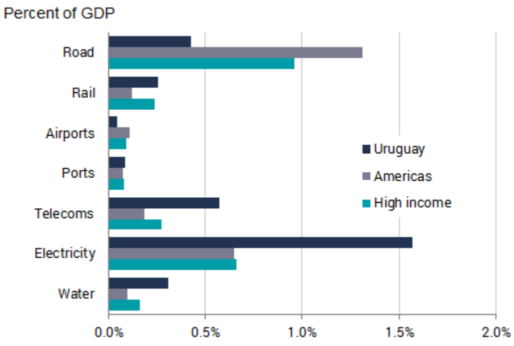
Uruguay

Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	53	95	2.3%
GDP per head ($US)*	15,572	25,989	2.1%
Population (000s)	3,432	3,653	0.2%
Urban population (% of total)**	95.3%	99.8%	0.2%
Population density (persons per km2	20	21	0.2%

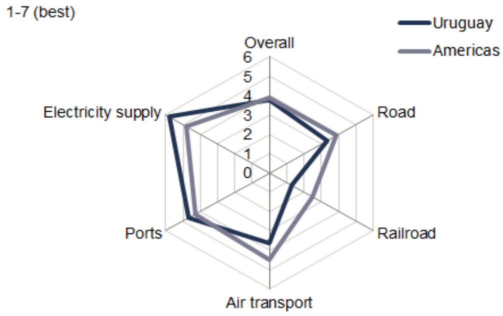
**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040



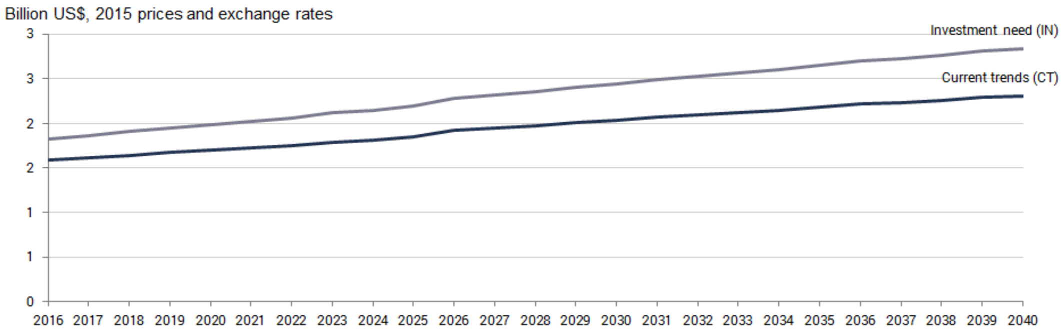
Source: Oxford Economics

Infrastructure quality



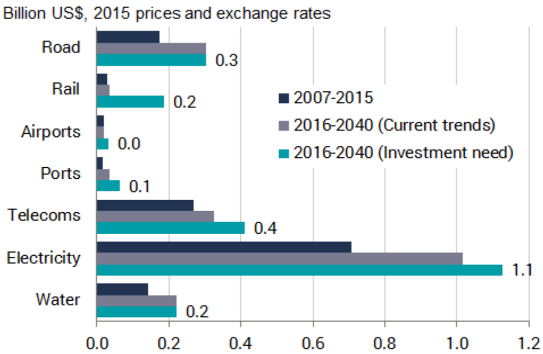
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

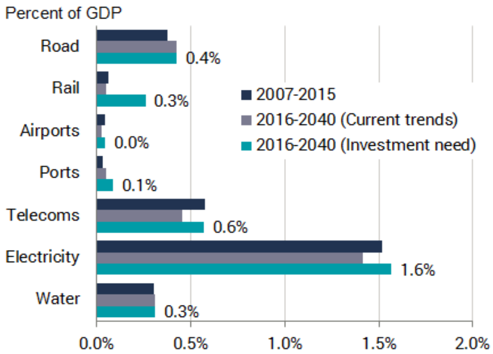


Source: Oxford Economics

Average annual investment



Infrastructure investment as a percentage of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	8	1	1	1	8	25	6	49
2016-2040 (Investment need)	8	5	1	2	10	28	6	59
2016-2040 (Gap between IN and CT)	0	4	0	1	2	3	0	10
2016-2030 (SDG - requirement over and above IN						0	0	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Vietnam

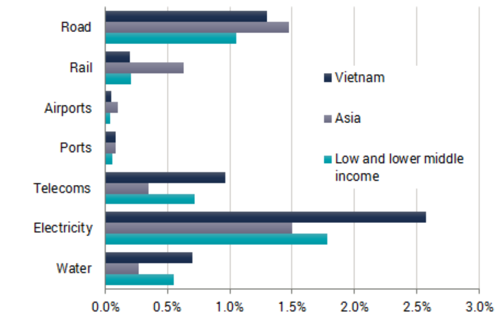
Key assumptions

	2015	2040	Av. annual growth
GDP (Billion $US)*	191	679	5.2%
GDP per head ($US)*	2,048	6,179	4.5%
Population (000s)	93,448	109,925	0.7%
Urban population (% of total)**	33.6%	49.3%	1.5%
Population density (persons per km2	301	355	0.7%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

Infrastructure investment need, 2016-2040

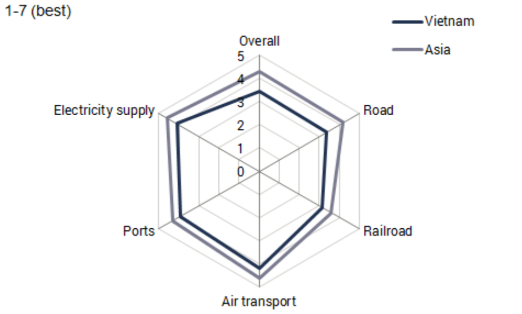
Percent of GDP



Source: Oxford Economics

Infrastructure quality

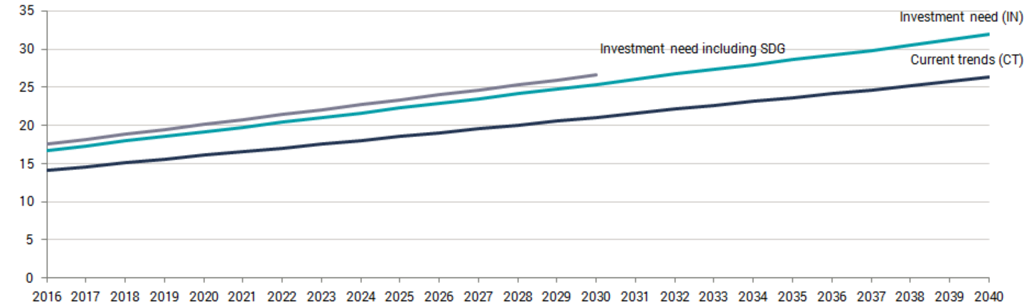
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

Total infrastructure investment 2016-40

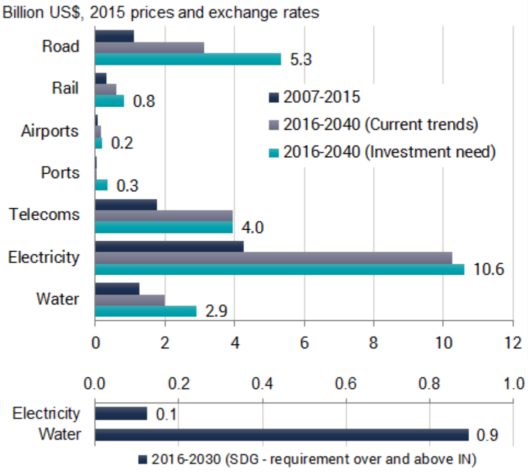
Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

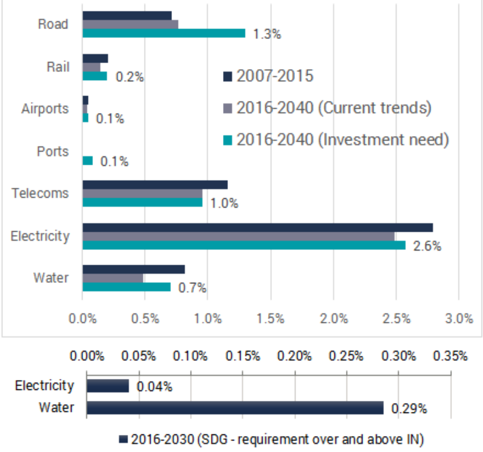
Average annual investment

Billion US$, 2015 prices and exchange rates



Infrastructure investment as a percentage of GDP

Percent of GDP



Cumulative infrastructure investment

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 (Current trends)	79	15	4	0	99	256	50	503
2016-2040 (Investment need)	134	21	5	9	99	265	72	605
2016-2040 (Gap between IN and CT)	55	6	1	8	0	9	23	102
2016-2030 (SDG - requirement over and above IN						2	13	

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

11. Technical appendix

11.1 DEFINITION OF INFRASTRUCTURE INVESTMENT

Our preferred definition of infrastructure investment is: "Gross Fixed Capital Formation (GFCF) by the public and private sectors on fixed, immovable assets that support long-term economic growth". GFCF is the measure of investment used to estimate GDP in national accounts. In addition to brand new investment, it includes replacement investment, and spending on maintenance where this will substantively extend the lifetime of an asset, but excludes land purchases. This concept is consistent with standard national accounting methodology adopted by most statistical agencies around the world.

While our definition of infrastructure spending is based on GFCF, infrastructure spending constitutes a subset of total GFCF in any economy in a given year. GFCF relating to non-fixed assets such as office equipment (computers and software) is generally excluded from our definition of infrastructure investment, as is GFCF relating to residential construction and other types of real estate such as office blocks. The term "gross" means that no adjustment is made for the depreciation of assets. Across the 50 countries in our study, estimated infrastructure spending across the seven sectors in our study is around 12 percent of total investment in 2015.

GFCF measures the cost of work done in any given year. For example, GFCF in the power generating industry would measure the investment in building a new power station, including the machinery and equipment needed to generate power. If the power station took five years to build and fit out, with an equal amount of spending in each year of the project, then the GFCF measure of investment would record a fifth of the total project amount per year over this period. This is different from the other principal approach to measuring investment in infrastructure, which is to measure the volume of deals agreed in any given year. Using the deals method in the example above, the investment would be recorded in the year the agreement to build the power station was signed, regardless of when (or indeed, even if) it was actually built.

Conceptually, these two approaches should be equal over the long run, assuming no projects are abandoned after being recorded. However, there will clearly be differences in the time profile of investment recorded. The case of an individual project has already been discussed, but the differences are also noticeable in aggregate. For example, deals typically pick up during periods of economic recovery, but dry up during recessions, and so can be highly cyclical. And even as deals pick up, the process of actually starting construction work may still lag behind. By contrast, GFCF numbers are not subject to the same uncertainty and volatility as deals data and so are better suited to the aims of the research.

It is important to note that while this is our *preferred* definition, it is necessary to collect data from a wide range of sources and definitions inevitably vary across those sources. Our objective in collecting data is therefore to identify the available data which align most closely with the definition above, but in the absence of a single consistent data source across countries and sectors it is not possible to obtain data fully aligned with our preferred definition in all cases.

11.2 DATA SOURCES

Overview

The main challenge when undertaking analysis of infrastructure spending across countries and sectors is the lack of a single and consistent dataset. While certain data sources provide information for some countries and some sectors, none cover all 50 countries and all seven sectors included in this study. We therefore undertook a comprehensive exercise to identify the best available sources of infrastructure spending for each country and sector. Nonetheless, we were forced to rely on data of variable quality, which have often been collected using different definitions and approaches.

One way to overcome such challenges is to undertake a detailed 'bottom-up' assessment on a country-by-country basis. This might involve some element of consultation with stakeholders, construction of a pipeline of past and future schemes, and the use of published (and sometimes unpublished) data. However, such an approach is extremely resource intensive, particularly for large countries, and is not well suited to a study that covers a large number of countries and sectors.

We therefore take a primarily 'top-down' approach which makes the fullest possible use of existing cross-country datasets from sources such as the OECD, INFRALATAM and Eurostat. However, such sources only provide a small amount of the coverage we required to study seven sectors across 50 countries. We have filled gaps using data from national statistics agencies and major infrastructure companies and, where no data source could be identified, we used econometric estimation to impute values. In total we have collected data from around 50 sources. Even where high-quality data do exist, time series are typically short and it was often necessary to estimate missing values. The combined effect of these challenges means that the final dataset contains a large degree of 'noise', which is unavoidable when bringing together information from different sources and applying estimation techniques. This means that the historic and forecast estimates of infrastructure investment should be treated with a degree of caution, particularly in areas where data are poorest.

The sources and techniques applied to collect and manipulate the data into a consistent format are described in the following sections. In some cases, no data sources could be identified and values were estimated through econometric estimation. Our approach to this is described later in this section.

Most data were collected during the second half of 2016, and so reflect the latest values available at that time. The most up-to-date datasets collected provided values to 2015, so 2016 is the first forecast year within our modelling.

We concur with the recommendation of the Asian Development Bank who suggest that "a concerted effort is needed to better measure and track infrastructure investments."[52] We hope that by presenting the best information we could identify for each country and sector we will stimulate discussion and debate, and possibly lead to other data sources being suggested and made available. The framework we have developed can be updated and refined as new, and hopefully improved, data become available.

Sources

We used data from respected international data sources as far as possible, for reasons of both consistency and efficiency. However, the coverage of such databases is often limited, particularly away from developed countries. National government sources were, as far as possible, used where international data were not available.

For a large proportion of country/sector combinations data on infrastructure investment are not readily available. Our objective within the data collection process was therefore to identify a series for each country and sector which is as similar as possible to our definition of infrastructure investment. To do this we worked down the hierarchy below until we identified a suitable source:

(1) **Best:** data from an international source such as the OECD, INFRALATAM, Eurostat, etc.

(2) **Next best:** data from a national statistics agency on infrastructure or fixed capital investment in the relevant sector.[53]

(3) **Next best:** for markets where a single provider accounts for a large share of the market we searched for company accounts data on investment in fixed assets by that provider.

(4) **Next best:** World Bank Private Participation in Infrastructure data (see box below).

(5) **No data identified:** stock values are estimated using econometric estimation. These are incorporated into a perpetual inventory model to estimate historic spending.

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[52] Asian Development Bank, *Meeting Asia's Infrastructure Needs* (Manila, 2017), pp.85.

[53] For certain countries we rely on data relating to total investment in the electricity and water sectors. This is likely to over-estimate infrastructure spending since it will include some degree of non-infrastructure capital expenditures. However, we took the view that this information is likely to provide the best available approximation in the absence of information which would permit infrastructure expenditures to be separately identified.

An important objective of this study is to publish the data set on a public website. Our data search was therefore constrained to published sources. Whilst we are aware that authors of some previous studies have managed to secure unpublished national accounts data for their work, for this study it was judged that few statistical agencies would be willing to share previously unpublished data and such an approach would be unlikely to justify the time required.

Where data series could be identified, further manipulation was often required to fill gaps in those series, obtain sufficiently long time series for use in the perpetual inventory models, or obtain a better alignment with our preferred definition. The main adjustment strategies we applied were as follows:

- interpolation, to fill gaps within data series;
- forecasting and back-casting to develop longer time series. To do this we assumed that infrastructure investment in the respective sector as a proportion of total GFCF remained at its average level in the missing years. GFCF data are usually available for a longer time series than infrastructure investment data, so we could multiply GFCF by the average share of infrastructure spending to extend the available infrastructure spending series backwards or forwards; and
- use of a secondary data source to attribute data for a broader sector to align with our preferred definition. In some countries we were able to obtain data for investment in the utilities sector rather than electricity or water. In such cases we search for some other data source which allows us to apportion utilities investment into the more detailed sectors, such as GVA by sector. If that tells us that electricity accounts for 60 percent of GVA in the utilities sector, say, then we allocate 60 percent of utilities investment to electricity.

OUR USE OF THE WORLD BANK PRIVATE PARTICIPATION IN INFRASTRUCTURE DATABASE

In some cases the only data identified are from the World Bank Private Participation in Infrastructure (PPI) database. These data relate to infrastructure investment, but exclude projects which are purely public. This raised the question of whether it would be possible to uplift the PPI data to adjust for the missing public element. However, based on analysis of INFRALATAM data (one of the few datasets which allows us to separately identify public and private investment) for Latin American countries, we find that the ratio between public and private investment can vary significantly between countries and sectors. It is also questionable whether Latin American countries represent a suitable proxy for upscaling estimates in regions such as Africa or Asia. We therefore decided that the PPI database was not suitable for our purposes in most cases, since it would lead to the systematic under-estimation of spending in countries and sectors where it was used.

An important exception is the telecommunications sector, where we believe it likely that most infrastructure investment has some degree of private sector involvement. For this sector we therefore assume that the PPI results are a reasonable proxy for the entire infrastructure market.[54]

Following the data collection and cleaning process, we categorised the data collected for each country and sector as green, amber or grey, based on the following typology:

- **Green (high quality):** data on historical spending available from an official source (national statistics or an international organisation). Some estimation and interpolation may be necessary to develop a full time series.
- **Amber (medium quality):** some relevant data identified, but the definition does not align well with our needs, the time series may be patchy or very short, or we may need to apply some sort of manipulation to produce an estimate of infrastructure investment. Substantial estimation is required.
- **Grey (no suitable data identified):** very little or no official data available. Historical time series estimated using econometric estimation.

We strongly recommend that users refer to these ratings when undertaking their own analysis of the data. The tables below summarise the source and quality of data identified for each country and sector.

[54] While the PPI dataset appears to be the best available source of data on telecoms infrastructure investment in a number of countries, stakeholders have noted that the data series should be interpreted with a degree of caution due to changes in the methodology over time.

*Fig. 80. Detailed list of data sources: **road***

Angola	Econometric estimate
Argentina	International Road Federation, 2004-2007, Road construction spend
Australia	OECD, 1995-2014, Road infrastructure investment
Azerbaijan	OECD, 1995-2014, Road infrastructure investment
Bangladesh	Econometric estimate
Brazil	INFRALATAM, 2008-2013, Total investment in road infrastructure
Cambodia	Econometric estimate
Canada	OECD, 2000-2014, Road infrastructure investment
Chile	INFRALATAM, 2008-2013, Total investment in road infrastructure
China	Ministry of Transport, 2001-2015, Highway transportation investment in fixed assets completion
Colombia	INFRALATAM, 2008-2013, Total investment in road infrastructure
Croatia	OECD, 1995-2014, Road infrastructure investment
Ecuador	International Road Federation, 2000-14 (selected years), Road construction spend
Egypt	IRF, 2008-2010, Road construction spend
Ethiopia	International Road Federation 2000-2003, World Bank Ethiopia Public Expenditure Review 2007-2013, Road capital expenditure
France	OECD, 1995-2014, Road infrastructure investment
Germany	OECD, 1995-2014, Road infrastructure investment
India	OECD, 2004-2014, Road infrastructure investment
Indonesia	World Bank "Investing in Indonesia's Roads", 1994-2009, Investment in roads
Italy	OECD, 1995-2013, Road infrastructure investment
Japan	OECD, 1995-2012, Road infrastructure investment
Jordan	Econometric estimate
Kazakhstan	International Road Federation, 2009-11, Road construction spend
Kenya	Ministry of Transport and Infrastructure, 2006-2012, Development expenditure on roads
Malaysia	Econometric estimate
Mexico	OECD, 1995-2013, Road infrastructure investment
Morocco	Econometric estimate
Myanmar	Ministry of Rail Transportation, Myanmar Railways, 2009 to 2013 Road infrastructure investment
New Zealand	OECD, 1995-2014, Road infrastructure investment
Nigeria	Econometric estimate
Pakistan	Econometric estimate
Paraguay	INFRALATAM, 2008-2013, Public investment in road infrastructure
Peru	INFRALATAM, 2008-2013, Total investment in road infrastructure
Philippines	International Road Federation, 2010-13, Road construction spend
Poland	OECD, 1995-2013, Road infrastructure investment
Romania	OECD, 1995-2014, Road infrastructure investment
Russia	OECD, 1995-2013, Road infrastructure investment
Saudi Arabia	Econometric estimate

Senegal	Econometric estimate
Singapore	International Road Federation, 2003-06 with gaps, Road construction spend
South Africa	International Road Federation, 2004-14 with gaps, Road construction spend
South Korea	OECD, 2001-2013, Road infrastructure investment
Spain	OECD, 1995-2014, Road infrastructure investment
Tanzania	National Statistics, 2001-2013, Gross fixed capital formation for roads and bridges
Thailand	Econometric estimate
Turkey	OECD, 1995-2014, Road infrastructure investment
United Kingdom	OECD, 1995-2014, Road infrastructure investment
United States	OECD, 1995-2014, Road infrastructure investment
Uruguay	INFRALATAM, 2008-2013, Public investment in road infrastructure
Vietnam	Econometric estimate

Fig. 81. Detailed list of data sources: ***rail***

Angola	Econometric estimate
Argentina	Econometric estimate
Australia	OECD, 1995-2014, Rail infrastructure investment
Azerbaijan	OECD, 1999-2014, Rail infrastructure investment
Bangladesh	Econometric estimate
Brazil	INFRALATAM, 2008-2013, Total investment in rail infrastructure
Cambodia	Econometric estimate
Canada	OECD, 1995-2013, Rail infrastructure investment
Chile	INFRALATAM, 2008-2013, Public investment in rail infrastructure
China	National Statistics, 1995-2014, Investment in fixed assets in railway transport
Colombia	INFRALATAM, 2008-2013, Total investment in rail infrastructure
Croatia	OECD, 1995-2014, Rail infrastructure investment
Ecuador	Econometric estimate
Egypt	Econometric estimate
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2005-2012, ERC capital spend
France	OECD, 1995-2014, Rail infrastructure investment
Germany	OECD, 1995-2014, Rail infrastructure investment
India	OECD, 2004-2014, Rail infrastructure investment
Indonesia	Kereta Api Railway annual reports, 2010-2015, Additions to fixed assets
Italy	OECD, 1995-2013, Rail infrastructure investment
Japan	OECD, 1995-2013, Rail infrastructure investment
Jordan	Econometric estimate
Kazakhstan	International Railway Statistics (Published by the UIC), 2008-2010, Railway investment - infrastructure sector
Kenya	Econometric estimate
Malaysia	Econometric estimate
Mexico	OECD, 1995-2013, Rail infrastructure investment
Morocco	Econometric estimate
Myanmar	Ministry of Rail Transportation, Myanmar Railways, 2009-2013, Railway infrastructure investment
New Zealand	KIWI Rail annual reports, 2007-2013, Additions to railway infrastructure
Nigeria	Econometric estimate
Pakistan	National Statistics, 2006-2016, Gross fixed capital formation in railways, public & general government sectors
Paraguay	Econometric estimate
Peru	INFRALATAM, 2008-2013, Total investment in rail infrastructure
Philippines	Econometric estimate
Poland	OECD, 1995-2013, Rail infrastructure investment
Romania	OECD, 1995-2014, Rail infrastructure investment
Russia	OECD, 1995-2013, Rail infrastructure investment
Saudi Arabia	Econometric estimate

Senegal	Econometric estimate
Singapore	SMRT Corporation, 2001-2016, Capital Expenditure on Rail
South Africa	Econometric estimate
South Korea	OECD, 2001-2013, Rail infrastructure investment
Spain	OECD, 1995-2014, Rail infrastructure investment
Tanzania	Econometric estimate
Thailand	Econometric estimate
Turkey	OECD, 1995-2014, Rail infrastructure investment
United Kingdom	OECD, 1995-2014, Rail infrastructure investment
United States	OECD, 1995-2014, Rail infrastructure investment
Uruguay	Econometric estimate
Vietnam	Econometric estimate

Fig. 82. Detailed list of data sources: ***airports***

Angola	Econometric estimate
Argentina	Econometric estimate
Australia	Australian Department of Infrastructure and Transport and Australian Competition and Consumer Commission, 1998-2015, Investment in airport infrastructure
Azerbaijan	OECD, 1995-2010, Airport infrastructure investment
Bangladesh	Econometric estimate
Brazil	INFRALATAM, 2008-2013, Total investment in airport infrastructure
Cambodia	Econometric estimate
Canada	OECD, 1995-2013, Airport infrastructure investment
Chile	INFRALATAM, 2008-2013, Total investment in airport infrastructure
China	Civil Aviation Administration of China, 2006-2015, Construction of Airports
Colombia	INFRALATAM, 2008-2013, Total investment in airport infrastructure
Croatia	OECD, 1995-2014, Airport infrastructure investment
Ecuador	Econometric estimate
Egypt	Econometric estimate
Ethiopia	Estimated from web research of major investments
France	OECD, 1995-2014, Airport infrastructure investment
Germany	OECD, 1995-2014, Airport infrastructure investment
India	OECD, 1995-2013, Airport infrastructure investment
Indonesia	Angkasa Pura 1 & 2 annual reports, 2007-2015, Additions to fixed assets
Italy	OECD, 1995-2013, Airport infrastructure investment
Japan	OECD, 1996-2013, Airport infrastructure investment
Jordan	Econometric estimate
Kazakhstan	Econometric estimate
Kenya	Econometric estimate
Malaysia	Malaysia Airport, 2006-2015, Additions of property and buildings and capital work in progress
Mexico	OECD, 1995-2013, Airport infrastructure investment
Morocco	Econometric estimate
Myanmar	Econometric estimate
New Zealand	Commerce Commission New Zealand, 2011-2015, Capital expenditure (unallocated works under construction)
Nigeria	Econometric estimate
Pakistan	Econometric estimate
Paraguay	INFRALATAM, 2008-2013, Public investment in airport infrastructure
Peru	INFRALATAM, 2008-2013, Total investment in airport infrastructure
Philippines	National Statistics, 2001-2005 (3 data points),Gross additions to fixed assets in the air transport industry
Poland	OECD, 1995-2013, Airport infrastructure investment
Romania	OECD, 1995-2014, Airport infrastructure investment
Russia	OECD, 1995-2013, Airport infrastructure investment

Saudi Arabia	Econometric estimate
Senegal	Econometric estimate
Singapore	Changi airport annual reports, 2010-2015, Additions to runways, taxiway, capital improvements and work-in-progress
South Africa	Econometric estimate
South Korea	OECD, 2001-2008, Airport infrastructure investment
Spain	OECD, 1995-2013, Airport infrastructure investment
Tanzania	Econometric estimate
Thailand	Airports of Thailand, 2006-2014, Additions to buildings, construction, landscape architecture and assets under construction
Turkey	OECD, 1995-2014, Airport infrastructure investment
United Kingdom	OECD, 1995-2005, Airport infrastructure investment
United States	OECD, 1995-2003, Airport infrastructure investment
Uruguay	Econometric estimate
Vietnam	Econometric estimate

*Fig. 83. Detailed list of data sources: **ports***

Angola	Econometric estimate
Argentina	Econometric estimate
Australia	OECD, 2005-2014, Port Infrastructure investment
Azerbaijan	OECD, 2011-2014, Port infrastructure investment
Bangladesh	Econometric estimate
Brazil	INFRALATAM, 2008-2013, Total investment in port infrastructure
Cambodia	Econometric estimate
Canada	OECD, 1995-2013, Port infrastructure investment
Chile	INFRALATAM, 2008-2013, Total investment in port infrastructure
China	China Ministry of Transport, 2003-2015, Water transportation investment in fixed assets completion
Colombia	INFRALATAM, 2008-2013, Total investment in port infrastructure
Croatia	OECD, 1995-2014, Port infrastructure investment
Ecuador	Econometric estimate
Egypt	Econometric estimate
Ethiopia	NA
France	OECD, 1995-2013, Port infrastructure investment
Germany	OECD, 1995-2013, Port infrastructure investment
India	OECD, 2004-2014, Port infrastructure investment
Indonesia	IPC annual reports, 2007-2015, Additions of fixed assets
Italy	OECD, 1995-2013, Port infrastructure investment
Japan	OECD, 2002-2013, Port infrastructure investment
Jordan	Econometric estimate
Kazakhstan	Econometric estimate
Kenya	Econometric estimate
Malaysia	Econometric estimate
Mexico	OECD, 1995-2013, Port infrastructure investment
Morocco	Econometric estimate
Myanmar	Econometric estimate
New Zealand	NZ Port Yearbook, 2012-2015, Investment by ports in New Zealand
Nigeria	WB PPI, 2005-2013, Investment in seaports with private participation
Pakistan	Econometric estimate
Paraguay	NA
Peru	INFRALATAM, 2008-2013, Total investment in port infrastructure
Philippines	Philippine Port Authority, 2006-2013, Addition to Construction in Progress
Poland	OECD, 1995-2013, Port infrastructure investment
Romania	Port Constanza, 2006-2013, Infrastructure, superstructure and equipment investment
Russia	OECD, 1995-2013, Port infrastructure investment
Saudi Arabia	Econometric estimate
Senegal	Econometric estimate
Singapore	Econometric estimate

South Africa	Econometric estimate
South Korea	OECD, 2001-2008, Port infrastructure investment
Spain	OECD, 1995-2013, Port infrastructure investment
Tanzania	Tanzania Port Authority, 2006-2014, Acquisition of property, plant and equipment
Thailand	Econometric estimate
Turkey	OECD, 1995-2014, Port infrastructure investment
United Kingdom	OECD, 1995-2005, Port infrastructure investment
United States	Econometric estimate
Uruguay	Administración Nacional de Puertos, 2003-2013, Increases to infrastructure work
Vietnam	Econometric estimate

Fig. 84. Detailed list of data sources: ***electricity***

Angola	Econometric estimate
Argentina	INFRALATAM, 2008-2013, Investment in Electricity Infrastructure
Australia	Annual Business Survey, 1986-2014, Energy infrastructure engineering construction work: Electricity generation, transmission and distribution
Azerbaijan	National Statistics, 1998-2013, Investment directed to fixed capital by electric power generation, transmission and distribution
Bangladesh	Econometric estimate
Brazil	INFRALATAM, 2008-2013, Total investment in electricity infrastructure
Cambodia	Econometric estimate
Canada	National Statistics CANSIM, 2006-2014, Capital expenditures on electric power infrastructure
Chile	WB PPI, 1986-2015, Total investment in electricity infrastructure
China	National Statistics, 1995-2014, Investment in fixed assets in the production and supply of electric power and heat power
Colombia	INFRALATAM, 2008-2013, Investment in electricity infrastructure
Croatia	EUROSTAT, 2008-2014, Gross investment in tangible goods, existing buildings and structures, construction and alteration of buildings, machinery and equipment in electric power generation, transmission and distribution
Ecuador	INFRALATAM, 2008-2013, Investment in electricity infrastructure
Egypt	World Bank "Infrastructure and Economic Growth in Egypt", 1983-2007, Electricity infrastructure investment
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2004-12, EEPCO capital spend
France	EUROSTAT, 2009-2014, Gross investment in tangible goods, existing buildings and structures, construction and alteration of buildings, machinery and equipment in electric power generation, transmission and distribution
Germany	National Statistics, 1980-2014, Investment in electric power generation, transmission and distribution
India	World Input Output Database and Second Report of the High Level Committee for Financing of Infrastructure, 1995-2009, GFCF in electricity
Indonesia	Estimated from World Input Output Database and National Statistics, 1995-2014, Investment in electricity
Italy	EUROSTAT, 1995-2014, Gross investment in tangible goods, existing buildings and structures, construction and alteration of buildings, machinery and equipment in electric power generation, transmission and distribution
Japan	Ministry of Economy, Trade and Industry, 1986-2015, Investment in electric power generation and distribution
Jordan	Econometric estimate
Kazakhstan	Econometric estimate
Kenya	KenGen and Kenya Power annual reports, 2002-2013, Purchase of property, plant and equipment
Malaysia	Econometric estimate
Mexico	INFRALATAM, 2008-2013, Investment in electricity infrastructure
Morocco	Econometric estimate
Myanmar	National Statistics, 2005-2014, Total investment in power

New Zealand	National Statistics, 1987-2013, Gross fixed capital formation in electricity
Nigeria	World Bank, 2001-2005, Capital expenditure on power sector
Pakistan	National Statistics, 2006-2016, GFCF in electricity generation and distribution
Paraguay	INFRALATAM, 2008-2013, Investment in electricity infrastructure
Peru	INFRALATAM, 2008-2013, Investment in electricity infrastructure
Philippines	Econometric estimate
Poland	Eurostat 2008-2014 and Central Statistical Office 1995-2007, Gross investment in tangible goods, existing buildings and structures, construction and alteration of buildings, machinery and equipment in electric power generation, transmission and distribution
Romania	Econometric estimate
Russia	National Statistics, 1994-2015, Fixed capital investment in electricity
Saudi Arabia	Saudi Electricity, 2006-2013, Additions to fixed assets
Senegal	World Bank, 2001-2005, Capital expenditure on power sector
Singapore	Singapore power, 2010-2014, Additions to property, plant and equipment, plus construction in progress
South Africa	ESKOM, 2002-2015, Eskom's capital expenditure
South Korea	Bank of Korea, 1980-2014, Gross Capital Formation in electricity
Spain	EUROSTAT, 1995-2014, Gross investment in tangible goods, existing buildings and structures, construction and alteration of buildings, machinery and equipment in electric power generation, transmission and distribution
Tanzania	World Bank, 2001-2005, Capital expenditure on power sector
Thailand	Econometric estimate
Turkey	National Statistics, 2009-2013, Gross investment in tangible assets in electric power generation, transmission and distribution
United Kingdom	National Statistics, 2006-2015, Capital expenditure in electricity
United States	OECD and US Capital Expenditure Survey, 1980-2014, GFCF in electricity and steam air
Uruguay	INFRALATAM, 2008-2013, Investment in electricity infrastructure
Vietnam	National Statistics, 1995-2014, Investment in electricity, gas, steam and air conditioning supply

Fig. 85. *Detailed list of data sources:* ***water***

Angola	Econometric estimate
Argentina	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Australia	Annual Business Survey, 1986-2014, Water infrastructure engineering construction work done
Azerbaijan	National Statistics, 1998-2013, Investment directed to fixed capital by water
Bangladesh	Econometric estimate
Brazil	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Cambodia	Econometric estimate
Canada	National Statistics and OECD STAN, 1980-2014, Capital expenditures on waterworks infrastructure and sewage infrastructure
Chile	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
China	National Statistics, 1995-2014, Investment in fixed assets in the production and distribution of water
Colombia	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Croatia	National Statistics, 2010-2015, Gross fixed capital formation in water supply and sewerage
Ecuador	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Egypt	Econometric estimate
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2008-12, Water supply and sanitation capital expenditure
France	National Statistics and Eurostat, 1980-2014, GFCF by water supply and sewerage sector
Germany	National Statistics, 1980-2014, Investment in water collection, treatment and supply
India	World Input Output Database and National Statistics, 1995-2009, GFCF in water
Indonesia	World Input Output Database and National Statistics, 1995-2014, GFCF in water supply
Italy	ISTAT, Eurostat, 1992-2014, GFCF in water supply, sewerage
Japan	Oxford Economics Industry Database, Japan National Statistics input-output table, investment in water
Jordan	Econometric estimate
Kazakhstan	Econometric estimate
Kenya	Kenya Ministry of Devolution and Planning, "Comprehensive Public Expenditure Review", 2009-11, Water capital expenditure
Malaysia	Econometric estimate
Mexico	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Morocco	Econometric estimate
Myanmar	Econometric estimate
New Zealand	National Statistics and Eurostat, 1987-2012, Gross fixed capital formation in water, sewerage, drainage
Nigeria	Econometric estimate
Pakistan	Econometric estimate
Paraguay	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Peru	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure

Philippines	Econometric estimate
Poland	Eurostat Structural Business Statistics and Central Statistics Office, 1995-2014, Gross investment in tangible goods, existing buildings and structures, construction and alteration of buildings, machinery and equipment in water supply and sewerage
Romania	Econometric estimate
Russia	National Statistics, 1994-2015, Fixed investment in water supply
Saudi Arabia	Econometric estimate
Senegal	Econometric estimate
Singapore	National Water Agency, 2005-2014, Capital expenditure by private sector and government
South Africa	National Statistics, 2014-2016, Capital expenditure actual and expected in water, sewerage and sanitation
South Korea	Bank of Korea, 1980-2014, Gross Capital Formation in water
Spain	EUROSTAT, 1995-2013, Gross fixed capital formation in water
Tanzania	National Statistics Office, 2001-2013, Gross Fixed Capital Formation in water
Thailand	Econometric estimate
Turkey	National Statistics and Eurostat, 2009-2013, Gross investment in tangible assets in water supply, sewerage
United Kingdom	OECD and Eurostat, 1997-2015, Gross fixed capital investment in water and sewerage
United States	OECD and EUROSTAT, 1980-2014, GFCF in water and sewerage
Uruguay	INFRALATAM, 2008-2013, Investment in water and sanitation infrastructure
Vietnam	National Statistics, 1995-2014, Investment in water supply, sewerage, waste management and remediation activities

Fig. 86. Detailed list of data sources: ***telecoms***

Angola	World Bank PPI, 2001-2012, Investment in telecommunications with private participation
Argentina	INFRALATAM, 2008-2013, Investment in telecommunications infrastructure
Australia	Annual Business Survey, 1986-2014, Telecommunications infrastructure engineering construction work done
Azerbaijan	National Statistics, 1998-2013, Investment directed to fixed capital by communications
Bangladesh	World Bank PPI, 1990-2014, Investment in telecommunications with private participation
Brazil	World Bank PPI, 1994-2014, Investment in telecommunications infrastructure with private participation
Cambodia	World Bank PPI, 1992-2014, Investment in telecommunications with private participation
Canada	National Statistics, 2006-2014, Capital expenditures on communications networks
Chile	World Bank PPI, 1982-2014, Investment in telecommunication infrastructure with private participation
China	National Statistics, 1995-2014, Investment in fixed assets in telecommunications and other information transmission services
Colombia	INFRALATAM, 2008-2013, Investment in telecommunications infrastructure
Croatia	National Statistics, 2010-2015, Gross fixed capital formation in information and communications
Ecuador	World Bank PPI, 1994-2015, Investment in telecommunications with private participation
Egypt	World Bank PPI, 1998-2014, Investment in telecommunications with private participation
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2004-2012, ETC capital spend
France	Eurostat, 1980-2014, GFCF by telecom sector
Germany	Eurostat, 1995-2013, GFCF by telecoms sector
India	World Bank PPI, 1993-2014, Investment in telecommunications with private participation
Indonesia	World Bank PPI, 1993-2014, Investment in telecommunications with private participation
Italy	Eurostat and OECD STAN, 1992-2014, Investment in telecommunications infrastructure
Japan	Oxford Economics Industry Database and Japan National Statistics input-output table, 1980-2014, Investment in information and communication
Jordan	World Bank PPI, 1994-2015, Investment in telecommunications infrastructure with private participation
Kazakhstan	World Bank PPI, 1994-2014, Investment in telecommunications infrastructure with private participation
Kenya	World Bank PPI, 1999-2014, Investment in telecommunications with private participation
Malaysia	World Bank PPI, 1989-2014, Investment in telecommunications infrastructure
Mexico	World Bank PPI, 1990-2014, Investment in telecommunications with private participation

Morocco	World Bank PPI, 1999-2015, Investment in telecommunications with private participation
Myanmar	Econometric estimate
New Zealand	National Statistics, 1987-2012, Gross fixed capital formation in telecommunications, internet and library services
Nigeria	World Bank PPI, 1997-2014, Investment in telecommunications with private participation
Pakistan	World Bank PPI, 1990-2014, Investment in telecommunications with private participation
Paraguay	World Bank PPI, 1992-2014, Investment in telecommunications with private participation
Peru	World Bank PPI, 1990-2014, Investment in telecommunications with private participation
Philippines	World Bank PPI, 1990-2014, Investment in telecommunications with private participation
Poland	OECD STAN and Czech National Statistics, 1995-2007, GFCF in telecommunications
Romania	World Bank PPI, 1993-2014, Investment in telecommunications with private participation
Russia	World Bank PPI, 1991-2014, Investment in telecommunications with private participation
Saudi Arabia	Saudi Telecoms, 2006-2013, Addition to property, plant and equipment (telecom network and equipment and capital progress)
Senegal	World Bank PPI, 1997-2014, Investment in telecommunications with private participation
Singapore	National Statistics, 1997-2014, Total development expenditure on info-communications and media development
South Africa	World Bank PPI, 1994-2014, Investment in telecommunications with private participation
South Korea	Bank of Korea, 1980-2014, Gross Capital Formation in communication
Spain	National Statistics, 2000-2011, GFCF in telecommunications
Tanzania	World Bank PPI, 1994-2014, Investment in telecommunications with private participation
Thailand	World Bank PPI, 1990-2014, Investment in telecommunications with private participation
Turkey	National Statistics, 2009-2013, Gross investment in tangible assets in the telecoms sector
United Kingdom	Eurostat and OECD STAN, 1980-2013, GFCF in telecoms
United States	US Capital Expenditure Survey and OECD, 1980-2014, GFCF in telecoms
Uruguay	INFRALATAM, 2008-2013, Investment in telecommunications infrastructure
Vietnam	National Statistics, 1996-2014, Investment in information and communication

Estimating missing values

We have developed econometric models to impute values for countries and sectors where no source of infrastructure spending data could be identified.[55] These models establish relationships between infrastructure stock per capita in countries for which we do have data and variables such as economic and demographic characteristics, IMF estimates of total value of capital stock[56] and World Economic Forum infrastructure quality indices.[57] The equations in these models are used to estimate values for countries where we do not have infrastructure spending (and therefore stock) data. The econometric equations and associated test statistics used to estimate these missing values are presented below.

This set of econometric models is used to estimate infrastructure stock per head for missing countries for the period 2006 to 2015. We use these results in conjunction with the perpetual inventory models (described in the next section) to estimate associated levels of spending back to 2007.

Rail

Source	SS	df	MS			
				Number of obs	=	309
				F(5, 303)	=	212.60
Model	966.785409	5	193.357082	Prob > F	=	0.0000
Residual	275.574548	303	.909486958	R-squared	=	0.7782
				Adj R-squared	=	0.7745
Total	1242.35996	308	4.03363622	Root MSE	=	.95367

lrail_stock~p	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
z1	1.14904	.1478901	7.77	0.000	.8580182	1.440062
rail_quality	.4063397	.0552174	7.36	0.000	.2976815	.5149979
total_stock	2.532849	.720998	3.51	0.001	1.114052	3.951646
total_stocksq	-.1409643	.0391456	-3.60	0.000	-.2179959	-.0639326
group_dummy	1.368409	.2349623	5.82	0.000	.9060441	1.830773
_cons	-17.82711	3.516288	-5.07	0.000	-24.74654	-10.90767

z1	GDP per head
rail_quality	WEF rail quality score
total_stock	IMF total value of capital stock
total_stocksq	IMF total value of capital stock squared
group_dummy	Country group dummy to account for outliers

[55] To test the reliability of this approach we developed estimates of the expected stock for countries which did have data, but were assumed to be missing for the purposes of the test. We found that in the majority of cases, these expected stock values aligned reasonably well with the corresponding actual stock values. In making these estimations, we had to be careful to avoid using the same set of explanatory variables which are also used in the regressions to forecast future infrastructure needs. Nonetheless, we did use GDP per head in both models as, on balance, we felt the value of including it in both stages of the modelling outweighed the risk of bias this may introduce.

[56] IMF, Estimating the stock of public capital in 170 countries, (Washington DC: IMF, 2017).

[57] Klaus Schwab and Xavier Sala-i-Martin, *The global competitiveness report 2015-16* (Geneva: World Economic Forum, 2015).

Road

Source	SS	df	MS			
Model	1098.5764	3	366.192134	Number of obs	=	608
Residual	247.560737	604	.40986877	F(3, 604)	=	893.44
				Prob > F	=	0.0000
Total	1346.13714	607	2.21768886	R-squared	=	0.8161
				Adj R-squared	=	0.8152
				Root MSE	=	.64021

lroad_stock_v~p	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_invest_pc	.1084321	.215954	0.50	0.616	-.3156799	.532544
log_invest_pcsq	-.0018622	.0061967	-0.30	0.764	-.0140319	.0103075
z1	1.006452	.0483628	20.81	0.000	.9114728	1.101432
_cons	-3.785073	2.181928	-1.73	0.083	-8.070161	.5000141

log_invest_pc	GFCF per head
log_invest_pcsq	GFCF per head squared
z1	GDP per head

Airports

Source	SS	df	MS			
Model	659.644859	6	109.94081	Number of obs	=	310
Residual	111.961009	303	.36950828	F(6, 303)	=	297.53
				Prob > F	=	0.0000
Total	771.605868	309	2.49710637	R-squared	=	0.8549
				Adj R-squared	=	0.8520
				Root MSE	=	.60787

lair_stock_~op	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
air_quality	-8.321666	1.446214	-5.75	0.000	-11.16756	-5.475772
air_qualitysq	1.513369	.2955599	5.12	0.000	.9317588	2.094978
air_qualitycub	-.109826	.0211942	-5.18	0.000	-.1515325	-.0681194
z1	.4650974	.4200945	1.11	0.269	-.3615746	1.291769
z11	-.0146125	.0488904	-0.30	0.765	-.1108201	.0815951
z1_air_quality	.1765749	.0669676	2.64	0.009	.0447944	.3083553
_cons	9.788808	3.189642	3.07	0.002	3.512154	16.06546

air_quality	WEF air transport quality score
air_qualitysq	WEF air transport quality score squared
air_qualitycub	WEF air transport quality score cubed
z1	GDP per head
z11	GDP per head squared
z1_air_quality	Interaction term between GDP per head and quality

Ports

Source	SS	df	MS
Model	844.726687	4	211.181672
Residual	400.866508	275	1.45769639
Total	1245.59319	279	4.46449174

Number of obs	=	280
F(4, 275)	=	144.87
Prob > F	=	0.0000
R-squared	=	0.6782
Adj R-squared	=	0.6735
Root MSE	=	1.2074

lport_stock_value_pop	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_invest_pc	.6407273	.1645499	3.89	0.000	.3167898	.9646649
port_quality	1.899319	.7356882	2.58	0.010	.4510224	3.347615
log_invest_pc_port_quality	-.0979046	.0336594	-2.91	0.004	-.1641675	-.0316418
z1	1.444894	.1019262	14.18	0.000	1.244239	1.645549
_cons	-21.94711	3.285402	-6.68	0.000	-28.41484	-15.47938

log_invest_pc	GFCF per head
port_quality	WEF port quality score
log_invest_pc_port_q	Interaction term between GFCF per head and ports quality
z1	Log GDP per capita

Electricity

Source	SS	df	MS
Model	652.936553	3	217.645518
Residual	155.085435	396	.391629886
Total	808.021988	399	2.02511776

Number of obs	=	400
F(3, 396)	=	555.74
Prob > F	=	0.0000
R-squared	=	0.8081
Adj R-squared	=	0.8066
Root MSE	=	.6258

lpower_stoc~p	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
total_stock	2.092554	.4174284	5.01	0.000	1.271901	2.913207
power_quality	.2740176	.0443915	6.17	0.000	.1867451	.3612901
total_stocksq	-.0677385	.0220108	-3.08	0.002	-.1110111	-.0244658
_cons	-8.764654	2.014588	-4.35	0.000	-12.72528	-4.804029

total_stock	IMF total value of capital stock
power_quality	WEF electricity quality score
total_stocksq	IMF total value of capital stock squared

Water

Source	SS	df	MS
Model	535.605575	6	89.2675959
Residual	224.523211	534	.420455451
Total	760.128786	540	1.4076459

Number of obs	=	541
F(6, 534)	=	212.31
Prob > F	=	0.0000
R-squared	=	0.7046
Adj R-squared	=	0.7013
Root MSE	=	.64843

lwater_stock_v~p	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
water_q_proxy	.2191895	.0868426	2.52	0.012	.0485946	.3897845
water_q_proxysq	-.0046367	.0012477	-3.72	0.000	-.0070877	-.0021857
water_q_proxycub	.0000253	5.79e-06	4.37	0.000	.0000139	.0000367
total_stock	.8017751	.0494077	16.23	0.000	.7047179	.8988324
z4Sig	4.989744	.5355492	9.32	0.000	3.937703	6.041786
group_dummy	.7297147	.0934688	7.81	0.000	.546103	.9133263
_cons	-3.528256	1.884067	-1.87	0.062	-7.229348	.1728354

water_q_proxy	Proportion of population with access to an improved water source
water_q_proxysq	Proportion of population with access to an improved water source squared
water_q_proxycub	Proportion of population with access to an improved water source cubed
total_stock	IMF total value of capital stock
z4Sig	Population density
group_dummy	Country group dummy to account for outliers

Telecoms

Source	SS	df	MS
Model	947.251664	4	236.812916
Residual	273.489931	730	.374643741
Total	1220.74159	734	1.66313569

Number of obs	=	735
F(4, 730)	=	632.10
Prob > F	=	0.0000
R-squared	=	0.7760
Adj R-squared	=	0.7747
Root MSE	=	.61208

ltelecom_stoc~p	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
log_invest_pc	1.088611	.1760794	6.18	0.000	.7429286	1.434293
log_invest_pcsq	-.0313596	.0051092	-6.14	0.000	-.04139	-.0213292
telecom_q_proxy	.1715405	.0266236	6.44	0.000	.1192725	.2238084
z1	.9419152	.0440751	21.37	0.000	.8553861	1.028444
_cons	-13.54581	1.756119	-7.71	0.000	-16.99346	-10.09817

log_invest_pc	GFCF per head
log_invest_pcsq	GFCF per head squared
telecom_q_proxy	Connections per head (broadband + mobile + fixed line)
z1	GDP per capita

11.3 APPROACH TO ESTIMATING INFRASTRUCTURE NEEDS

Introduction

Economic infrastructure typically has a lifespan of decades, or sometimes even longer. Looking only at the flow of expenditure in recent years is therefore insufficient to understand the current state of provision within any given country and sector. To do so it is necessary to look at the accumulated stock of infrastructure.[58]

One possibility, often followed in previous research in this area, is to look at the volume of physical infrastructure stock in each country, using measures such as the length of road, length of rail lines, number of telephone lines, and so on.[59] We initially experimented with this type of approach, but were unable to obtain satisfactory results for individual countries and sectors. This appeared to be due to the fact that an approach based on physical measures ignores infrastructure quality—a km of road in the US may be very different to one in Sub-Saharan Africa; the service level provided by a km railway line in Japan may be very different to that available in some of the world's poorest countries, and so on.[60]

We therefore adopted a different approach based on estimates of the *value* of infrastructure stock, which should, at least in theory, incorporate information on both the quantity and quality of infrastructure.

In seeking to understand how much infrastructure investment will be 'needed' in the coming years—we look at the years to 2040—a central question is how we are determining the 'need' for infrastructure. This is not straightforward and will differ on a case-by-case basis. For example, even in countries with similar levels of economic development, policymakers may have very different objectives in providing infrastructure, based on demand from citizens, economic expediency and political outlook. This might, for instance, affect how much a government prioritises rail over road connectivity or transport investment as a whole vis-à-vis other needs, such as providing citizens with access to clean water etc. Undertaking individual country-specific assessments of infrastructure, however, is a complex exercise requiring considerable resources.[61] Such an approach within a global study looking at 50 countries was not feasible so a broader approach was necessary.

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[58]For a discussion of why investment stock should be considered rather than flows, see Michael Pettis, "How much investment is optimal", in Carnegie Endowment for International Peace <http://carnegieendowment.org/chinafinancialmarkets/52078> [accessed 12 May 2017]

[59]A key paper in this field is Marianne Fay and Tito Yepes, *Investment in infrastructure: what is needed from 2000 to 2010?* (Washington DC: World Bank, 2003).

[60]A secondary issue was that to move from estimates of physical infrastructure needs to spending needs requires estimates of the cost of building a unit of infrastructure (cost per km of road or km of railway line, for example). However, our research suggested that such costs are not widely available on a country-by-country basis leading, for certain sectors, to a reliance on averages which may not reflect the conditions within a specific country.

[61]For example, the UK government established a National Infrastructure Commission to look at this very issue: https://www.gov.uk/government/news/chancellor-announces-major-plan-to-get-britain-building

Rather than look at each country individually, we made comparisons across countries to determine the infrastructure investment that each country is likely to make to accommodate future growth, under the assumption that countries' future investment performance is either in line with current trends, or increases such that countries match the performance of their best performing peers in terms of the resources they dedicate to infrastructure investment. We refer to the latter scenario as 'investment need'.

The methodological approach and econometric modelling used in this study are explored in more detail in the sections below. Here we provide an overview of the stages of analysis.

The objective of our study was to forecast values of infrastructure spending, but doing so required us to first estimate the value of infrastructure stock. Our initial step **(1)** was, therefore, to estimate the value of infrastructure stock per person in our 50 countries (and in seven sectors within each country).

We then sought to understand which variables explained differences in the value of stock across the countries **(2)**. This included examining the importance of factors such GDP per head, the sectoral structure of the economy, population density and so on, as well as a set of country-specific factors.

Having developed an explanatory model for each sector, we could forecast values of infrastructure stock per head through to 2040, based on forecasts of how each of the explanatory variables was expected to change over that period **(3)**. In this first set of forecasts (the *current trends scenario*), we assumed that the influence of country-specific factors would remain unchanged in the future, thereby exerting a similar influence on the accumulation of infrastructure through to 2040. This enabled us to forecast the infrastructure spending required in each country and sector to accommodate changes in all the other variables (i.e. the economic and demographic growth anticipated for the period to 2040).

Under this forecast infrastructure investment as a proportion of GDP can diverge from its historic trend, reflecting that the forecast takes into account changes in a number of economic and demographic characteristics, as well as a country's requirement for replacement investment. The current trends forecast is not, therefore, a simple extrapolation of infrastructure investment as a share of GDP.

This study aimed not just to explore what a 'business as usual' scenario might look like but also to identify how much it would cost to raise the game across the board, to a situation in which countries with similar characteristics dedicated a similar amount of resources to infrastructure. In effect, this meant understanding what the model predicts stock per head in 2015 *should be* given the country's characteristics **(4).**

Comparing the 'actual' and 'expected' infrastructure stocks provided us with an indication of a given country's performance in terms of the resources it dedicates to infrastructure provision**.** This performance measure was adjusted to account for the current quality of infrastructure stock in each country and sector **(5)**, based on infrastructure quality indicators from the World Economic Forum Global Competitiveness Report.[62,63]

The 'quality-adjusted' performance measure was compared across countries, and allowed us to determine the spending required for a country to match the performance of its best performing peers—defined as the 75th percentile amongst countries with similar income levels. This is our *investment need scenario* **(6).**

It is important to note that alignment to the performance of the best of one's peers in the investment need scenario does not mean increasing stock per head to a certain specific amount. Rather it means the difference between what it actually spends, and what it would be expected to spend is in line with the best performer. This means raising the game across the board, but to a level that is appropriate to the circumstances of the country in question. The actual value of stock might well be lower or higher, reflecting country-specific characteristics—such as a different level of GDP per head, population density, and so on.

The ability to compare forecasts of spending under current trends to the spending which would occur if each country matched the observed performance of its best-performing peers is a central innovation in our study.[64]

Comparing the spending requirements under the investment need and current trends scenarios allows us to assess the extent of the *'infrastructure investment gap'* for each country and sector.

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[62]This reflected the observation that some countries are building on a longer legacy of investment than others or may be more efficient at developing infrastructure, requiring less investment to deliver a given quality of infrastructure, for example. We used evidence from sector-specific infrastructure quality indicators from the World Economic Forum Global Competitiveness Report to make these adjustments.

[63]The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

[64]Previous research has benchmarked infrastructure stocks against other countries and regions (see for example Daniel E. Perrotti and Ricardo J. Sanchez, "La brecha de infraestructura en America y el Caribe", *CEPAL - Serie recursos naturales e infraestructura*, 153 (2011). However, we believe this to be the first time that benchmarking has been undertaken in terms of *performance*, where the latter is assessed as actual –v- expected infrastructure stock.

SELECTION OF THE BENCHMARK COUNTRIES

Central to our approach is the identification of a benchmark country, or set of countries to act as the 'best performer' for each sector and income group. These best performers were defined as the countries which have the highest (quality-adjusted) value of infrastructure stock *relative to what they would be expected to have given their characteristics*. Best performers were identified within three income groups based on World Bank definitions: low and lower-middle income; upper-middle income; and high income.

We explored several approaches to selecting best performers. We found that when using a single country as the top performer for any group there is a risk of skewing results by linking the forecasts for all countries in a group to an unrepresentative country, or 'outlier' country which has invested an unusually high amount in infrastructure. We decided to mitigate this risk by comparing to the country at the 75th percentile, based on the observation that there were often at least one or two outliers in each income group in each sector. Countries which are already positioned above the 75th percentile do not receive any uplift since the value of their infrastructure stock, relative to expectation, is already high compared to their peers. The objective for these countries in the years ahead is, therefore, to sustain relatively high levels of investment and maintain their strong performance.

An alternative would have been to simply compare the performance of each country to its own 'expected' performance, which would reflect the average performance of all countries, controlling for countries' individual characteristics. However, we felt this would be insufficiently ambitious given the objective of the study to compare countries to their best performing peers.

We also explored having a single comparison with no segmentation by income group, so that all countries were compared to the same benchmark country. This resulted in extremely large uplift factors in certain cases which, in turn, implied implausibly high spending levels. On balance, we felt that comparing countries to peers with similar income levels provided the most reasonable basis for comparison, and would produce estimates of infrastructure need which, though stretching, could be achievable.

Limitations

While we believe that our approach offers a reasonable basis for assessing infrastructure needs under the current trends and investment need scenarios, a number of limitations were identified during the study and the peer review process.

Firstly, focusing on the value of infrastructure stock effectively means that our models assess the volume of resources dedicated to infrastructure investment, rather than the outcomes of that investment. It provides a basis for benchmarking what investment needs would look like if all countries were to match their best performing peers in terms of the resources they dedicate to infrastructure investment. To the extent that there is a systematic tendency for countries to under-invest in infrastructure as discussed in section one, our approach is helpful in understanding which countries are investing more or less than would be expected, given their characteristics. However, it is important to recognise that the same value of investment may result in different outcomes in different countries.

Secondly, within our models we implicitly assume that 'more is better' and our forecasts imply that where countries have under-invested in infrastructure they should raise investment levels such that they increase the value of their infrastructure stock. We protect against the risk of recommending inefficient over-investment in two ways. Firstly, we benchmark performance against the 75th percentile of each peer group to avoid linking the forecasts to countries with unusually high rates of investment and, secondly, we take account of current infrastructure quality so that our model does not propose large amounts of additional investment where provision is already good. However, an alternative recommendation in some cases might be to increase the efficiency of infrastructure investment such that better quality infrastructure is delivered from the same value of investment.[65]

A third limitation, linked to the previous point, is that we do not assess *optimality*. While it is intuitively attractive to expect that the marginal benefit of additional infrastructure might decline as more is built, it is unclear at what point this might occur, and to what degree, for any given country and sector. In addition, selecting objective criteria against which to assess optimality would require careful consideration. Beyond protecting against the risk of recommending over-investment as described above, we do not seek to formally determine an optimal level of infrastructure stock for each country and sector.

Fourthly, we assume that causality runs in one direction from economic growth to infrastructure demand. It is also possible that the reverse is true, i.e. that developing infrastructure leads to faster economic growth. We investigated this within our econometric analysis, but we were unable to identify a satisfactory 'instrument' to control for the potential endogeneity bias that this two way causality may cause.

[65] The question of the efficiency of public infrastructure is discussed in IMF, *World Economic Outlook: Legacies, Clouds, Uncertainties* (Washington DC, 2014).

A fifth caveat relates to the role of technology. Over a 25-year forecasting horizon it is likely that technological change could influence both the value and the nature of investment required across countries and sectors. However, such technological change is extremely uncertain, particularly in dynamic sectors such as telecoms and, increasingly, electricity where off-grid and renewable technologies are evolving rapidly. While we cannot forecast the impact of technological changes, it is important to recognise that disruptive technological changes could lead to different outcomes to those suggested by our forecasts.

Finally, and as discussed in section 11.2, we have faced significant data challenges in undertaking this research, and we have been forced to rely on estimated values in cases where no suitable sources of infrastructure investment data could be identified. This adds a further degree of uncertainty to our findings, particularly for countries and sectors where data are poorest.

In light of these limitations, the research we have undertaken here should be regarded as a complement to rather than a substitute for more detailed country-specific research.

Econometric specification

Our methodology is based on tested econometric approaches, but takes them a step further to provide new insights.

Our econometric framework is motivated by the infrastructure research undertaken by Fay[66] and Fay and Yepes.[67] We use this as a starting point for identifying the determinants of the per capita stock of infrastructure in each sector. Our approach is therefore similar to Bogetic and Fedderke,[68] Battacharya[69] and Chatterton and Puerto[70] amongst others who follow the functional form used to forecast the per capita stock of infrastructure originally established by Fay and Yepes.

The key innovation of our study is to combine the approaches used by these authors to model infrastructure needs, with the stochastic frontier modelling techniques undertaken by, for example, Bhattacharyya[71], and the inefficiency modelling exercise in

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[66]Marianne Fay, Financing the future: infrastructure needs in Latin America, 2000-2005 (Washington DC: World Bank, 2001).

[67]Marianne Fay and Tito Yepes, *Investment in infrastructure: what is needed from 2000 to 2010* (Washington DC: World Bank, 2003).

[68]Johannes Fedderke and Zeljko Bogetic, *Infrastructure and growth in South Africa: Benchmarking productivity and investment needs* (Presentation to Economic Society of South Africa Conference, 2005).

[69]Biswa Nath Bhattacharyay, Estimating demand for infrastructure in energy, transport, telecommunications, water and sanitation in Asia and the Pacific: 2010-2020 (Tokyo: Asian Development Bank, 2010).

[70]Isabel Chatterton and Olga Susana Puerto, Estimation of infrastructure investment needs in South Asia region: executive summary (Washington DC: World Bank, 2011).

[71]Bhattacharyya, "Adjustment of Inputs and Measurement of Technical Efficiency: A Dynamic Panel Data Analysis of Egyptian manufacturing sectors", *Empirical economics*, 42(3) (2012): 863-80.

Khumbhakar et al.[72] Similar techniques have been applied by a number of UK regulators such as Ofwat and Ofgem to estimate optimal investment levels for regulated industries. Outside of the UK, other regulators and institutions, including the European Commission, have used similar approaches. However, to our knowledge this is the first time this type of approach has been used to estimate countries' infrastructure requirements relative to a best performer.

The models developed are standard static panel data models with fixed effects and take the form:

Infrastructure stock per head = Constant + Explanatory variables reflecting economic and demographic characteristics + Country-specific fixed effect term + Unexplained error term

We estimated a separate model for each of the seven sectors in our study, based on a general-to-specific approach to identify key determinants of infrastructure demand in each case. These models were also informed by model specification tests.[73]

The choice of a static, rather than dynamic specification reflects that we require the forecasts under the best performer scenario to reflect the infrastructure each country *should have*, given its characteristics, irrespective of its past performance.

The choice of the fixed effects approach was based on a series of statistical tests, including Hausman and Sargan-Hansen tests.[74] These tests confirmed that the fixed effects approach was appropriate for our purposes. The fixed effect model allows us to account for unobserved country specific effects that persist over time. Accounting for these effects allows us to mitigate the omitted variable bias problem, as well as account for heterogeneity in the data. This ensures that any systematic differences between countries are reflected in the final individual country forecasts.

The country-specific fixed effect term captures unexplained differences between countries which persist over time. It tells us whether a country has a tendency to over- or under-invest in infrastructure. A large positive fixed effect term suggests a country

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[72] Hung-Jen Wang and Alan P. Horncastle Subal C. Kumbhakar, *A practiitioner's guide to stochastic frontier analysis using Stata* (New York: Cambridge University Press, 2015).

[73] Because we developed independent models for each sector, we do not account for potential complementarities between sectors, e.g. the requirement for rail infrastructure may be lower in countries with a dense road network. While we briefly explored this point, we were unable to establish satisfactory relationships, but this is an issue which could usefully be explored further in future research.

[74] We have gone a step further than performing the standard Hausman test which is invalid when heteroscedasticity is present. We used the Sargan-Hansen (Arellano, 1993) test which is not only robust to heteroscedasticity but unlike the Hausman test is guaranteed always to generate a non-negative test statistic. Specifically, the version of the Sargan-Hansen test we used re-estimates a random effects model augmented with additional variables consisting of the original regressors transformed into deviations-from-mean form. The test statistic is a Wald test of the significance of these additional regressors. Under conditional homoscedasticity, this test statistic is asymptotically equivalent to the usual Hausman fixed vs random effects test. We also used the Pesaran CD test for cross sectional dependence to ascertain whether cross sectional dependence was an issue. However, it is worth pointing out that the Pesaran CD test should normally be used with long time series (over 20-30 years). Since our time dimension is shorter than this, the test statistics from this model should be treated with care.

typically has more infrastructure stock per head than would be expected, while a large negative number suggests a country tends to have less stock per head than would be expected. On this basis we can use the country-specific fixed effect terms to calculate countries' 'performance' as described by Khumbhakar et al.[75].

A further consideration was whether to model all countries together, or to develop separate models for each income group to reflect that there may be inherent differences in the nature of infrastructure need between countries at different stages of development. We explored this point but, on balance, obtained more satisfactory results when countries were pooled into a single model for each sector. We believe this reflected two factors. Firstly, the sample size for each group became small if we split it into three income groups. Secondly, data availability was typically a much greater problem for poorer countries. By treating all countries within one sample we were effectively able to use information on the wealthier countries with better data to help understand developing economies with poor data.

The models control for differences in GDP per head, so there is no reason why countries in higher income groups should necessarily perform better than those in lower income groups. Richer countries are usually observed to have higher values of stock per head, but what is important is the value of stock per head *after controlling for GDP per head and the other explanatory variables*.

Details of the panel data econometric models are provided below and in the next section we provide further details of how these models were applied alongside other analytical techniques to develop forecasts of infrastructure investment.

[75] Hung-Jen Wang and Alan P. Horncastle Subal C. Kumbhakar, *A practiitioner's guide to stochastic frontier analysis using Stata* (New York: Cambridge University Press, 2015).

Rail

```
Fixed-effects (within) regression               Number of obs      =       681
Group variable: dmu                             Number of groups   =        50

R-sq:                                           Obs per group:
     within  = 0.4843                                         min =         10
     between = 0.7804                                         avg =       13.6
     overall = 0.7654                                         max =         16

                                                F(3,628)           =    196.59
corr(u_i, Xb)  = 0.3028                         Prob > F           =    0.0000

------------------------------------------------------------------------------
lrail_stoc~p |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.490188   .0780622    19.09   0.000     1.336893    1.643482
          z3 |   .1410964   .0190603     7.40   0.000     .1036668    .1785261
         z13 |   -.017429   .0021096    -8.26   0.000    -.0215717   -.0132863
       _cons |  -7.993961   .6875705   -11.63   0.000    -9.344177   -6.643746
-------------+----------------------------------------------------------------
     sigma_u |  .93803586
     sigma_e |  .17866665
         rho |  .96499165   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 628) = 356.69                   Prob > F = 0.0000
```

z1	GDP per head
z3	Manufacturing share of GDP
z13	Interaction term between GDP per capita and manufacturing share

Road

```
Fixed-effects (within) regression               Number of obs      =       795
Group variable: dmu                             Number of groups   =        50

R-sq:                                           Obs per group:
     within  = 0.7272                                          min =        13
     between = 0.7951                                          avg =      15.9
     overall = 0.7927                                          max =        16

                                                F(6,739)           =    328.32
corr(u_i, Xb)  = -0.5042                        Prob > F           =    0.0000

------------------------------------------------------------------------------
lroad_stoc~p |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.140791   .0343326    33.23   0.000      1.07339    1.208192
          z3 |   .0068947   .0054215     1.27   0.204    -.0037486     .017538
         z33 |  -.0002436   .0001254    -1.94   0.052    -.0004898    2.56e-06
      z4_low |  -.2432224    .177228    -1.37   0.170    -.5911527    .1047079
      z4_mid |  -.2784796   .0890213    -3.13   0.002    -.4532443    -.103715
     z4_high |  -.4287239   .2525858    -1.70   0.090    -.9245951    .0671473
       _cons |  -2.376124   .2876205    -8.26   0.000    -2.940775   -1.811473
-------------+----------------------------------------------------------------
     sigma_u |  .77703039
     sigma_e |  .12477346
         rho |  .97486308   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 739) = 297.24                   Prob > F = 0.0000
```

z1	GDP per capita
z3	Manufacturing share of GDP
z33	Manufacturing share of GDP squared
z4_low	Population density dummy capturing countries with low density
z4_mid	Population density dummy capturing countries with moderate density
z4_high	Population density dummy capturing countries with high density

Airports

```
Fixed-effects (within) regression               Number of obs     =        686
Group variable: dmu                             Number of groups  =         50

R-sq:                                           Obs per group:
     within  = 0.4496                                         min =         10
     between = 0.7461                                         avg =       13.7
     overall = 0.7283                                         max =         16

                                                F(5,631)          =     103.07
corr(u_i, Xb)  = 0.3847                         Prob > F          =     0.0000

------------------------------------------------------------------------------
lair_stoc~op |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   .6169008   .0464243    13.29   0.000     .5257361    .7080656
      z4Sig  |  -7.488363    2.03332    -3.68   0.000    -11.48126   -3.495469
          z5 |  -.0857826   .0295848    -2.90   0.004    -.1438792   -.0276861
         z55 |   .0036748   .0010592     3.47   0.001     .0015948    .0057548
        z555 |  -.0000103   2.95e-06    -3.49   0.001    -.0000161   -4.51e-06
       _cons |    -.78874   .5355167    -1.47   0.141     -1.84035    .2628705
-------------+----------------------------------------------------------------
     sigma_u |   .8635668
     sigma_e |  .14428403
         rho |  .97284266   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 631) = 221.02                   Prob > F = 0.0000
```

z1	GDP per capita
z4Sig	Population density
z5	Urban share of population
z55	Urban share of population squared
z555	Urban share of population cubed

Ports

```
Fixed-effects (within) regression               Number of obs      =       668
Group variable: dmu                             Number of groups   =        50

R-sq:                                           Obs per group:
     within  = 0.6352                                         min =        10
     between = 0.3985                                         avg =      13.4
     overall = 0.3951                                         max =        16

                                                F(4,614)           =    267.25
corr(u_i, Xb)  = 0.1095                         Prob > F           =    0.0000

------------------------------------------------------------------------------
lport_stoc~p |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   3.431892   .3470962     9.89   0.000     2.750253    4.113532
         z11 |  -.2902494   .0411399    -7.06   0.000    -.3710414   -.2094575
          z4 |   2.287722   .3332159     6.87   0.000     1.633341    2.942103
         z44 |  -.4855211   .0778839    -6.23   0.000    -.6384723   -.3325698
       _cons |  -20.17032   1.623602   -12.42   0.000     -23.3588   -16.98183
-------------+----------------------------------------------------------------
     sigma_u |  1.7603624
     sigma_e |  .14363038
         rho |  .99338687   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 614) = 740.87                   Prob > F = 0.0000
```

z1	GDP per capita
z11	GDP per capita squared
z4	Population density
z44	Population density squared

Electricity

```
Fixed-effects (within) regression               Number of obs      =       794
Group variable: dmu                             Number of groups   =        50

R-sq:                                           Obs per group:
     within  = 0.5426                                         min =         13
     between = 0.7194                                         avg =       15.9
     overall = 0.7122                                         max =         16

                                                F(7,737)           =    124.91
corr(u_i, Xb)  = -0.0008                        Prob > F           =    0.0000

------------------------------------------------------------------------------
lteleco~s~p |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
         z1 |   1.997885   .3426233     5.83   0.000     1.325251    2.670519
        z11 |  -.1076914   .0425581    -2.53   0.012    -.1912409   -.0241419
         z3 |    .096727    .016031     6.03   0.000     .0652551    .1281988
        z13 |  -.0105165   .0018375    -5.72   0.000    -.0141238   -.0069091
         z5 |   .1242409   .0317951     3.91   0.000     .0618211    .1866607
        z55 |    -.00368   .0011527    -3.19   0.001    -.0059431    -.001417
       z555 |   7.72e-06   3.23e-06     2.39   0.017     1.38e-06     .000014
      _cons |  -9.720828   1.138557    -8.54   0.000    -11.95603   -7.485627
------------+-----------------------------------------------------------------
    sigma_u |  .68503481
    sigma_e |   .1774173
        rho |  .93714044   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 737) = 131.77                   Prob > F = 0.0000
```

z1	GDP per head
z11	Log GDP per head squared
z3	Manufacturing share of GDP
z13	Interaction term between GDP per head and manufacturing share
z5	Urban share of population
z55	Urban share of population squared
z555	Urban share of population cubed

Water

```
Fixed-effects (within) regression               Number of obs      =       795
Group variable: dmu                             Number of groups   =        50

R-sq:                                           Obs per group:
     within  = 0.4230                                         min =        13
     between = 0.6235                                         avg =      15.9
     overall = 0.6189                                         max =        16

                                                F(5,740)           =    108.50
corr(u_i, Xb)  = -0.3472                        Prob > F           =    0.0000

------------------------------------------------------------------------------
lwater_sto~p |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.099597       .095    11.57   0.000      .9130949    1.286098
          z2 |   .1134701   .0157152     7.22   0.000      .0826183    .1443219
         z12 |  -.0162971   .0020514    -7.94   0.000     -.0203244   -.0122698
          z3 |   .0542132   .0165985     3.27   0.001      .0216275    .0867989
         z13 |   -.005672    .001895    -2.99   0.003     -.0093923   -.0019517
       _cons |  -3.998942   .8473542    -4.72   0.000     -5.662446   -2.335438
-------------+----------------------------------------------------------------
     sigma_u |  .77081411
     sigma_e |  .17306452
         rho |  .95200921   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 740) = 251.89                   Prob > F = 0.0000
```

z1	GDP per head
z2	Agriculture share of GDP
z12	Interaction term between GDP per head and agriculture share of GDP
z3	Manufacturing share of GDP
z13	Interaction term between GDP per head and manufacturing share of GDP

Telecoms

```
Fixed-effects (within) regression               Number of obs      =       794
Group variable: dmu                             Number of groups   =        50

R-sq:                                           Obs per group:
     within  = 0.5426                                         min =        13
     between = 0.7194                                         avg =      15.9
     overall = 0.7122                                         max =        16

                                                F(7,737)           =    124.91
corr(u_i, Xb)  = -0.0008                        Prob > F           =    0.0000

------------------------------------------------------------------------------
ltelecom_s~p |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          z1 |   1.997885   .3426233     5.83   0.000     1.325251    2.670519
         z11 |  -.1076914   .0425581    -2.53   0.012    -.1912409   -.0241419
          z3 |    .096727    .016031     6.03   0.000     .0652551    .1281988
         z13 |  -.0105165   .0018375    -5.72   0.000    -.0141238   -.0069091
          z5 |   .1242409   .0317951     3.91   0.000     .0618211    .1866607
         z55 |    -.00368   .0011527    -3.19   0.001    -.0059431    -.001417
        z555 |   7.72e-06   3.23e-06     2.39   0.017     1.38e-06     .000014
       _cons |  -9.720828   1.138557    -8.54   0.000    -11.95603   -7.485627
-------------+----------------------------------------------------------------
     sigma_u |  .68503481
     sigma_e |   .1774173
         rho |  .93714044   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(49, 737) = 131.77                   Prob > F = 0.0000
```

z1	GDP per head
z11	Log GDP per head squared
z3	Manufacturing share of GDP
z13	Interaction term between GDP per head and manufacturing share
z5	Urban share of population
z55	Urban share of population squared
z555	Urban share of population cubed

Further details of the forecasting process

Our forecasting process comprised six steps, as described in the overview in section 0. We provide further details of each step below. The italicised text within each step provides an example of how the process works for one country and sector, UK roads.

(1) Estimating the value of infrastructure stock in each country

The study aims to forecast values of infrastructure spending. Doing so required us to estimate the value of infrastructure stock. Such estimates should, at least in theory, indicate both the quantity and quality of infrastructure available at any given time.

Estimates of the value of infrastructure stock are not widely available, and so we estimated these from spending flows using a 'perpetual inventory model' (PIM). The PIM enables the user to transform a set of information about spending flows (investment) into a stock equivalent measure, factoring in assumptions for the service life of an asset and depreciation. This is a standard approach for estimating capital stock values, as recommended by the OECD[76] and previously used by McKinsey in their analysis of global infrastructure needs.[77]

As well as using the PIMs to convert from spending to investment, we also used them in reverse to convert our forecasts of infrastructure needs in 2040 into spending requirements. Further details of the perpetual inventory models used and the assumptions within them are provided in section Fig. 88.

For example, we collected time series data on the value of road investment in the UK from the OECD. After a series of manipulations to put the data into a common currency and price basis, and to estimate values for years before the data series starts, we used the perpetual inventory model to estimate the value of the UK's road stock per head. This worked out at around $2,400 per person in 2015.

(2) Explaining the differences in the value of infrastructure stock

We used econometric models to identify a set of determinants (or 'explanatory variables') to explain the value of infrastructure stock per head in each sector in the years up to 2015 (the precise reference period depends on data availability for each country and sector). Determinants include variables which previous research has shown to explain infrastructure provision, including GDP per head, the sector structure of the economy, population density and so on. These models were described in detail in section 0.

In the case of roads, our econometric modelling suggested that the value of road stock per capita could best be explained by GDP per capita, the manufacturing share of GDP, and population density.

[76] OECD, Measuring Capital OECD Manual, Second Edition (Paris: OECD, 2009).

[77] McKinsey Global Institute, Infrastructure productivity: How to save $1 trillion a year (2013).

(3) Forecasting infrastructure investment under current trends

Once a model had been established, we incorporated forecast values of the explanatory variables to produce forecasts of infrastructure stock per head in 2040.

The seven models developed (one for each sector assessed) were based on a 'fixed effects panel data approach', and so estimate historic relationships across both time and countries. The fixed effects component means that the models control for unexplained country-specific factors which affect the value of infrastructure stock consistently over time. For our 'current trends' forecast we assumed that these factors remain unchanged in future years, and so changes to 2040 only result from changes in the explanatory variables, for example where population or GDP growth is forecast.

The resulting forecasts of infrastructure stock per head were converted into investment values using the perpetual inventory models.

For roads we incorporated our forecasts of GDP per capita, the manufacturing share of GDP and population density for the UK into the econometric model. This suggested that to accommodate anticipated growth in these variables, and assuming that the UK's behaviour in terms of infrastructure investment remains similar in future to in the past, that the UK would need to increase the value of its road infrastructure stock to $3,223 per person in 2040 (in 2015 prices and exchange rates). Using the perpetual inventory model, we estimated that the UK would need to invest a total of $319 billion in road infrastructure between 2016 and 2040 to achieve a stock value of $3,223 per person in 2040.

(4) Determining an 'expected' amount of infrastructure stock

This element of our methodology is the key innovation of our study. We adopted an approach known as a 'stochastic frontier model' (SFM) to compare how much infrastructure stock a country has in 2015 to how much it would be expected to have given its characteristics. The expected value of stock is the fitted value from the econometric model for the respective sector, and therefore represents the value of stock a country would be expected to have, on average, given its characteristics.

The fixed effect term is used to calculate each country's 'performance' at building its infrastructure stock. Performance is calculated as the difference between a country's observed and expected value of infrastructure stock in 2015. Our calculation of 'performance' follows the approach of Kumbhakar et al.[78]

For roads in the UK, we found that the value of stock per head in 2015 was less than our econometric model predicts the country should have, based purely on its economic fundamentals. The performance score for the UK, calculated using the UK's 'fixed effect' was also less than the 75th percentile of scores for other high income countries. This implies that the UK needs to increase investment to align performance with its best performing peers. If this were the final step in the process, our analysis would suggest that the forecast for stock per head in the UK in 2040 should increase from $3,223 under the current trends forecast to around twice that value.

[78] Hung-Jen Wang and Alan P. Horncastle Subal C. Kumbhakar, *A practiitioner's guide to stochastic frontier analysis using Stata* (New York: Cambridge University Press, 2015), pp. 271.

(5) Adjusting performance measures to account for infrastructure quality

We observed that some countries which are commonly regarded as having very good infrastructure had a poor performance on our measure. This may reflect that some countries are building on a longer legacy of investment than others or may be more efficient at developing infrastructure, requiring less investment to deliver a given quality of infrastructure, for example. We therefore 'quality-adjusted' our performance measure using sector-specific infrastructure quality measures from the World Economic Forum Global Competitiveness Report.[79]

The quality adjustment process is illustrated in Fig. 87, below. For each income group[80] and sector, we established the average relationship between our performance measure, and the corresponding World Economic Forum (WEF) infrastructure quality score.[81] Where a country had a high performance score relative to its WEF score, we reduced the performance score to align with the line of best fit (country A moves to A^{qa} in the diagram). In such cases, a country has a high value of infrastructure stock relative to what would be expected given its characteristics, but its WEF quality score is lower than would be expected given this relative stock value.[82]

Country B in the diagram illustrates the opposite case. The performance of this country is initially lower than of A, suggesting that the country's stock is relatively low compared to what would be expected given the country's characteristics. Nonetheless, the country has a high WEF score. The quality adjustment step therefore led to an increase in the country's performance score.

In making this adjustment it is important to acknowledge the WEF data are based on *perceptions* of quality, rather than some more objective measure of infrastructure quality. A further, related limitation is that perceptions of infrastructure quality might themselves depend on service delivery rather than the adequacy of physical infrastructure. For example, a poorly managed rail network may result in a low quality service, even if there is sufficient good quality physical infrastructure in place. While we acknowledge the limitations of relying on the WEF data, they are, to our knowledge, the best available measures of infrastructure quality for the countries and sectors in our study.

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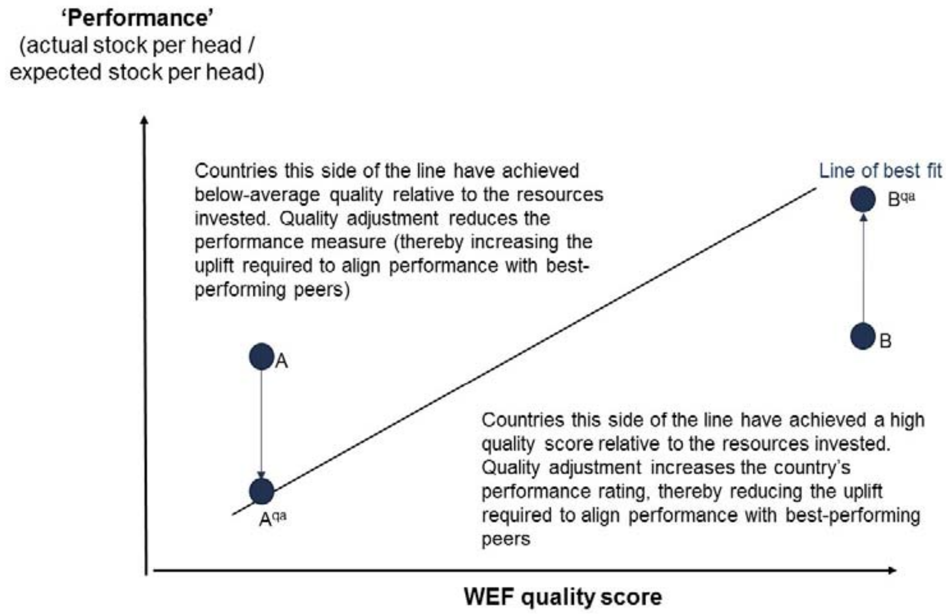
[79] Klaus Schwab and Xavier Sala-i-Martin, *The global competitiveness report 2015-16* (Geneva: World Economic Forum, 2015).

[80] The model is based on three income groups: low and lower middle income; upper middle income; and high income. Countries are allocated to an income group based on World Bank definitions.

[81] Our quality adjustment model is based on a cross sectional model. This model regresses the predicted individual specific effect from an auxiliary model on our quality indicator. We use a cross sectional model here because the individual specific effects do not change over time.

[82] Other studies have applied quality adjustment within the PIM equation, see for example Alvar Kangur, Chris Papageorgiou and Abdoul Wane Sanjeev Gupta, "Efficiency-Adjusted Public Capital and Growth", *World Development*, 57 (2013): 164-78. We experimented with a variant of this approach based on the WEF data but we were unable to obtain satisfactory estimates.

Fig. 87. The quality adjustment process



No quality adjustment was applied in cases where no investment data could be identified from which to estimate stock values because, in most such cases, the WEF information had already been factored in to estimated values of stock per head. And in the road sector we only applied quality adjustment to the high income group because no relationship could be established between the WEF indicator and our performance measure for the other two groups.

The WEF score suggests that the UK has a high quality of road infrastructure, relative to its investment performance. This, in turn, may reflect either that the UK is efficient at converting investment in roads into high quality infrastructure, or that it continues to benefit from an unusually high rate of investment in years before available data series start. That is, it falls below the line in the diagram above. As such the quality adjustment step increased the UK's performance score.

(6) Forecasting infrastructure investment needs

The quality-adjusted performance measure provides a basis for comparing across countries, and we can determine the extent to which any given country (for any given sector) needs to increase its infrastructure stock to match the performance of the best performers in its peer group (defined as the 75th percentile in each income group). This 'uplift factor' was applied to the 2040 forecast from step (3) to determine a forecast of investment need. We again use the perpetual inventory models to determine the investment required between 2016 and 2040 to reach this uplifted stock value in 2040.

We assume that investment occurs at a higher rate throughout the forecast period than in the current trends scenario. That is, we do not assume a period of convergence from the current trends trajectory to the investment need trajectory. We adopted this simplifying assumption for two reasons. Firstly, it is unclear what an appropriate rate of convergence might be and, secondly, it would add considerable modelling complexity to assume a varying rate of uplift across the forecast period.

After having applied the quality adjustment for all relevant countries, we found that the UK's quality-adjusted performance score for roads was much closer, though still slightly below, to the 75th percentile within its peer group of high income countries. As such, the uplift identified after quality adjustment was much smaller than before quality adjustment. On this basis we estimated that to match its best performing peers, the UK would require road stock to the value of $3,225 in 2040, a slight uplift of what would be delivered under current trends. Using the perpetual inventory model, we estimate that the UK would need to invest $320 billion in roads to achieve this stock value, a very slight increase over the $319 billion identified in the current trends scenario.

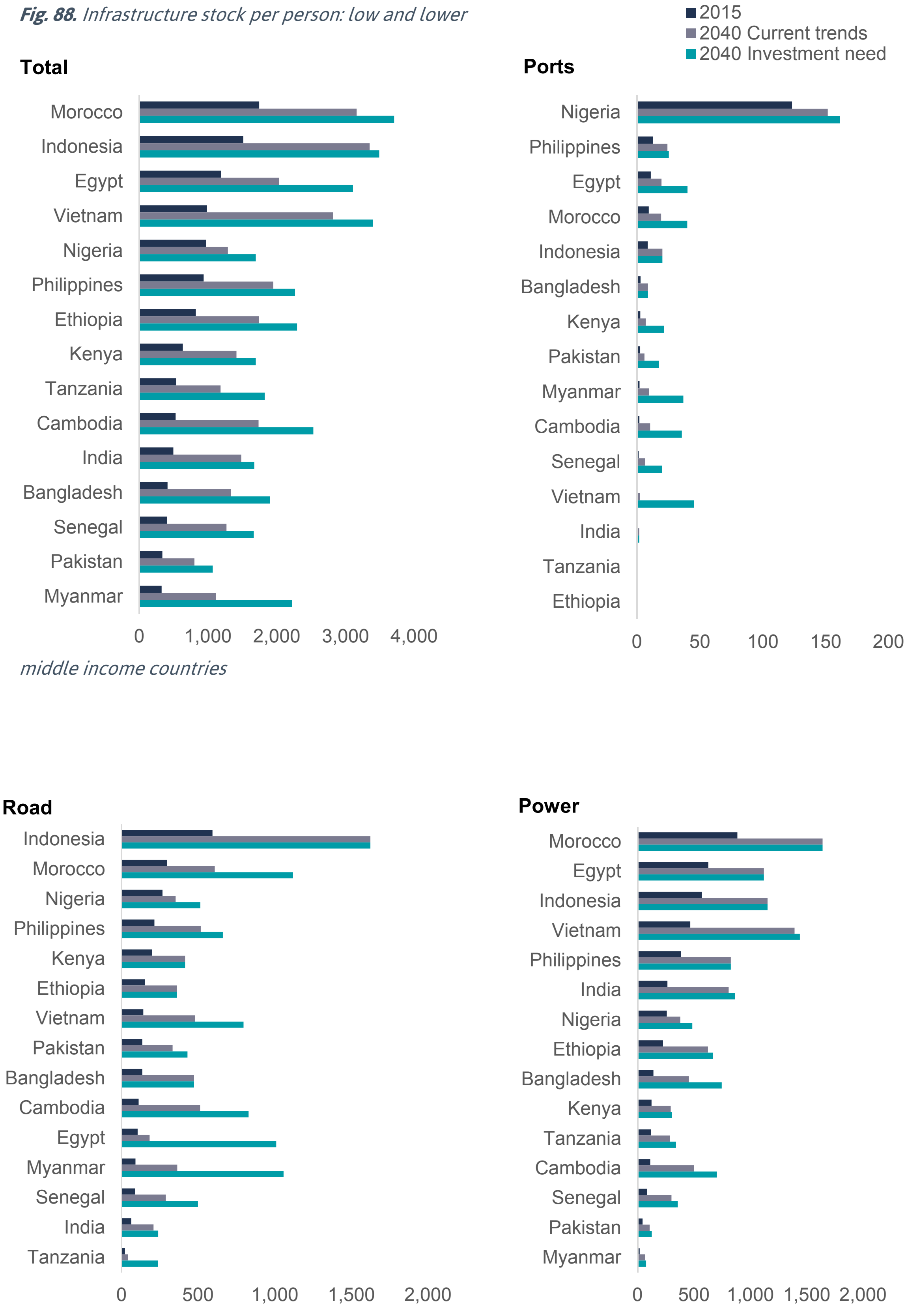
Estimated value of infrastructure stock

The charts below show the estimated value of infrastructure stock in each country and sector which resulted from the process outlined above. Three values are presented in each case:

- The 2015 values are estimated using the perpetual inventory model (or through econometric estimation where no investment data were found).
- The 2040 current trends forecast is derived from the econometric model as described in step (3) above.
- The 2040 investment need forecast is estimated to align each country's quality adjusted performance with the 75th percentile of each country's peer group as described in step (6) above.

The infrastructure stock per head values presented below were subsequently converted into the forecasts of investment need discussed in sections three to nine, using perpetual inventory models.

Fig. 88. Infrastructure stock per person: low and lower middle income countries



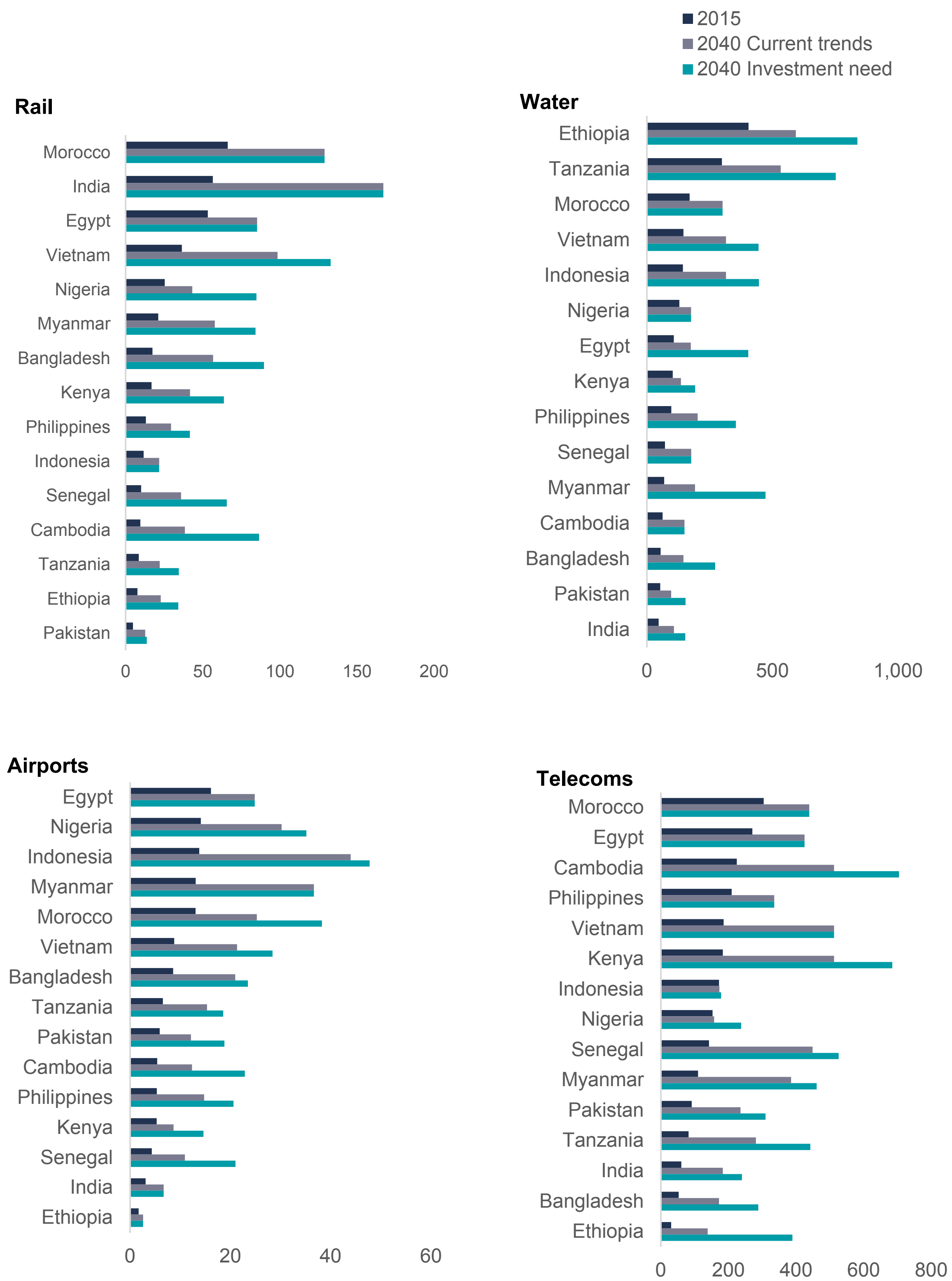
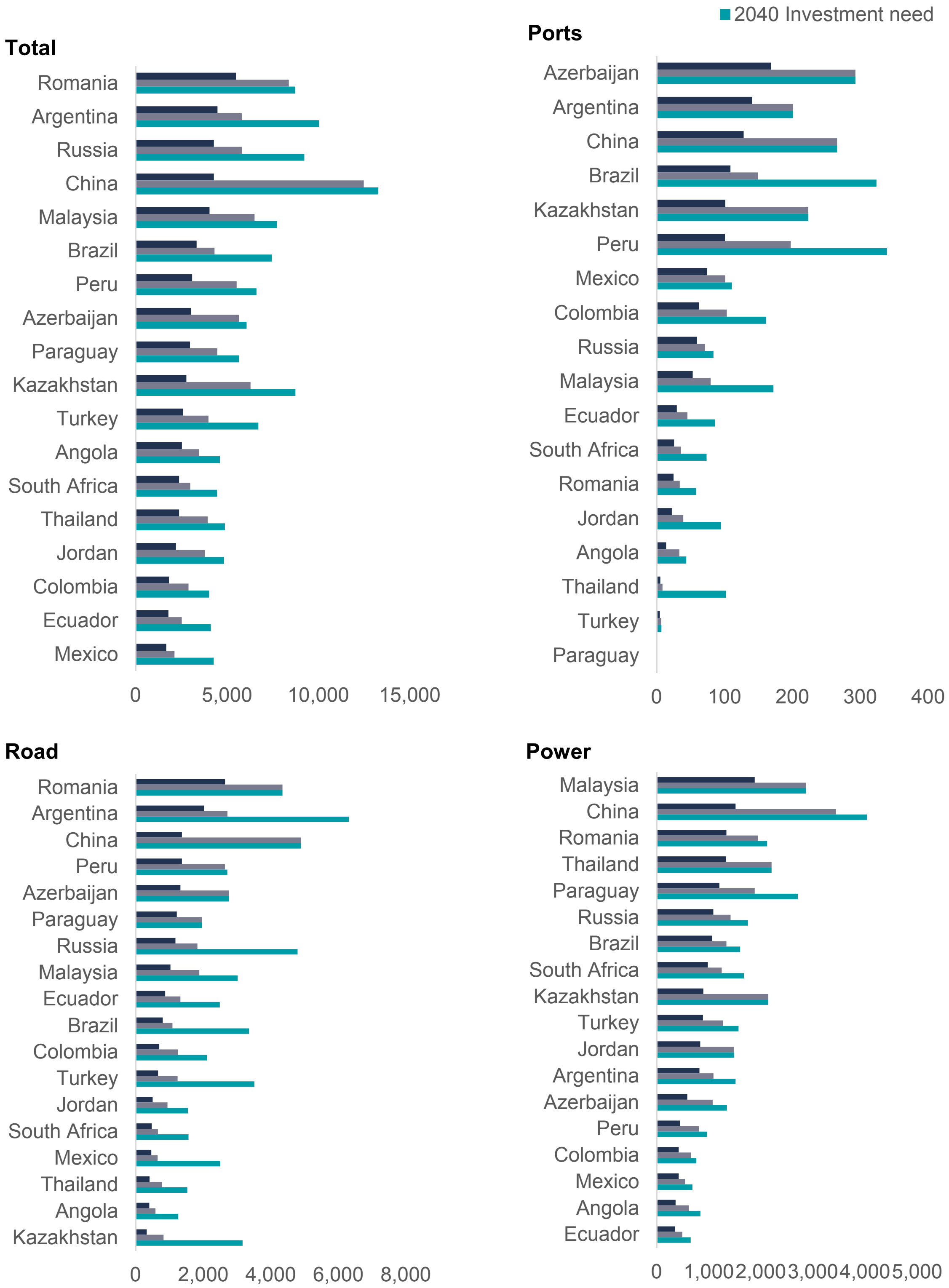
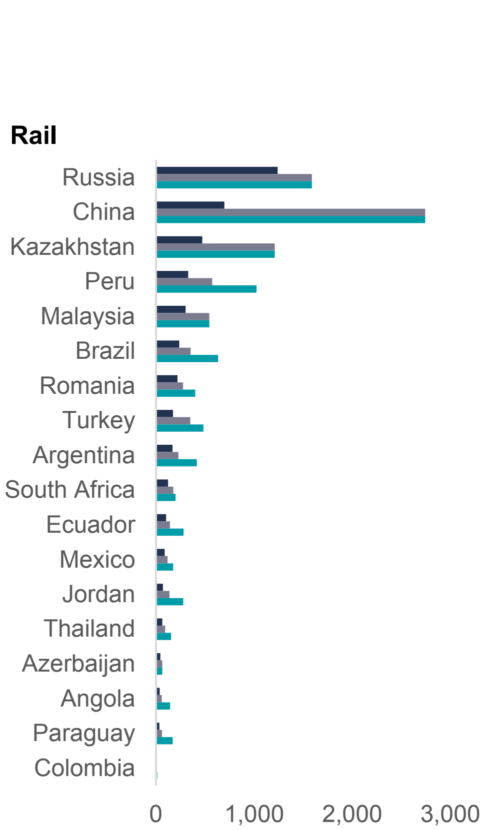
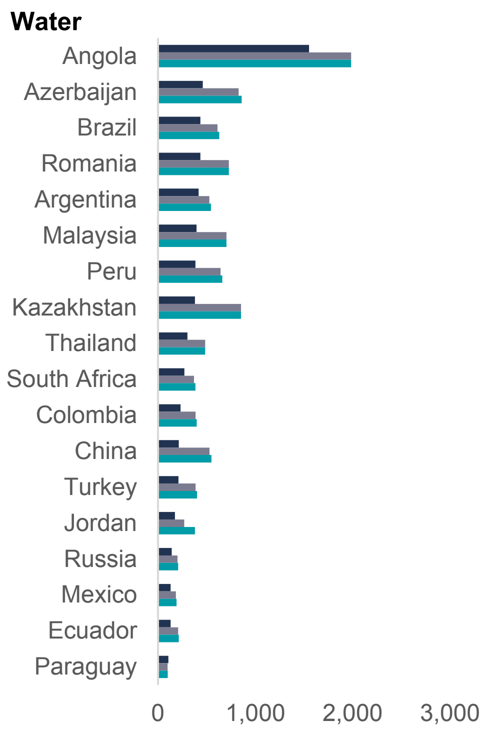
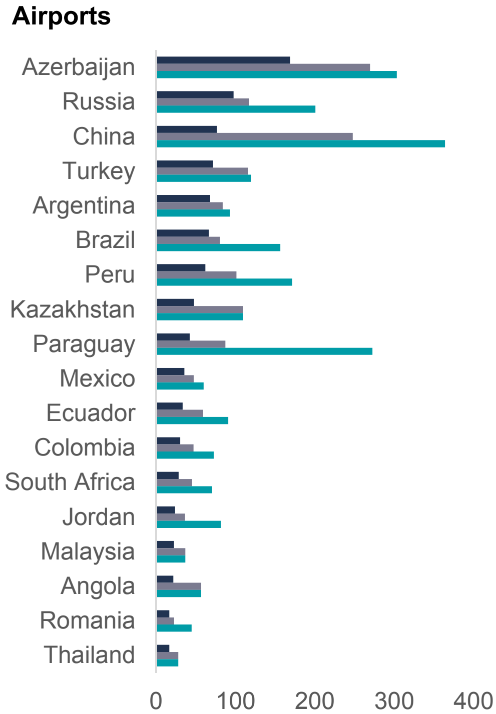

2015
2040 Current trends
2040 Investment need
Rail
Morocco
India
Egypt
Vietnam
Nigeria
Myanmar
Bangladesh
Kenya
Philippines
Indonesia
Senegal
Cambodia
Tanzania
Ethiopia
Pakistan
0
50
100
150
200
Water
Ethiopia
Tanzania
Morocco
Vietnam
Indonesia
Nigeria
Egypt
Kenya
Philippines
Senegal
Myanmar
Cambodia
Bangladesh
Pakistan
India
0
500
1,000
Airports
Egypt
Nigeria
Indonesia
Myanmar
Morocco
Vietnam
Bangladesh
Tanzania
Pakistan
Cambodia
Philippines
Kenya
Senegal
India
Ethiopia
0
20
40
60
Telecoms
Morocco
Egypt
Cambodia
Philippines
Vietnam
Kenya
Indonesia
Nigeria
Senegal
Myanmar
Pakistan
Tanzania
India
Bangladesh
Ethiopia
0
200
400
600
800

Fig. 89. Infrastructure stock per person: upper middle income countries




2015
2040 Current trends
2040 Investment need
Rail
Russia
China
Kazakhstan
Peru
Malaysia
Brazil
Romania
Turkey
Argentina
South Africa
Ecuador
Mexico
Jordan
Thailand
Azerbaijan
Angola
Paraguay
Colombia
0
1,000
2,000
3,000


Water
Angola
Azerbaijan
Brazil
Romania
Argentina
Malaysia
Peru
Kazakhstan
Thailand
South Africa
Colombia
China
Turkey
Jordan
Russia
Mexico
Ecuador
Paraguay
0
1,000
2,000
3,000


Airports
Azerbaijan
Russia
China
Turkey
Argentina
Brazil
Peru
Kazakhstan
Paraguay
Mexico
Ecuador
Colombia
South Africa
Jordan
Malaysia
Angola
Romania
Thailand
0
100
200
300
400

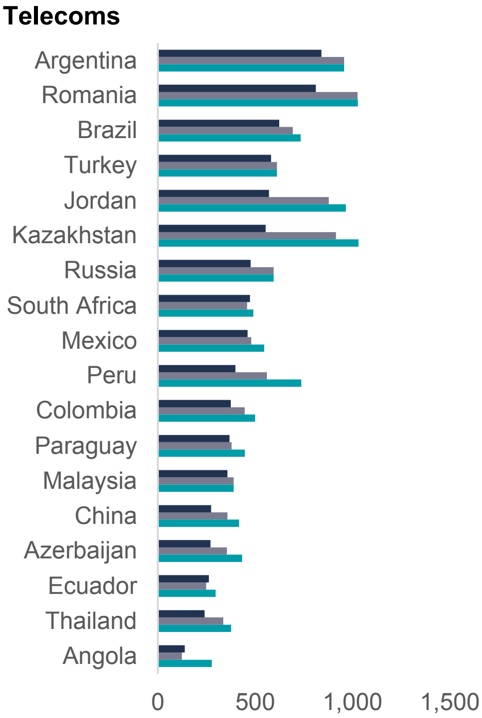
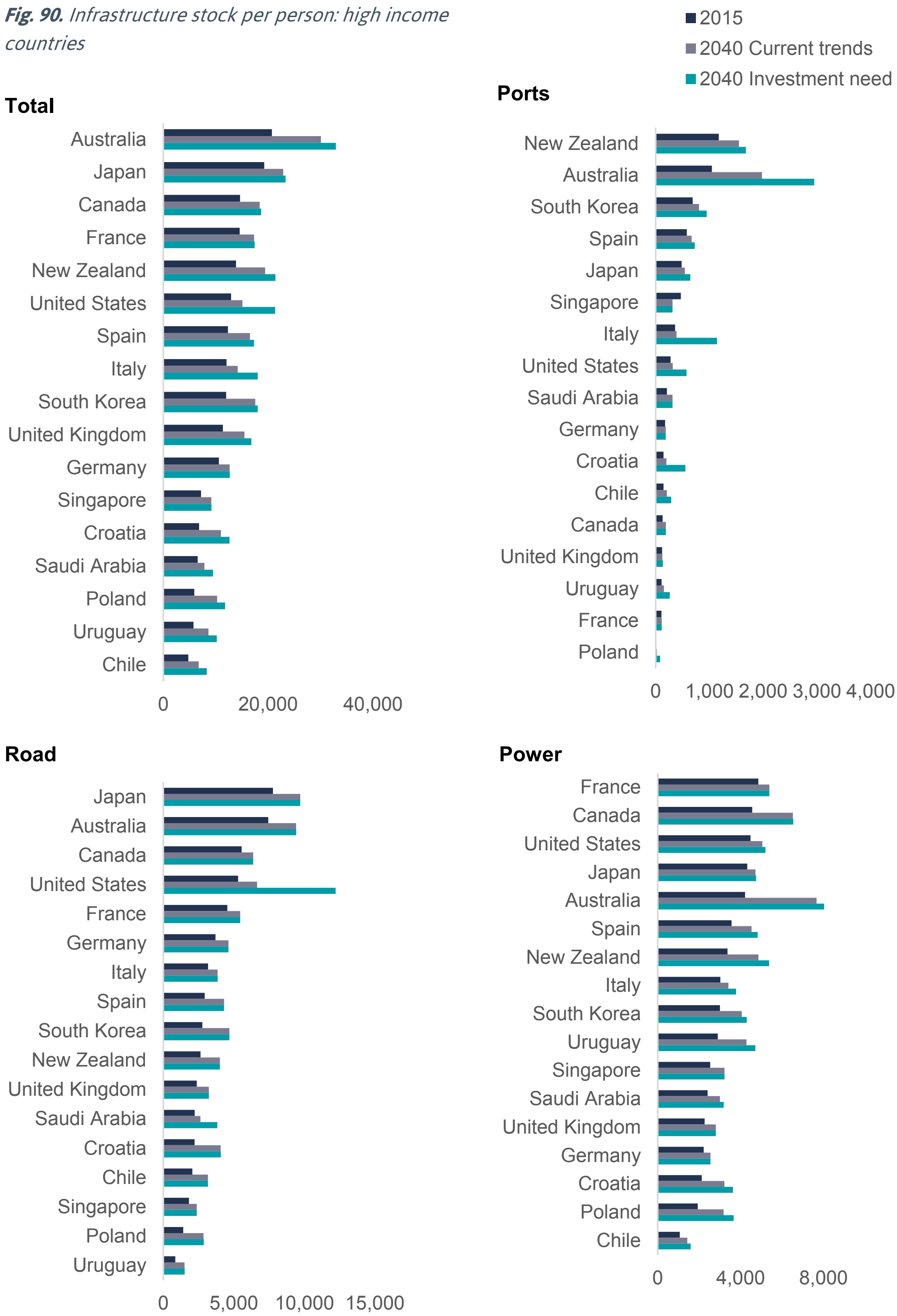
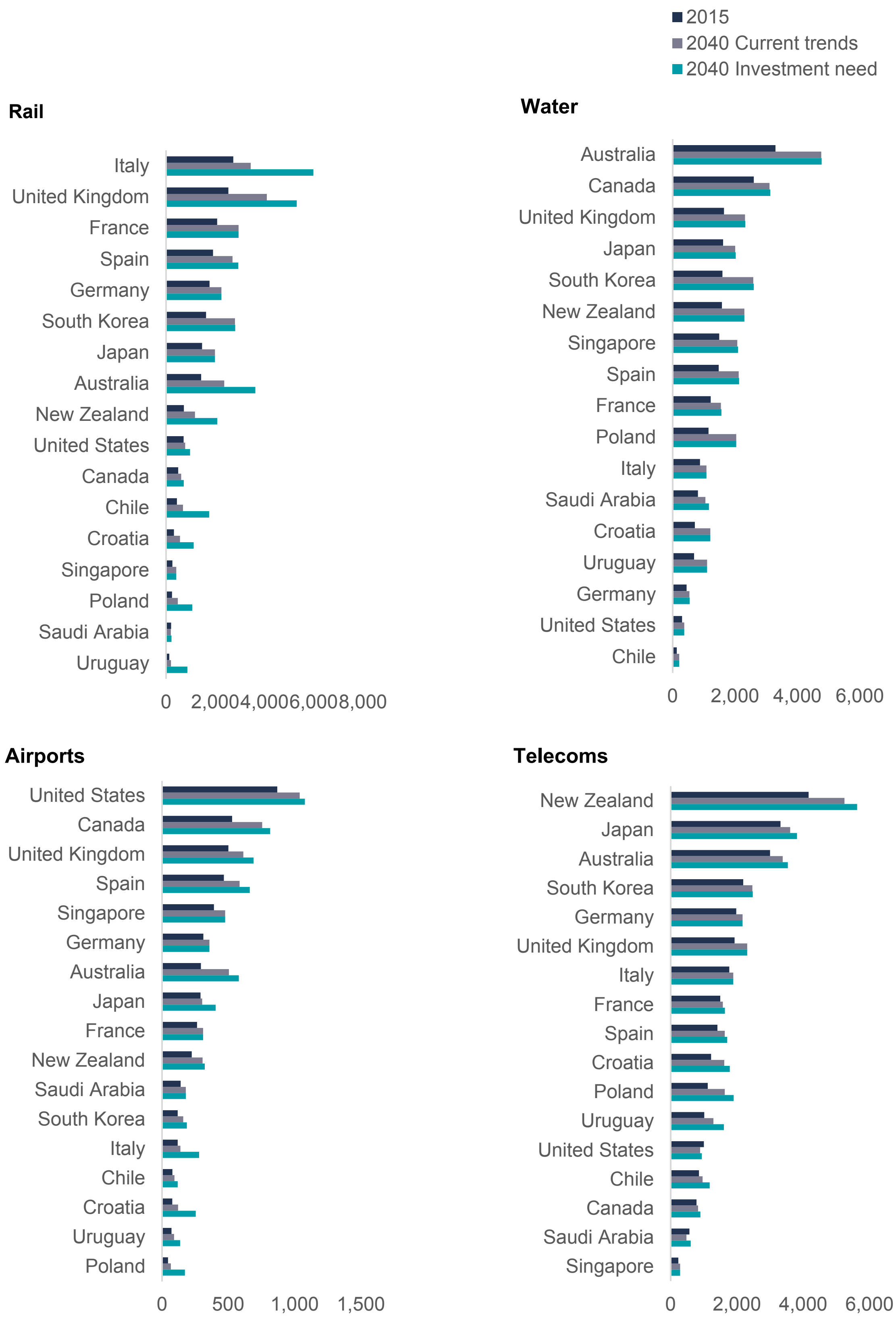

Telecoms
Argentina
Romania
Brazil
Turkey
Jordan
Kazakhstan
Russia
South Africa
Mexico
Peru
Colombia
Paraguay
Malaysia
China
Azerbaijan
Ecuador
Thailand
Angola
0
500
1,000
1,500

Fig. 90. Infrastructure stock per person: high income countries




2015
2040 Current trends
2040 Investment need
Rail
Italy
United Kingdom
France
Spain
Germany
South Korea
Japan
Australia
New Zealand
United States
Canada
Chile
Croatia
Singapore
Poland
Saudi Arabia
Uruguay
0
2,0004,0006,0008,000
Water
Australia
Canada
United Kingdom
Japan
South Korea
New Zealand
Singapore
Spain
France
Poland
Italy
Saudi Arabia
Croatia
Uruguay
Germany
United States
Chile
0
2,000
4,000
6,000
Airports
United States
Canada
United Kingdom
Spain
Singapore
Germany
Australia
Japan
France
New Zealand
Saudi Arabia
South Korea
Italy
Chile
Croatia
Uruguay
Poland
0
500
1,000
1,500
Telecoms
New Zealand
Japan
Australia
South Korea
Germany
United Kingdom
Italy
France
Spain
Croatia
Poland
Uruguay
United States
Chile
Canada
Saudi Arabia
Singapore
0
2,000
4,000
6,000

11.4 ESTIMATING THE VALUE OF INFRASTRUCTURE STOCK: THE PERPETUAL INVENTORY APPROACH

In this section we set out our approach to estimating the value of infrastructure stock in each country and sector.

The perpetual inventory method

The methodology we have chosen to estimate the value of infrastructure stocks is the result of a comprehensive research exercise and complies with recommended best practice in the field wherever possible.

We use an approach known as the 'Perpetual Inventory Method' (PIM), which is the most widely used means of measuring the value of a group of economic assets. This is typically referred to as a capital stock and can be equivalently thought of from both an income perspective (the discounted stream of future benefits that will derive to the owner of the asset) or from a production perspective (how it contributes to economic activity).

In essence, the PIM is an economic model which enables the user to transform a set of information about expenditure flows (investment) into a balance sheet or stock-equivalent measure.

PERPETUAL INVENTORY METHOD TERMINOLOGY

The PIM is derived from a set of key parameters as follows:

- **Gross Fixed Capital Formation (GFCF)**: at the heart of any PIM model is data on investment over time as measured by GFCF. It captures the value of the purchase of all assets used in the production process that firms hold for over a year. In this context the measure used relates to investment in infrastructure. The measure is 'gross' in the sense that it excludes the depreciation in value of any existing assets.
- **Asset service life**: the estimated average economic life span of an asset of that type. An asset could become of no economic value when it is no longer used in the production process.
- **Depreciation rate:** the rate at which past investments diminish in value due to everyday wear and tear, accidental loss and voluntary obsolescence.[83]
- **Depreciation function:** describes the shape of the depreciation of the asset over time. Typically, this is either arithmetic (straight-line) or geometric (a constant annual rate of depreciation).

[83]This could occur because of technological progress meaning that superior alternative forms of capital have become available or due to a structural change in economic conditions which results in the asset becoming uneconomic.

Data inputs

The most important input to any perpetual inventory model is the underlying investment data. We require series which are reasonably consistent and close to our preferred definition of infrastructure investment to be able to make meaningful cross-country comparisons.

For use in the PIM, data need to be expressed in constant prices, implying that any nominal price data need to be suitably 'deflated' to adjust for changes in prices over time. In addition, for this type of exercise, where cross-country comparisons are of some relevance, we also converted all investment data into the same currency (US$) at a fixed (2015) exchange rate.

The investment data collected for this study are described in section 11.2. All of the data gathered were expressed in nominal prices. To derive consistent datasets across countries and asset types the following 'transformation' process was applied:

- any series in USD were converted into local currency using the average market exchange rate for that year based on information from the Oxford Economics macroeconomic databank;
- the series is rebased into constant (2015) prices using a selected deflator. To ensure as high a degree of consistency as possible, a hierarchy of deflators was established based on their applicability to the infrastructure asset in that country; and
- all series were then converted into USD using a fixed exchange rate (again 2015), again based on data from the OE macroeconomic databank.

EXTENDING TIME SERIES DATA

A well-functioning PIM model requires a lengthy time series of investment data. However, many of the longest available series collected during the data collection process were too short in this respect. Therefore, we have extrapolated data back to 1980 where possible using the long-term infrastructure investment rate as a share of total GFCF in each economy. The advantage of this approach is that it controls for differences in GDP levels *and* overall investment rates between countries.

We also tested an extrapolation approach based on holding infrastructure investment constant as a share of GDP, as recommended by the OECD in their user guide to measuring the value of capital stocks.[84] However, we identified that this approach risks exaggerating the value of capital stock in economies where investment has risen as a proportion of GDP over time, which tends to occur in developing economies.

A third approach was also tested, under which we grew backwards and forwards the available infrastructure investment data using total GFCF growth in each economy. That is, we took the first or last value in the investment spending time series and assumed that in earlier or later years for which data are unavailable the growth rate of infrastructure spending was the same as for total GFCF. This approach was also rejected on the grounds that the estimated time series were very sensitive to the first and last values available within the investment spending data series.

Selection of average service lives

It is fair to describe the process of estimating service lives for capital as far from an exact science. According to the OECD,[85] the following sources are used as a means of estimation:

- asset lives as defined by tax authorities;
- information from corporate accounts;
- statistical surveys;
- administrative records;
- expert advice; and
- benchmarking based on estimates from other countries.

[84]OECD, Measuring Capital OECD Manual, Second Edition (Paris: OECD, 2009).

[85]Ibid.

As part of this project, we reviewed a range of literature to gather evidence on estimated service lives. This revealed substantial variations across countries even for the same asset class. This is perhaps of little surprise given the diversity of methodological approaches used. The most detailed information identified within our research is summarised in the table below.

Fig. 91. *Average service life by country and asset class*

COUNTRY	RAIL	ROAD	AIRPORTS	PORTS	POWER	WATER	TELECOMS
AUSTRALIA	67	33	32	48	38	72	50
CANADA	31	31	27	45	38	27	16
CHILE		40					
FRANCE	40	60	40	40	40	40	40
GERMANY	41	57	43	43	62	77	38
JAPAN	51	22			24	25	13
MEXICO		60					
SOUTH KOREA	62	60	57	45	40	29	30
UNITED KINGDOM	100	80	40	20	34	78	60
UNITED STATES	38	45	38	38	40	40	40
Average	54	49	40	40	39	48	36

Having collected this information, we needed to decide whether to adopt country-specific service lives where available, or whether to use a global average for all countries. Sensitivity testing was undertaken to assess the impact of the two approaches. This revealed that in practice it makes little difference to results whether country-specific or world average service life assumptions are used. The main exception is Japan, where the country-specific estimates were found to be notably lower than those for other countries. Given the objective of the study to compare infrastructure stock across countries, we took the view that it would be better to apply world average service lives to all countries so that countries may be compared on a like-for-like basis.[86]

Estimating a depreciation rate and depreciation function

Depreciation in a PIM model is typically assumed to follow either an arithmetic or a geometric function. A number of academic studies have estimated the actual path of depreciation using econometric models.[87] The evidence from these studies indicates that no single pattern of depreciation is capable of adequately capturing the profile for

[86] Stakeholders noted that, in reality, there may be a tendency for average service lives to differ between income groups. However, it is unclear whether average service lives would be positively or negatively related to income level. On the one hand, low income countries might dedicate less spending to maintenance, meaning that assets depreciate more quickly. On the other hand, technology may become obsolete more quickly in developed economies. The limited information identified on service lives in countries outside of the high income group meant that this issue could not be researched as part of this study.

[87] D Jorgenson, *New Methods for Measuring Capital* (Paper presented to the meeting of the Canberra I Group on Capital Measurement, 1999); F Hulten C Wykoff, "The Measurement of Economic Depreciation Using Vintage Asset Prices", *Journal of Econometrics*, 15 (1981).

all capital assets. However, the pattern that most typically describes the depreciation function is a line which falls over time with some convexity to the origin i.e. a geometric trend. In this light, we have decided to assume a geometric depreciation function.

In the absence of direct information about the depreciation rate of an asset, a common means of estimation is the declining balance method. This links the depreciation rate to the estimated service life of the asset using the following formula: $\delta = R / T^A$ where δ is the rate of depreciation, R is the assumed declining-balance parameter and T^A is the average service life of the asset class. Several studies have attempted to estimate the value of the declining-balance parameter for different asset classes based on econometric analysis of used asset prices. These typically report a parameter of between 1.5 and 3. For the purposes of this study we have assumed that the declining balance rate is related to the service life as follows: $R = T^A * (1 - (\alpha\hat{}(1 / T^A)))$ where R is the declining balance rate, T^A is the assumed average service life of the asset and α is set at 0.1.[88]

Estimating the initial value of the capital stock

In all cases, no data existed on the value of the capital stock for a given asset class. In its absence, it was necessary to estimate a starting value for the capital stock which will evolve depending on the path of investment, depreciation of the existing stock, and so on. Starting values were estimated using an approximation which can be applied when using a geometric depreciation function as follows: $K^{t0} = I^{t0} / (\delta + \theta)$, where K^{t0} is the value of the capital stock in year t0, I^{t0} is the value of capital investment in year t0, δ is the rate of depreciation and θ is the estimated long-run growth rate of real GDP in that country.[89] The latter was estimated based on the average rate of real GDP growth during the horizon for which investment data was available.[90]

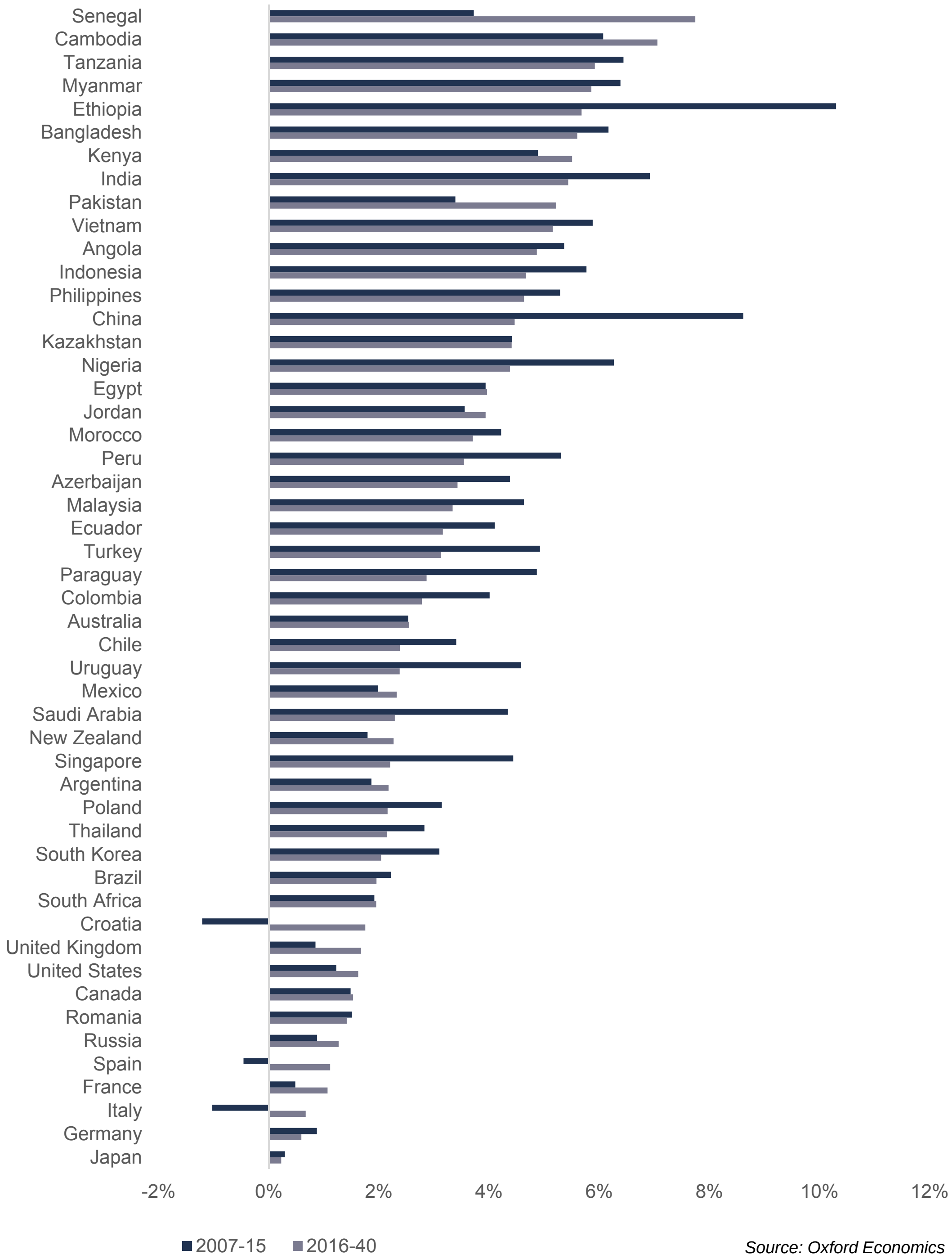
[88] A product of this formula is that an asset will have lost 90 percent of its initial value by the end of its service life.

[89] First derived in U Kohli, "Production Theory, Technological Change, and the Demand for Imports: Switzerland 1948-1974", *European Economic Review*, 18 (1982): 369-86. We use growth rates since 1980 for most countries, where data permit. For transition economies we use growth rates since 1995.

[90] For transition economies we use post-1995 growth

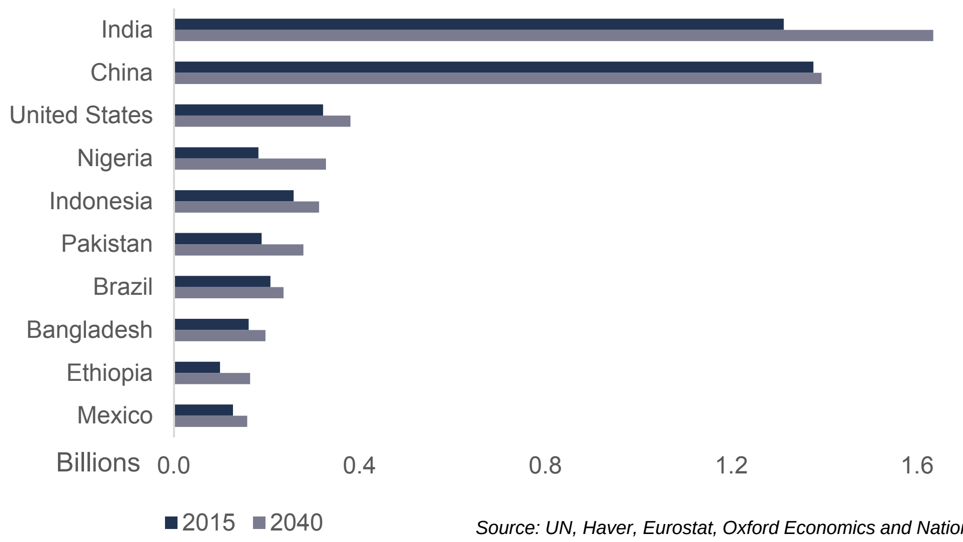
11.5 DETAILED FORECASTING ASSUMPTIONS

Fig. 92. *Average annual GDP growth, 2007-2040*



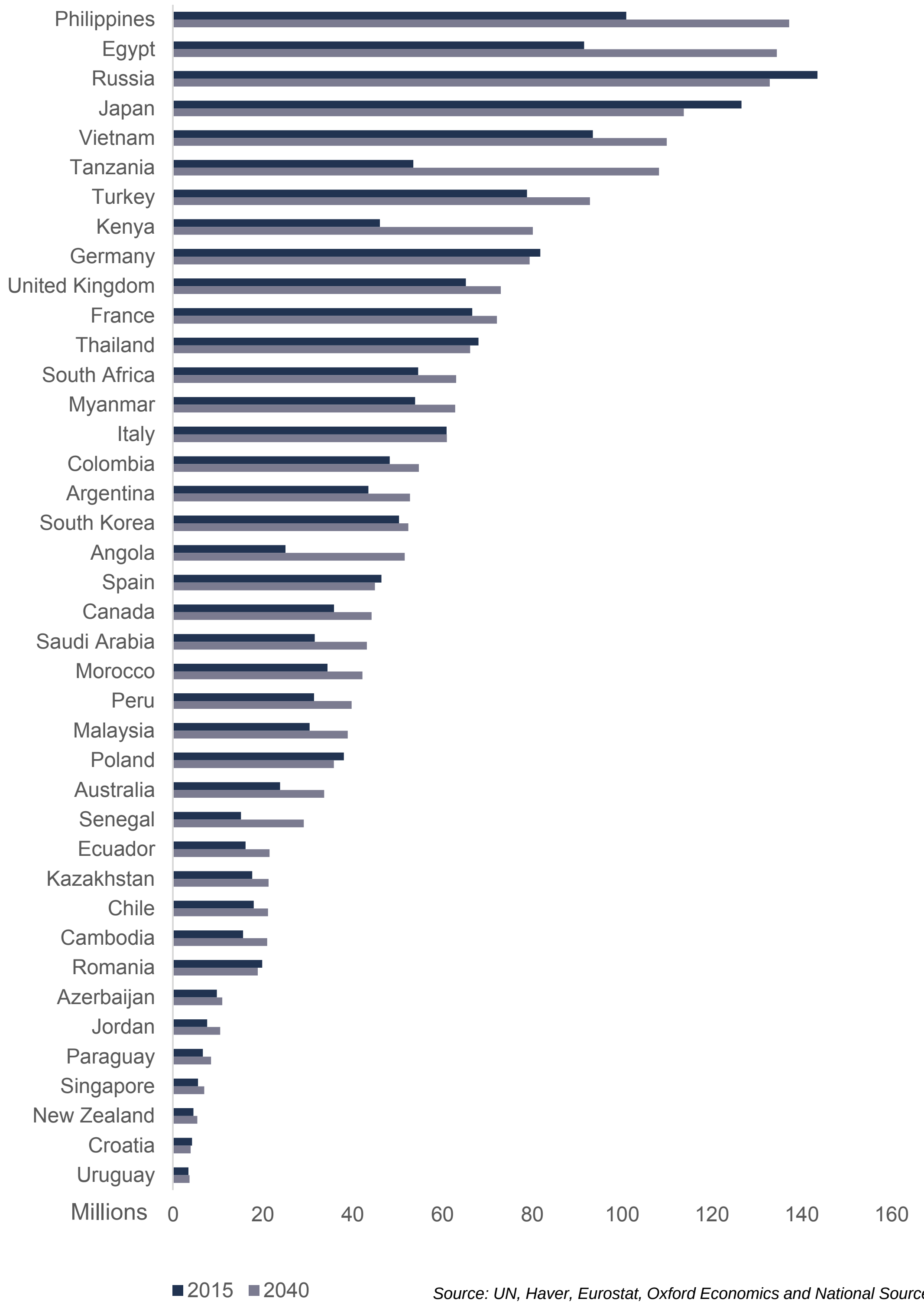
Source: Oxford Economics

Fig. 93. Population, 2015 and 2040 – 10 largest countries



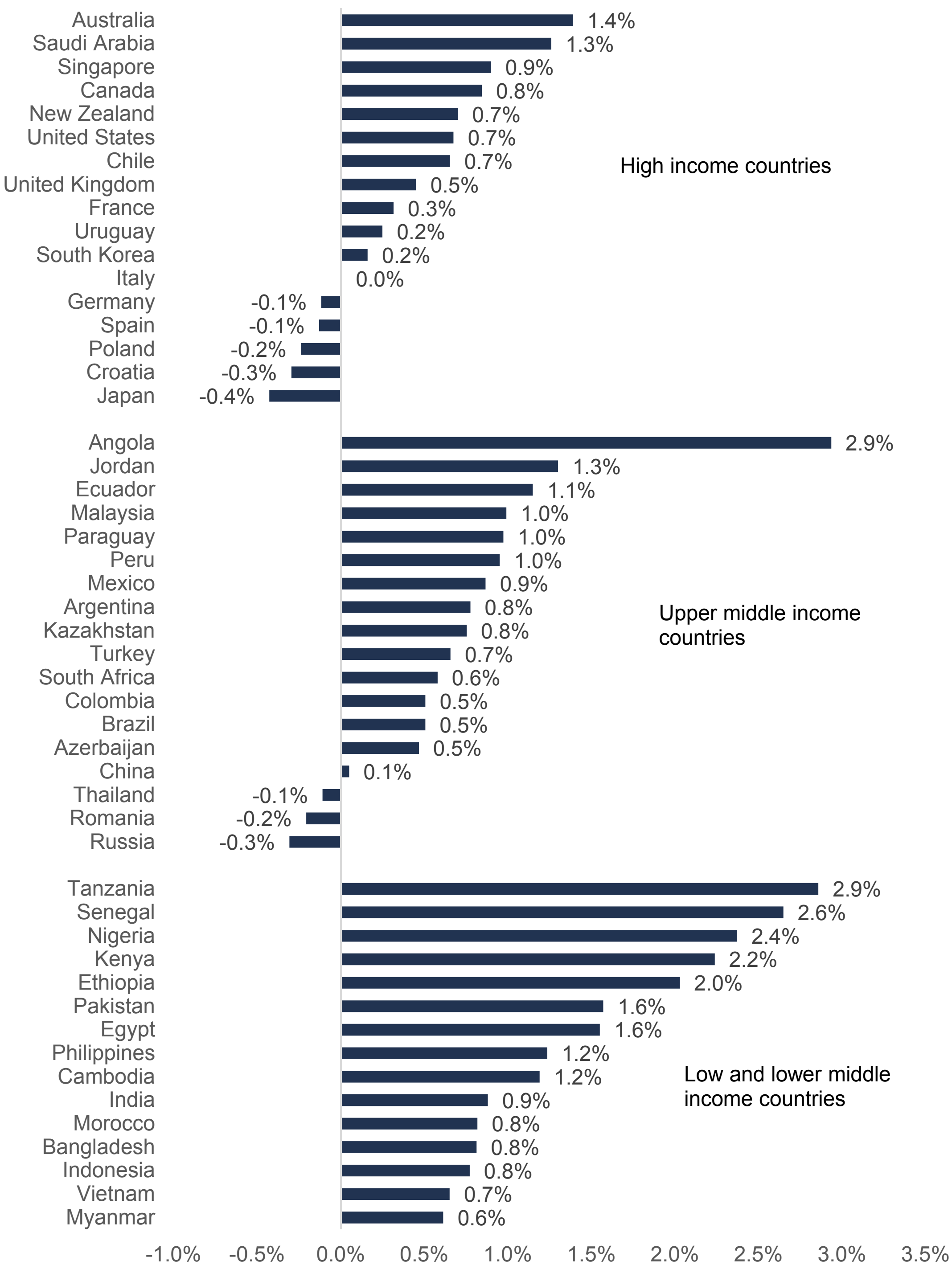
Source: UN, Haver, Eurostat, Oxford Economics and National Sources

Fig. 94. *Population, 2015 and 2040 – other countries*



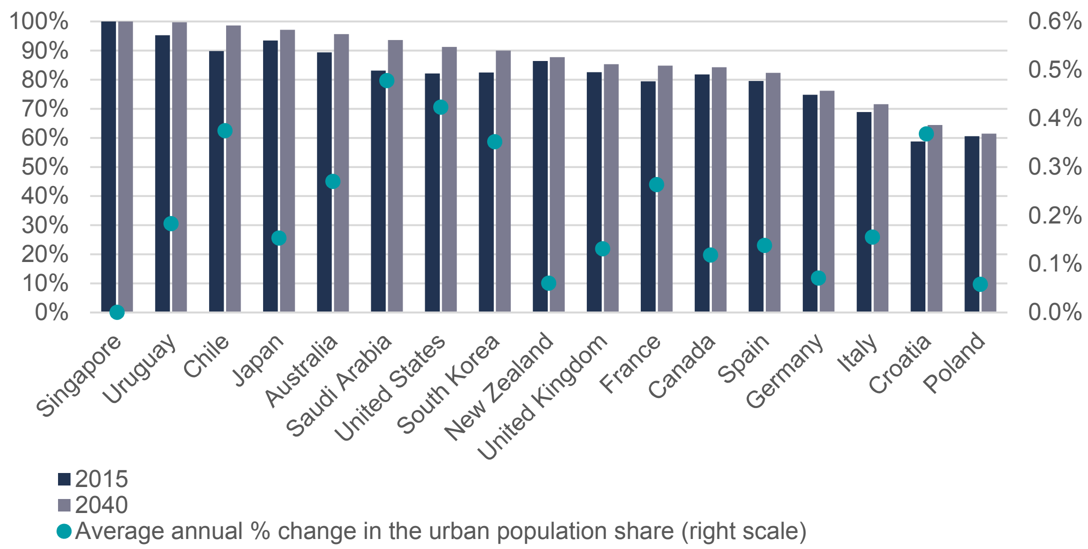
Source: UN, Haver, Eurostat, Oxford Economics and National Sources

Fig. 95. *Average annual population growth, 2016-2040*



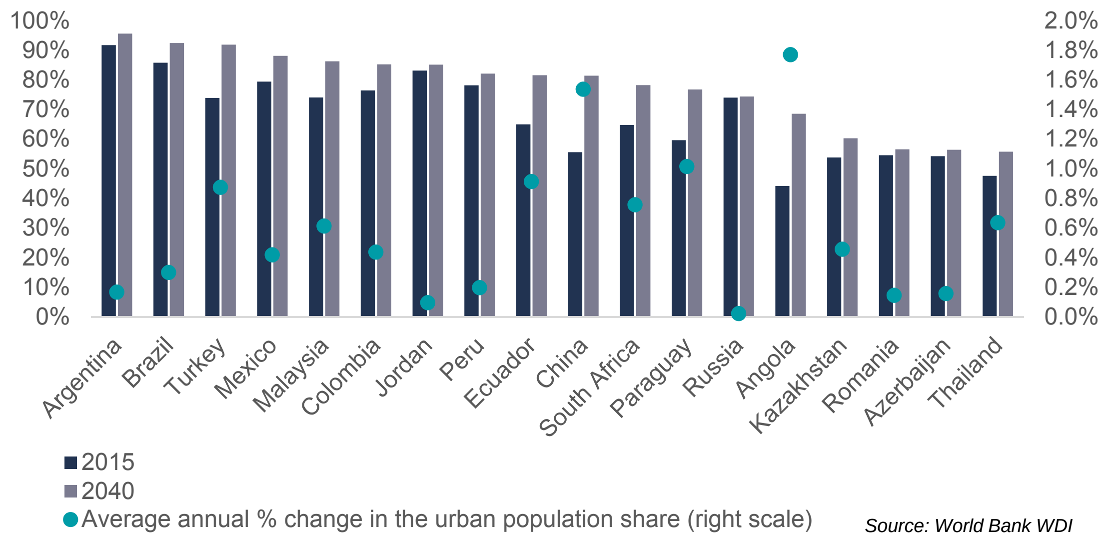
Source: UN, Haver, Eurostat, Oxford Economics and National Sources

Fig. 96. *Urban share of population, 2015 and 2040, high income countries*



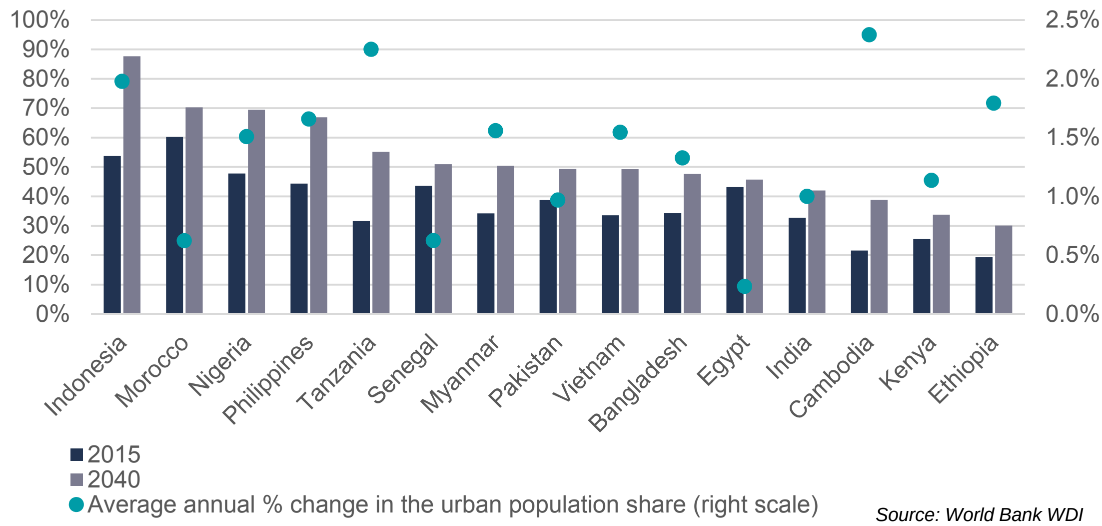
Source: World Bank WDI

Fig. 97. *Urban share of population, 2015 and 2040, upper middle income countries*



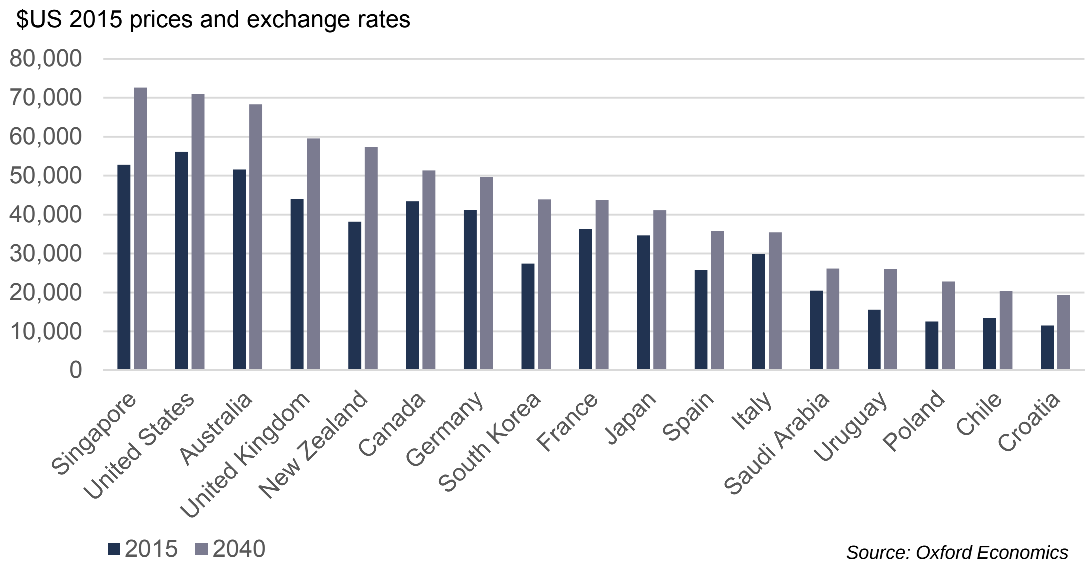
Source: World Bank WDI

Fig. 98. *Urban share of the population, 2015 and 2040, low and lower middle income countries*



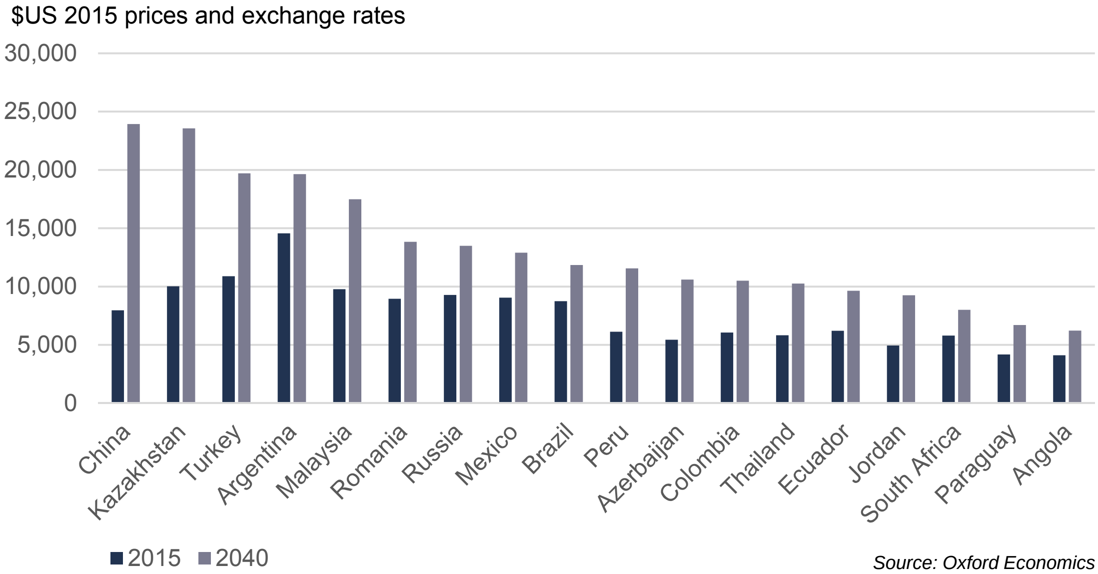
Source: World Bank WDI

Fig. 99. *GDP per head, US$ 2015, prices and exchange rates, high income countries*



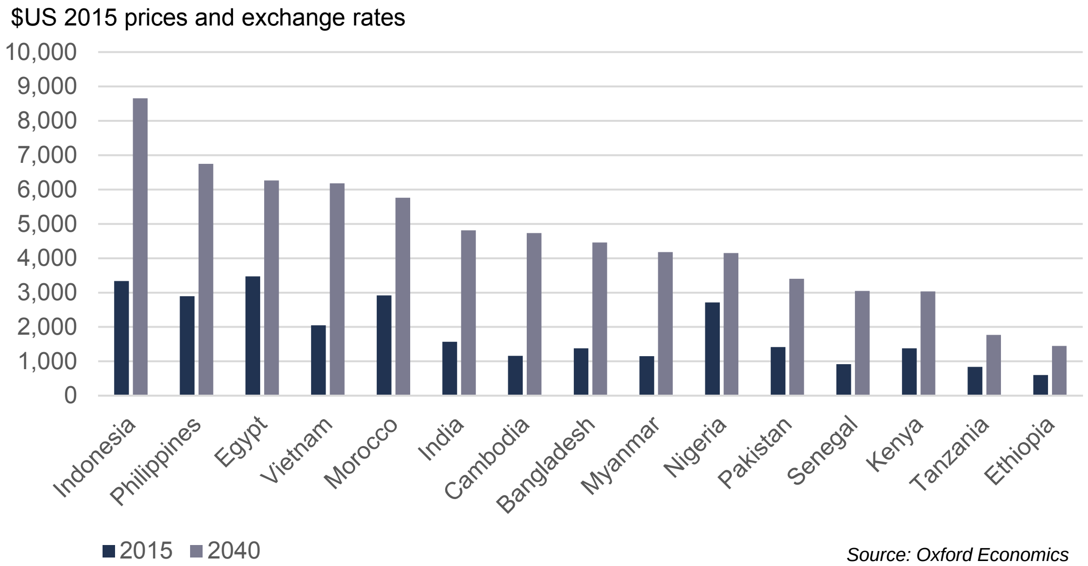
Source: Oxford Economics

Fig. 100. GDP per head, US$ 2015, prices and exchange rates, upper middle income countries



Source: Oxford Economics

Fig. 101. GDP per head, US$ 2015, prices and exchange rates, low and lower middle income countries



Source: Oxford Economics

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OXFORD ECONOMICS

Global Infrastructure Hub

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