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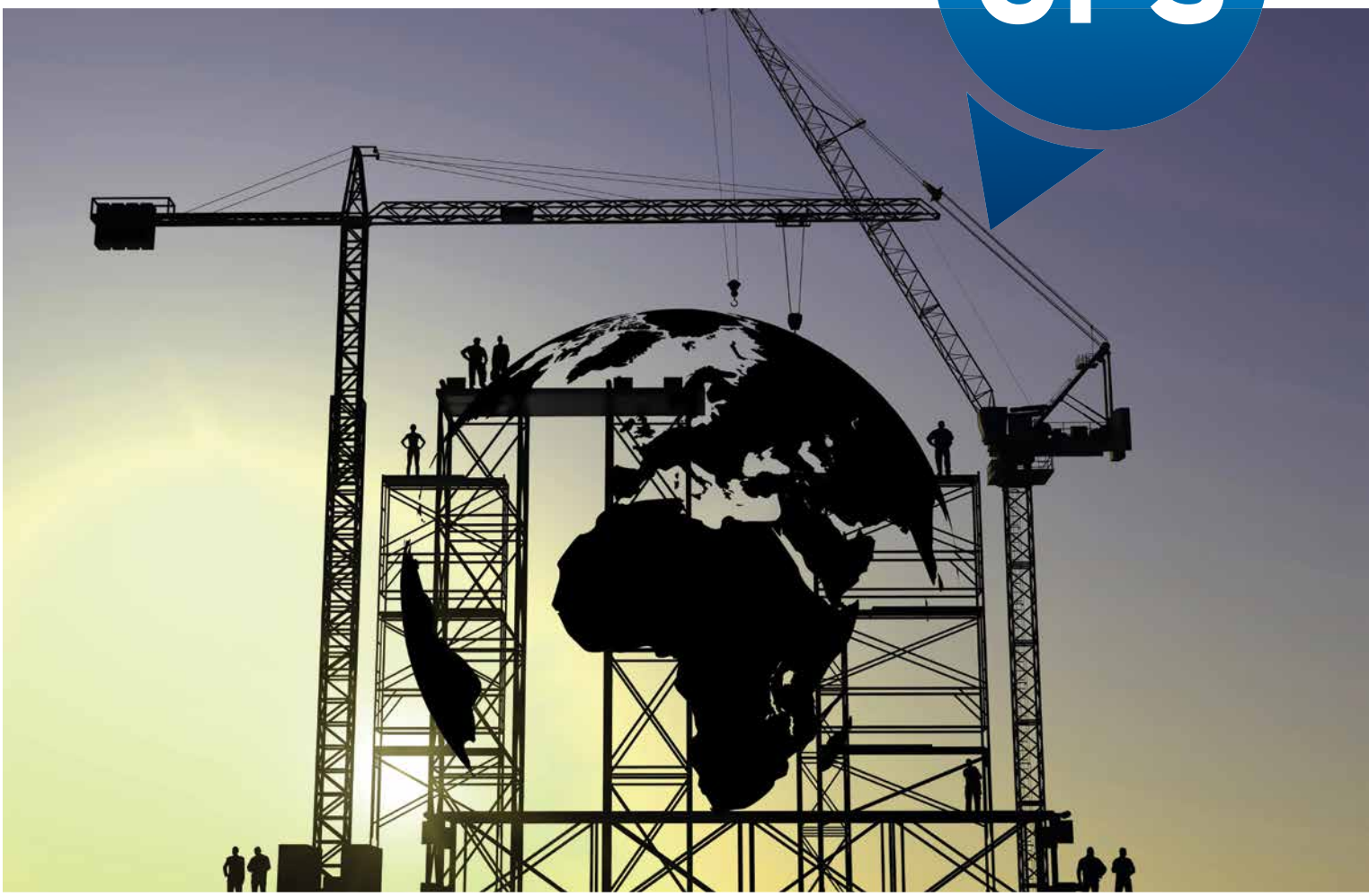

INFRASTRUCTURE FOR GROWTH

The dawn of a new multi-trillion dollar asset class

Citi GPS: Global Perspectives & Solutions

October 2016

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INFRASTRUCTURE FOR GROWTH

The dawn of a new multi-trillion dollar asset class

Throughout history, economic and social development have gone hand in hand with infrastructure development, be it the road networks and sanitation advances of the Romans (what *did* they do for us?), the Silk Road, or the maritime advances which led to the age of exploration and resulting global trade. Our modern era has been similarly transformed by the availability of energy, electronic communications, and modern travel which have made the world a much smaller place.

However, the amount which we spend on infrastructure has gradually been falling as a percentage of GDP, and, while there are justifications for this, the stock of infrastructure compared to global GDP has fallen.

At the same time, there is an enormous social need for infrastructure investment. Over 1.5 billion people have no access to electricity; just under 1 billion still live without safe drinking water, and over 2.5 billion are without access to basic sanitation. If the UN are right, and we need to accommodate an additional 1.5 billion people in the next 20 years, most of whom will be in emerging markets, and most of them in infrastructure-heavy urban centers, then there will be an ever more pressing need for infrastructure investment.

The global economy though seems mired in a period of sluggish growth. With interest rates close to zero, or in some cases negative in real terms, and the bazooka of QE already widely deployed, policymakers are running out of monetary levers to pull. This leaves us with the potential of fiscal stimulus, one aspect of which is infrastructure spending which can boost growth using both short-term demand effects, and longer-term supply effects, with the so-called multiplier effect implying that, if done correctly, the resulting GDP boost is larger than the initial investment.

However, developed market governments find themselves with debt at typically 100% of GDP, and hence limited capacity to spend, and, while emerging markets are less indebted at 40%, they are reluctant to boost debt and place sovereign ratings at risk. Traditional sources of infrastructure finance such as banks find themselves constrained by regulations such as Basel III, while insurance companies are constrained by Solvency II. Two factors, however, offer an enormous opportunity for the world. Firstly, governments can borrow at historically low rates (if not for free) for incredibly long durations. Perhaps most importantly, though, and the focus of this report, is the potential offered by private sector investment.

Returns on equities and bonds have in recent years been at historic lows, and Investors are crying out for yield, in particular for long-dated, stable cashflows and income streams. Infrastructure assets lend themselves perfectly to this need, with often predictable operating characteristics, and very long, multi-decade, useful lives.

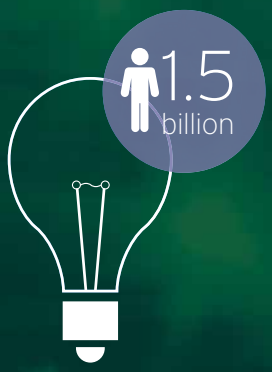
Moreover, the scale of the opportunity is vast — we estimate a global need for infrastructure spending of $58.6 trillion over the next 15 years. In this report we examine why now could be the time for a global infrastructure push, and where the most exciting opportunities are by region and industry. Most importantly, though, with a need for infrastructure from a social and economic perspective and with funding keen to participate, we examine why it isn't happening, and what stakeholders, both government and financial, need to do to make it happen.

We are faced with a rare opportunity to create and grow a new asset class, build a better world that is fit for the future, and create millions of jobs in the process; and who knows, we may just kick-start the global economy in the process.

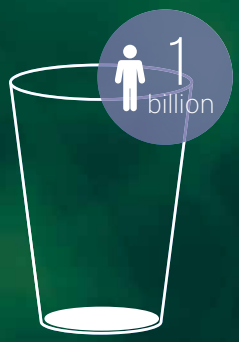
The Very Strong Case for Boosting Infrastructure Investment

DESPITE ENORMOUS SOCIAL NEEDS FOR INFRASTRUCTURE

Source: IMF



People have no access to electricity



People have no access to safe drinking water

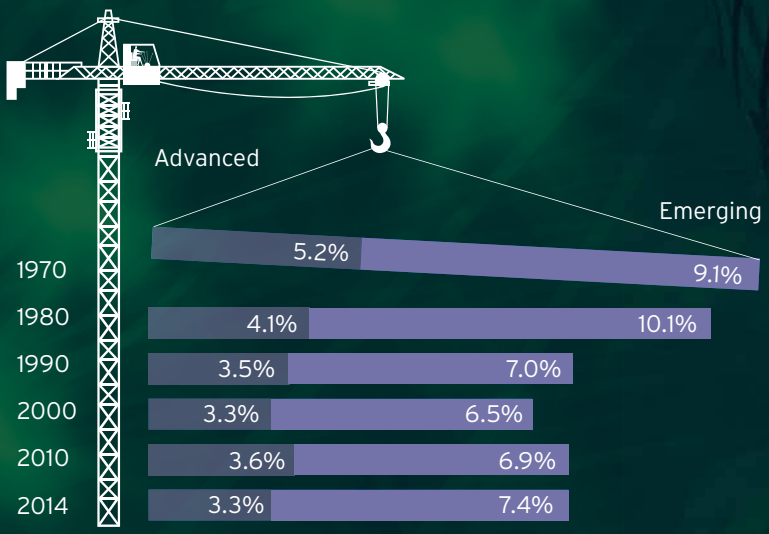
People have no access to basic sanitation

Additional people over the next 20 years

PUBLIC INVESTMENT IN INFRASTRUCTURE HAS BEEN FALLING IN BOTH ADVANCED AND EMERGING ECONOMIES

(Real public investment as % of GDP)

Source: IMF



HOWEVER, INFRASTRUCTURE COULD BE A WELL-NEEDED BOOST TO GLOBAL GROWTH

Source: Citi Research

1% increase in infrastructure investment...

...is associated with a **1.2% increase** in GDP growth

HOW MUCH SHOULD WE BE INVESTING TO GET GLOBAL GROWTH TO OECD GROWTH FORECAST OF 3.8%?

Average annual global spend:

2013	~$2.5 trillion
2016-2020	~3.5 trillion
2020-2030	~4.0 trillion

BIGGEST CHALLENGE? MATCHING UP INVESTORS WITH INVESTMENTS

With the outlook for bond and equity returns below historical levels and higher rates of returns available in infrastructure investing with relatively low loss levels, the biggest challenge is matching the up to $200 trillion in equity and credit markets with infrastructure investments

HOW?

Keys to developing a large and liquid global market for infrastructure investment vehicles

1. Transparency to create a visible pipeline of bankable projects
2. Regulatory and political stability
3. Collation and availability of data
4. Specialized institutions
5. Financial and structural innovation

Contents

The Case for Infrastructure

What exactly is infrastructure? We all use it every day, but rarely stop to think about it. As Margaret Thatcher once put it, "*You and I come by road or rail, but economists travel on infrastructure.*"

Infrastructure refers to assets that allow the efficient operation of economies and are an important driver of productivity

Infrastructure is not a term that's very well defined, which is the first problem for the industry. Our attempt to define it would be to say that infrastructure refers to the assets that allow the efficient operation of economies and societies, and are an important driver of productivity (i.e., the amount of output we get, measured in GDP or its elements, per unit of input, such as labor or capital).

It is usually split into four main areas of activity, namely:

- **Transportation** – including rail, road, air, airports, maritime, and ports.
- **Telecommunications** – encompassing fixed line networks, broadband networks, mobile networks (including towers), and satellite networks.
- **Energy** – including electricity generation, transmission, distribution, storage, and for oil & gas, upstream activities, refining, conversion, transportation, and distribution and storage, as well as coal mines, nuclear facilities, renewable assets, etc.
- **Water & Sanitation** – assets such as water treatment facilities and distribution networks, wastewater collection and treatment, sanitation, irrigation, and potentially broader waste collection and treatment.

That list alone captures an enormous amount of activities, but should we include educational infrastructure such as schools, healthcare institutions such as hospitals (that's still the easy bit), social housing, before we even start to think about government buildings, let alone the quality of the judiciary and government?

This report focuses on four sectors: transport, telecommunications, energy and water and sanitation

For the purposes of this economically-focused report we will limit ourselves to the four key sectoral groups, given our focus on economics, financing, and facilitating private sector investment, as it is most applicable to these areas.

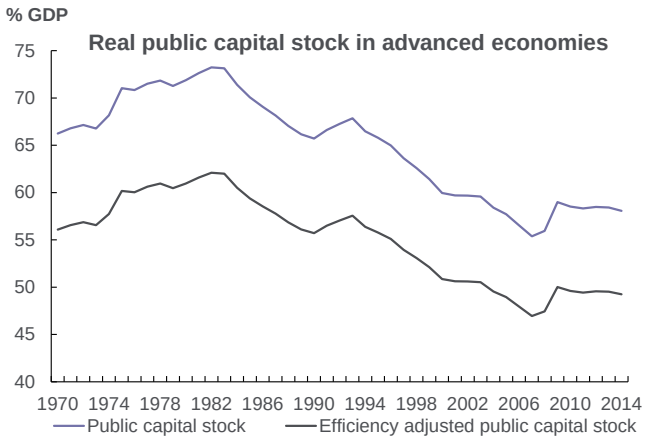
Historic spending

If we start by looking at what we have spent on infrastructure historically, one thing becomes very clear: considerably fewer resources are devoted to infrastructure today than was the case in the past.

Real public capital stock has fallen over the years in both advanced and emerging economies

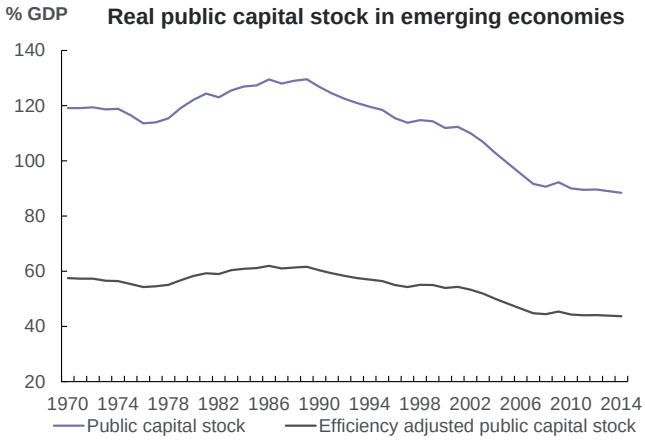
This is true both in advanced and emerging economies, as illustrated in Figure 1 and Figure 2. These charts adapt a methodology used by the International Monetary Fund (IMF) to calculate the real stock of public capital. That stock has fallen from an early-1980s peak of almost 75% of GDP to just below 60% today. In emerging economies, the stock has fallen from a late-80s peak of around 130% GDP to a level nearer 90% today.

Figure 1. The Stock of Public Capital has Fallen Sharply in Advanced Economies...



Source: OECD World Development Indicators, Haver Analytics, Citi Research

Figure 2. ...and in Emerging Economies Too

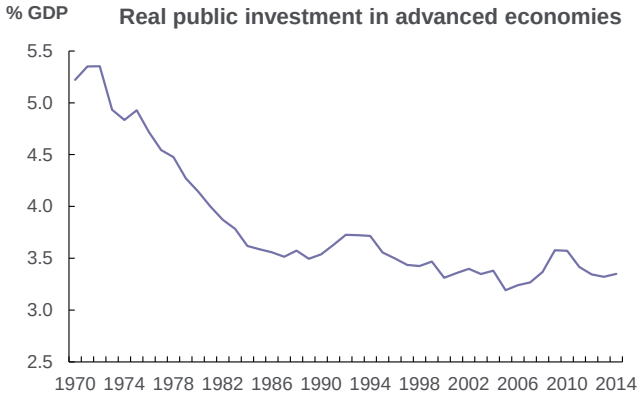


Source: OECD World Development Indicators, Haver Analytics, Citi Research

This isn't necessarily to say that infrastructure is 'worse' than it was two or three decades ago, as we must remember that GDP has increased dramatically over the period. What appears to be true is that the rate of public investment has fallen, and the capital stock relative to GDP too. Some of the latter may be entirely technological or measurement-driven.

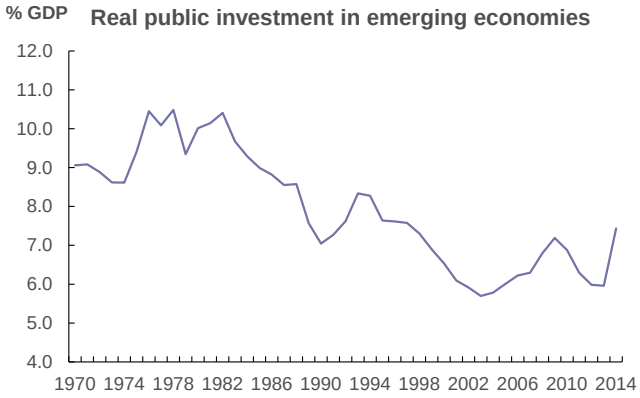
One of the most obvious reasons for the reduction in public capital stock, or the 'infrastructure deficit', is that we spend less on it proportionately than we used to, as shown in Figure 3 and Figure 4.

Figure 3. One Reason Why the Stock of Infrastructure Has Fallen in Advanced Economies is That the Flow of Public Investment Is Weak...



Source: OECD World Development, Haver Analytics, Citi Research

Figure 4. ...and the Same Is True of Emerging Economies



Source: OECD World Development, Haver Analytics, Citi Research

One of the problems with the 'capital stock' approach though is that it is based on all public capital formation and hence captures all investment, including inventories etc. Therefore while it presents an informative 'top down' picture on overall investment levels and the relative value of capital stock, it perhaps doesn't present a pure enough picture of investment in the four key areas of infrastructure which we are attempting to analyze in this report.

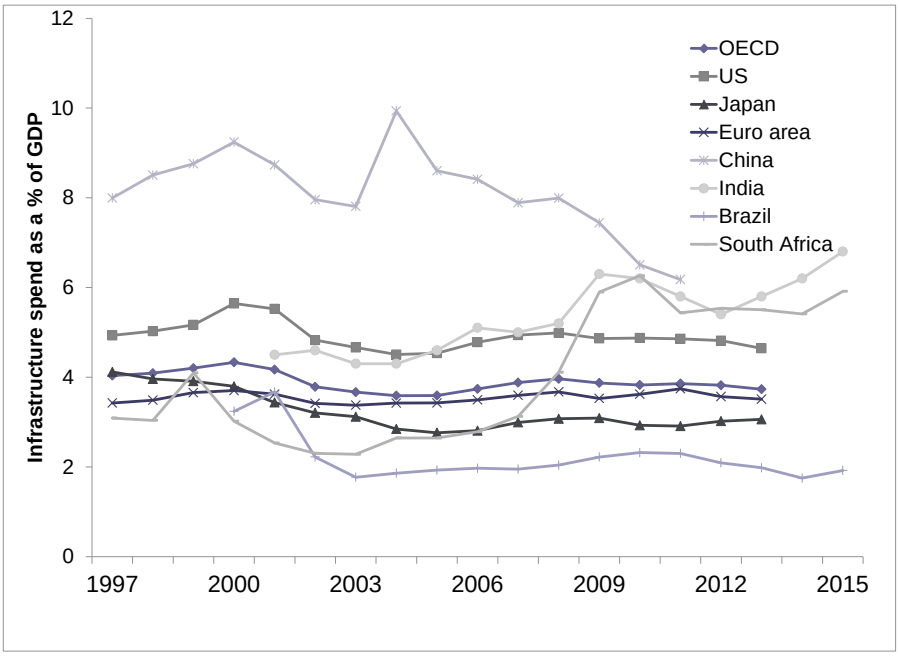
Conducting a bottom-up analysis of infrastructure spend has proved to be difficult due to the lack of available data

However, when one attempts to conduct a bottom-up analysis of investment by sector or country, one hits the first (rather surprising) hurdle – the data either doesn't exist, is incomplete, or has never been collated. Given the significance of infrastructure investment and the scale of the industry, this is rather staggering.

The availability of data varies significantly between countries and sectors with, unsurprisingly, data being (usually but not always) better from developed markets (DMs) than emerging markets (EMs). Moreover, certain markets are clearly more important in a global context given their scale and/or rate of growth, and for the purpose of our analysis in this report we have focused on the main markets of the US, UK, Japan, China, South Africa, and Brazil, and we also collate where possible data for the Euro Area, Organization for Economic Co-operation & Development (OECD), and 'Rest of World'.

If we examine more recent history across these markets, we can see quite how much infrastructure spend (both public and private) has varied across those markets.

Figure 5. Infrastructure Spend as a % of GDP Against Time



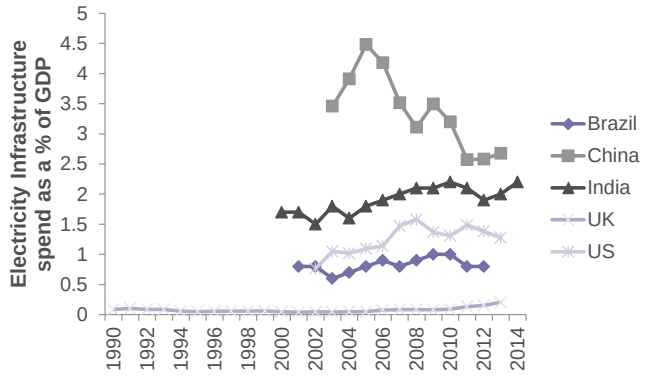
Source: OECD, Planned Commission of India, Consultoria Pezco Microanalysis, Citi Research

As Figure 5 shows, while Chinese spending has been high in a relative context, spending in Brazil, another 'BRIC' country[1], has been lower even than in developed markets, and few countries, with the exception of India and South Africa, have been increasing infrastructure investment, with spending in most either static or falling.

This can be further broken down into investment into the four main areas of infrastructure, namely transport, telecoms, energy, and water, which we address in dedicated chapters later in this report.

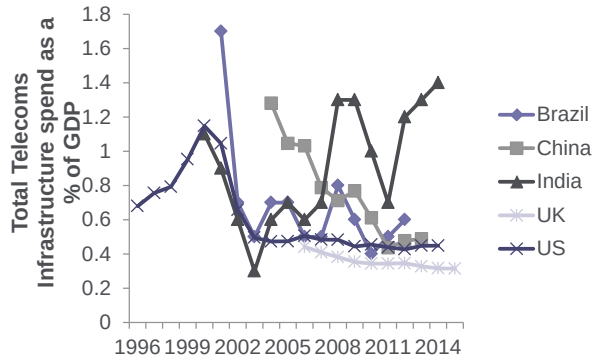
[1] BRIC is a grouping acronym referring to the countries of Brazil, Russia, India and China.

Figure 6. Electricity Investment as a % of GDP



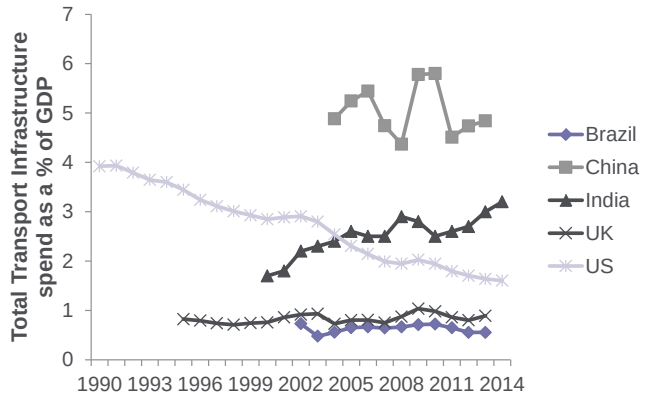
Source: China Statistics, BNDES, Planning Commission India, Citi Research

Figure 7. Telecoms Investment as a % of GDP



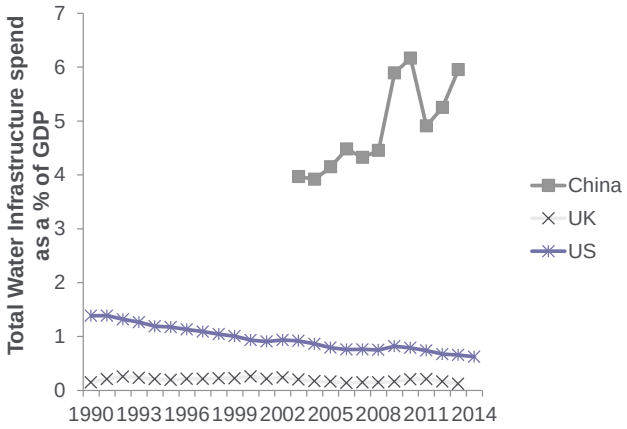
Source: Planning Commission India, US Telecoms, China Statistics, Citi Research

Figure 8. Transport Investment as a % of GDP



Source: Planning Commission India, China Statistics, Congressional Budget Office, OECD, Citi Research

Figure 9. Water Investment as a % of GDP



Source: Planning Commission India, China Statistics, Congressional Budget Office, OECD, Citi Research

These produce an even 'messier' dataset, with even greater divergences of spend between countries, even those at similar stages of development.

This highlights the second of the 'surprises' versus our expectations for this report. Intuitively we had expected that there would be an 'order' to investment, with countries investing first in energy and transport, with telecoms coming later. However, combining all of the data sets does not produce the 'waterfall' time series that we would have expected to see globally; rather it seems to imply that countries invest in all forms of infrastructure in a consistent relative profile, though admittedly at differing overall levels vs. GDP. This may be partly to do with the rather short-dated nature of our dataset; however, collating any sort of consistent data from pre-2000 becomes even more problematic.

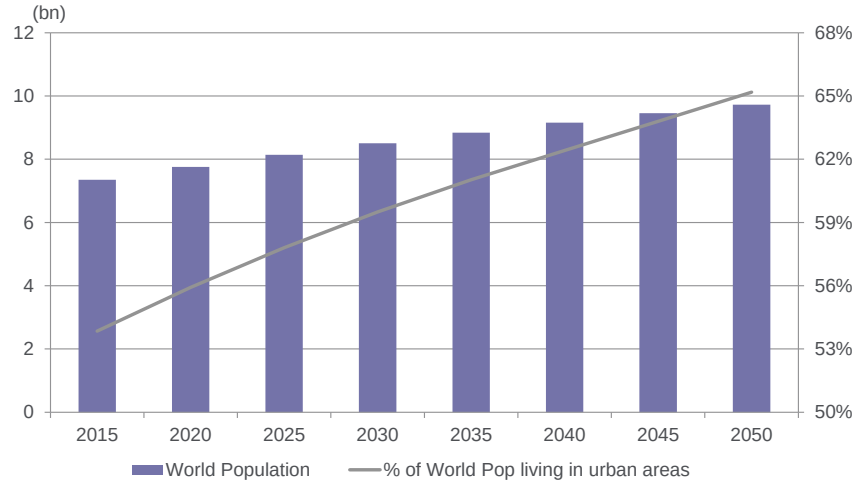
So much for the historic levels of spend – so how do we work out what we should be spending?

The Social Argument for Infrastructure Investment

There are still over 1.5 billion people who have no access to electricity

As discussed, infrastructure forms a basic part of our modern societies. Yet around the world, over 1.5 billion people have no access to electricity, and just under 1 billion still live without safe drinking water. Over 2.5 billion are without access to basic sanitation. The UN thinks the planet will have to accommodate an additional 1.5 billion people in the next 20 years, an increase of 20%. Almost all of that will be in the developing world, and almost all of that will be in urban centers which, by definition, are infrastructure-heavy.

Figure 10. Global Population Forecast to Increase to 2050, with Greater Urbanization



Source: UN, Department of Economic and Social Affairs, Population Division, Citi Research

We believe that (1) there is a strong argument for investment in infrastructure on economic grounds alone and (2) we also believe that the private sector can step up to the plate in conjunction with public finances to fill the financing gap

So the social argument for more infrastructure investment, especially in emerging markets, is self-evident and compelling. The usual argument against it goes along the lines of 'we can't afford it' or 'where will the money come from?', and we address these two points in turn. First, we believe that there is a strong argument for investment in infrastructure on economic grounds alone, and second, we believe that the private sector can step up to the plate, in conjunction with public finances — aided by historically low borrowing costs — to fill that financing gap.

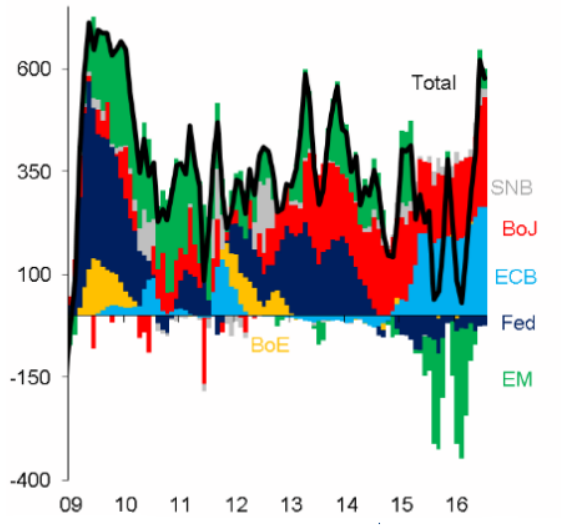
The Economic Case for Infrastructure Investment

A fiscal policy opportunity

Policymakers seem to be running out of levers to pull to try to boost global economic growth. We now live in a world of historically low, or even negative real interest rates, and quantitative easing (QE) has been deployed widely, and on a staggering scale, as highlighted by Figure 11 and Figure 12. In developed markets, central bank asset purchases are raising questions about the risk of asset bubbles, while negative interest rates are generating doubts about bank profitability and nervousness about the business models of pension providers, insurance companies, and money market funds.

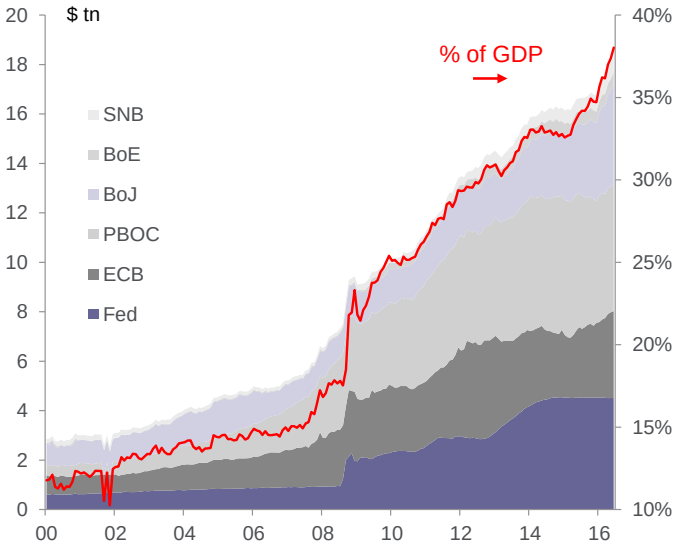
It is also true in emerging economies that monetary policy may be losing its effectiveness. The reason for this is that many countries in EM have had a credit boom at some point in the past few years – Russia, India, Brazil, China, Turkey and Indonesia are all good examples – so further interest rate cuts might have a scant effect in revving up credit markets if borrowers and lenders are already feeling overfed by credit.

Figure 11. Global Central Bank Securities Purchases (rolling 3m, $bn)



Source: National central banks. Fed data are >5y maturity so as to better capture Operation Twist; recent negatives simply show securities moving <5y

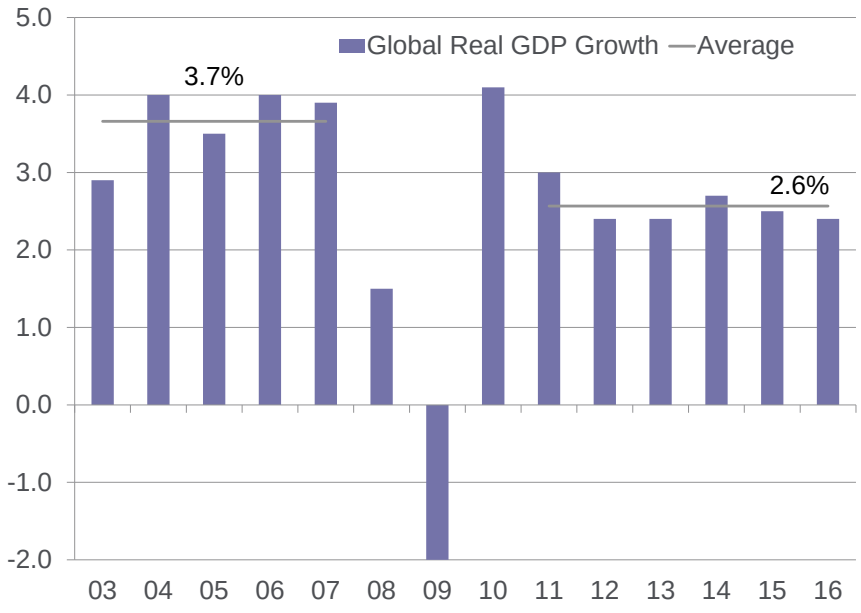
Figure 12. Aggregate Balance Sheet of Large Central Banks ($trn, and % of GDP)



Source: Citi Research, Haver

Despite all these measures, we see signs of weak demand globally (Figure 13), as suggested by sluggish global growth and low inflation rates (at least in DM). At the same time, people worry about weak supply, as suggested by low recent productivity growth almost anywhere (including in EMs), aging populations, and generally relatively low potential growth estimates.

Figure 13. Global GDP Growth Has Been, and Remains, Sluggish



Source: Citi Research

Accordingly, monetary policy is now viewed widely as being ineffective in supporting growth, and indeed as creating its own problems.

So, if central banks are running out of monetary rope, then maybe fiscal policy can come to the rescue? And if fiscal policy is the right tool, then maybe infrastructure spending is an obvious way to deploy the tool. After all, infrastructure spending tends to be equivalent to fiscal spending (or, at least, the borrowing that's done to finance infrastructure tends to end up as a liability of the state).

The theory

Any improvement in infrastructure can help boost growth by boosting demand and supply

At its most basic, the case for infrastructure spending is that almost any improvement in transport, communications, and utilities can help boost growth by boosting demand in the near term and supply in the long term. These two separate effects on income can be described as follows:

- The first is the 'demand effect' from the immediate boost to GDP growth that is generated by an increase in investment spending. This leads to increased demand for goods and services, and to job creation both in building it, and potentially also in 'operating' the asset. The income/wages generated by the increased demand are then spent elsewhere, resulting in a so-called 'fiscal multiplier' effect.

- The second effect is longer-term, because of the increase in productive capacity that is supposed to result from better roads, faster trains, bigger ports, more reliable power supplies, cleaner water, and broader wireless access. This can be thought of as the 'supply' effect. That's not true for any type of infrastructure, such as the stereotypical bridges to nowhere, but is rather obvious for electricity or basic transport infrastructure.

The construction of the Panama Canal eliminated 8,000 miles and weeks off a maritime journey between the Atlantic and Pacific Oceans

A perfect example of the second effect is the Panama Canal; its construction eliminated 8,000 miles and weeks from a maritime journey between the Atlantic and Pacific Oceans, a journey that previously would have entailed travelling around the notorious Cape Horn, with all its associated risks. Infrastructure is also hugely important in terms of relative economics and profitability (or even viability). In Indonesia, the cost of a container shipment from Padang to Jakarta is some three times the cost of the same container getting from Jakarta to Singapore, an almost identical distance. Brazilian soybean farmers have to spend a quarter of their income getting crop to Santos, the country's main port; Iowan farmers spend a tiny fraction of that. Developed markets, though, are hardly a shining model for the rest of the world to emulate. The American Society of Civil Engineers gave the US a 'D+' or 'poor' grade in its most recent report card on the state of American infrastructure.

Infrastructure spending may also offer some scope or hope for ideological and political consensus: it can potentially unify supply-siders that otherwise tend to think of fiscal stimulus in the form of consumption as wasteful and the Keynesians who can potentially warm to any form of fiscal stimulus.

The multiplier effect

The IMF found a 1% point of GDP rise in public investment spending can raise output by 0.4% in the same year, and 1.5% four years later

Let's imagine that governments make an effort to increase the stock of public capital[2] in an attempt to reduce the world's infrastructure deficit. Will this boost growth? Probably the rosiest view of the impact of infrastructure spending on growth comes from the IMF, in an assessment published in the 2014 World Economic Outlook[3]. The Fund's conclusion is that, for advanced economies, a 1 percentage point of GDP rise in public investment spending can raise output by 0.4 percent in the same year, and by 1.5 percent four years later. The impact is higher when growth is weak: then, the level of output rises by 1.5 percent in year one, and by 3 percent in the medium term.

By contrast, when growth is high or output gaps are small, the long-term effect of public investment 'is not statistically significantly different from zero', largely because it 'crowds out' other spending and hence does not induce incrementally faster growth. Compared to other types of spending, though, infrastructure does bring the promise of reducing supply constraints in the future so today's crowding out may still be a good price to pay.

The case for investment is clearest for EMs, but also exists in DMs, though the case for infrastructure is not obvious everywhere. In Spain, elements of transport infrastructure are excellent and the same applies in Portugal. In Japan, pre-earthquake, the room for more infrastructure investment was also far from obvious. However, in many countries such as Germany, 'excess infrastructure' coexists with shortages: for example there are lots of underutilized airports, while many bridges are in need of expenditure.

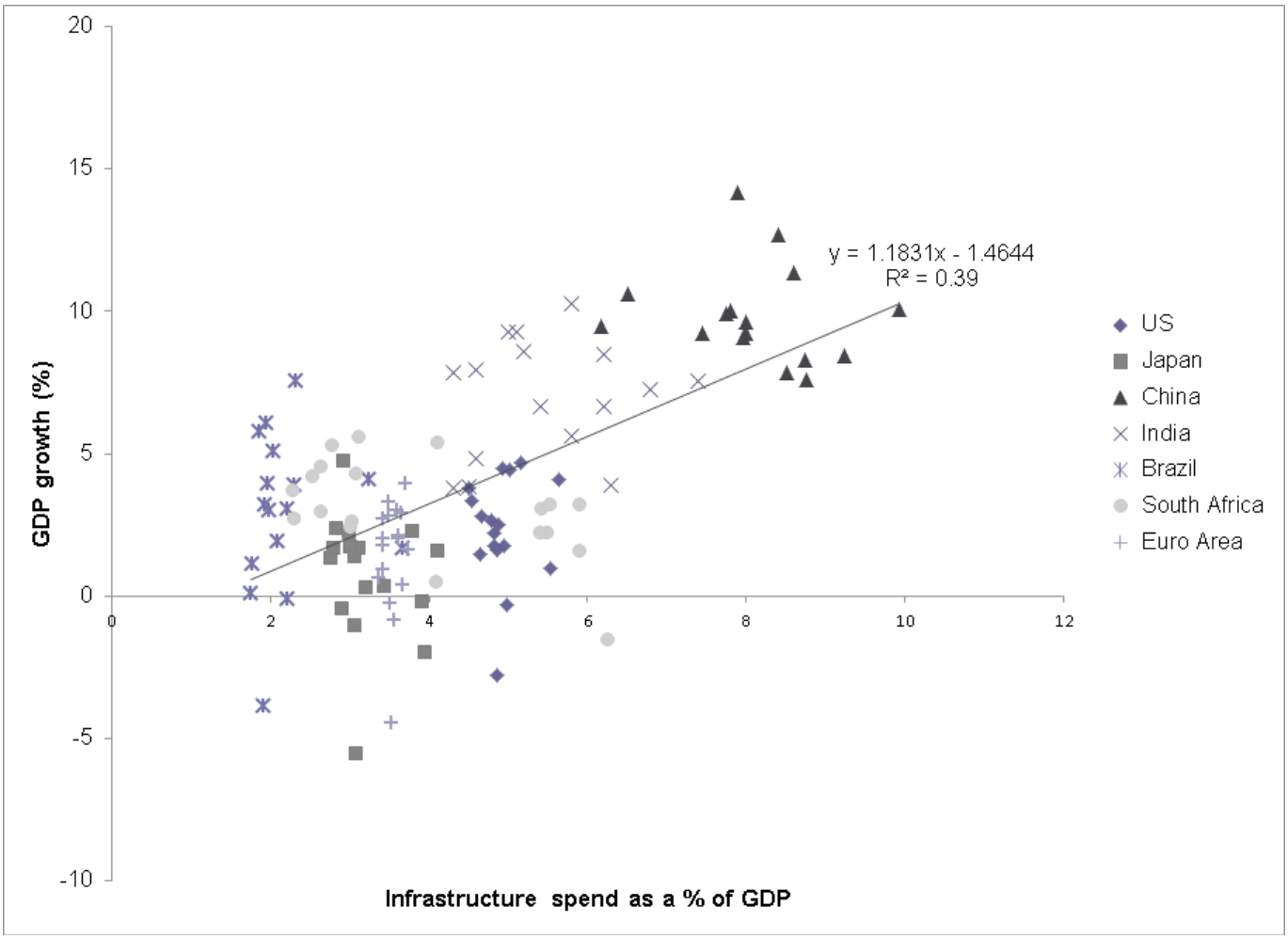
Our data finds a 15 increase in infrastructure investment is associated with a 1.2% increase in GDP growth

We have constructed our own dataset covering global infrastructure investment by country and industry over the last 15 years, with longer historic data where available, which appears to back up these theories empirically, as shown in Figure 14. The gradient of this line implies that, on average, a 1% increase in infrastructure investment is associated with a 1.2% increase in GDP growth.

[2] Public capital is the aggregate body of government-owned assets that are used as the means for private productivity. Infrastructure is the largest component of public capital and is sometimes referred to as 'physical stock'. (Wikipedia)

[3] '*Is it time for an infrastructure push? The macroeconomic effects of public investment*', IMF WEO 2014, Chapter 3. https://www.imf.org/external/pubs/ft/weo/2014/02/pdf/c3.pdf

Figure 14. GDP Growth vs Investment in Infrastructure as a % of GDP



Source: OECD, Citi Research

While there is an obvious 'shape' to the above data, it is clearly once again, 'messy', as shown by the R^2 figure of 0.39[4]. Experimenting with various orders of 'lines of best fit' provides mixed results, and R^2s improve only marginally. While some higher orders make sense intuitively (flattening off with higher expenditure, implying a law of diminishing returns), they also produce non-sensical inferences, such as turning back up as spend reduces below 1%, implying spending close to zero improves GDP, an outcome that is unlikely to be true. Accordingly, while clearly not perfect, we have chosen to keep it simple, and adopt a linear best-fit approach.

We also experimented with the second derivative of the data, plotting the change in infrastructure investment (both absolute and proportionate) against the change in GDP growth. Again, disappointingly, these produced even lower correlations, even when experimenting with time-lags.

[44] The R^2 (also known as the coefficient of determination) is a statistical measure that tells you how often one variable changes when another variable changes

There are clearly many other factors affecting the impact of infrastructure spend on the growth of the economy- including economic cycles, time lags etc.

The low R^2 in the basic data highlights that there are clearly many other factors affecting the impact of infrastructure spend on the rate of growth in an economy, such as:

- **Economic cycles** – We exist in global marketplace, and clearly the economic growth of one country will be impacted by the economic health of its trading partners. If we look for example at the Eurozone or US data on Figure 14, we can see that despite relatively constant levels of infrastructure spend, growth has varied between about +5% and -5%.

- **Natural resources and commodity cycles** – How have some countries (such as Brazil) managed to achieve relatively high levels of growth in some years, despite apparently spending very little on infrastructure overall? This is likely to have a lot to do with the 'make-up' of the economy, with for example heavily commodity-based economies benefitting from commodity cycles, whilst still apparently investing very little in infrastructure (though of course they do need to have invested in the infrastructure such as upstream energy and ports to allow them to benefit from those cycles).

- **Infrastructure stocks and output gaps** – An output gap refers to the difference (or gap) between actual GDP levels and the maximum potential levels of GDP, the latter often being defined by 'full employment'. A negative output gap implies sluggish growth (weak demand) and low levels of employment, effects which can be seen currently in many areas around the world. Simplistically, a dollar spent on infrastructure in a country where there is no infrastructure is likely to be more productive than one spent in a country where there is lots. In fact, there's some evidence that when a government increases spending on infrastructure where a lot already exists, that might have the effect of crowding out private sector activity and actually *reducing* the rate of growth, instead of increasing it. One example of this on Figure 14 is Japan, where the historic data shows a majority of years with either negative, or close to zero, growth despite levels of investment which have facilitated growth in other economies. Japan invested heavily in infrastructure in earlier decades and hence further investment in infrastructure may have had a more limited effect on economic growth. Other factors such as demographics (aging populations) will clearly have an impact, as will the high levels of debt associated with earlier infrastructure pushes. While the historic data relates to significant negative output gaps, it is notable that the most recent Bank of Japan data shows an output gap approaching zero, with implied growth levels improving accordingly.

- **Time lags** – Given the long lead times on infrastructure, it is unlikely that the full effects of investments made in one year will be realized in the same year. We explore this effect in more detail later under 'causality'.

- **'Institutional capacity'**[5] – This relates to the efficiency with which infrastructure spending is conducted. Can a government choose and design the right infrastructure projects? Will officials select projects that are genuinely bottleneck-releasing, or will they choose 'white elephants'? Are officials the target of lobbyists that will put private interests above social ones? And once a government announces an 'infrastructure push', will that mean that project analysis becomes less rigorous when everyone understands that the government's priority is merely to get digging? Will this lead to enormous over-spends and delays? Accordingly the multiplier effect can be heavily influenced by the efficiency of infrastructure investment, meaning that, in some countries with fragile political and legal systems, spend can vastly outweigh any potential economic benefit in a supply sense. Ironically, while the basic multiplier effects might be better in EMs, the efficiency of investment tends to be lower. Accordingly, both EMs and DMs have their positives and negatives.

So there are many other factors affecting growth rates which Figure 14 is unable to capture. It would theoretically be possible to screen and manipulate this data to exclude effects such as global recessions, excessive infrastructure spend (potentially via levels of indebtedness, capital stock vs GDP, output gaps), exposure to commodity cycles etc., but these rather complex analytical processes will at this stage have to remain areas for future investigation.

These caveats could cast doubts on the relationship between infrastructure spend and economic growth

Everyone will be happy to acknowledge these caveats, and maybe it is precisely because of all these caveats that it is possible to cast doubt on the idea that infrastructure spending does anything really to support growth rates. Ironically, the best statement of this 'infrastructure pessimism' in recent years comes from the IMF — the very institution that has also published the most optimistic assessment of the effectiveness of infrastructure spending. In a 2014 paper, Andrew Warner concludes that public investment pushes have a small positive and instantaneous effect on growth, but little long run impact.[6] His conclusion is that overall, "it is difficult to find a clear-cut example that fits the oft-repeated narrative of a public investment boom followed by an acceleration in GDP growth". At best then, this analysis suggests that infrastructure spending may have no better effect than any ordinary fiscal stimulus: the bottleneck-releasing effect is difficult to identify.

Causality

The other significant debate is about which way causality runs. The common intuition is that infrastructure spending *causes* growth. But maybe it's simply the case that higher income levels increase the demand for infrastructure? So periods of growth can be *associated* with an infrastructure push, but may not be caused by it. In Korea and Taiwan, for example, infrastructure pushes were a response to congestion caused by several years of rapid growth. Korea's President Park announced a major national reconstruction plan in 1967 largely because of the infrastructure shortages exposed after a period of very rapid growth in the mid-1960s. Taiwan's surge in public investment during the 1970s, which centered on ten major construction projects, followed the same pattern: it was a response to years of rapid growth, rather than the cause of them. A surge in commodity prices might prompt the government of a commodity-exporting country to invest in infrastructure

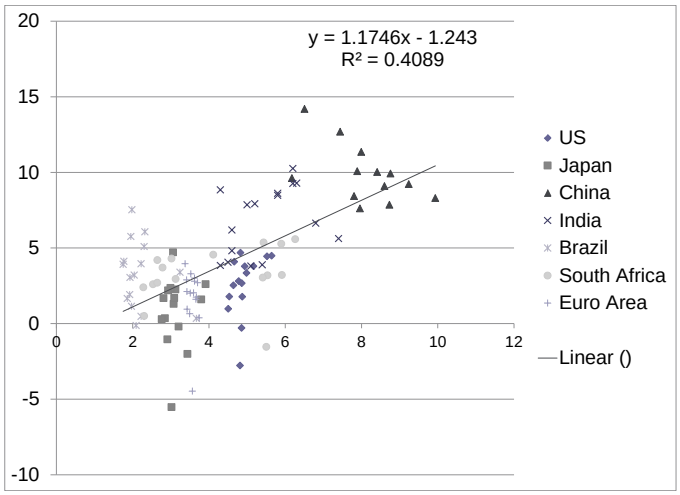
[5] See '*Infrastructure spending as a catalyst of growth and transition'*, Piroska Nagy, Michel Nies and Alexander Plekhanov, August 2015. http://www.ebrd.com/news/2015/infrastructure-spending-as-a-catalyst-of-growth-and-transition.html

[6] '*Public investment as an engine of growth'*, Andrew M Warner, August 2014. https://www.imf.org/external/pubs/ft/wp/2014/wp14148.pdf

to take advantage of the boom, but where did growth come from: the gain in the terms of trade or the infrastructure spending?

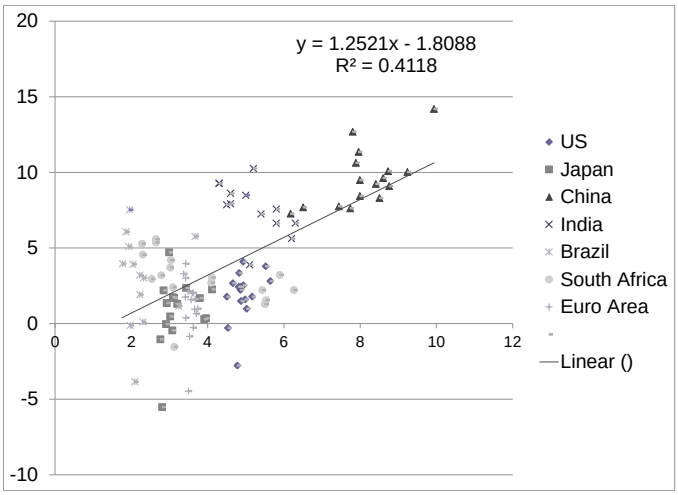
We can 'test' for this causality by examining time leads and time lags between investment and GDP growth. For this analysis we examined the relationship between GDP growth in a particular year, and infrastructure investment in both the three years prior, and the three years post that year, and screened for any significant shift in the R^2 correlation on the chart. Rather than posting all seven charts, Figure 15 and Figure 16 show the -3 and +3 year time leads and lags.

Figure 15. Infrastructure Investment vs GDP Growth 3 Years Later



Source: Citi Research

Figure 16. Infrastructure Investment vs. GDP Growth 3 Years Prior



Source: Citi Research

Interestingly across all seven scenarios (-3 to +3 years), the R^2 correlation hardly varies at all, as shown in Figure 17.

Figure 17. Correlation Between GDP Growth and Infrastructure Investment, with Various Time Lag-Lead Scenarios (+3 Implies Expenditure 3 Years after Year of GDP Growth)

Time Lag	R Squared	Gradient
3	0.41	1.25
2	0.41	1.24
1	0.39	1.21
0	0.39	1.18
-1	0.40	1.18
-2	0.41	1.18
-3	0.41	1.17
Average	0.40	1.20

Source: Citi Research

With an R^2 barely changing between 0.39 and 0.41, this implies (again rather disappointingly) that there is no simple answer to the argument over causality, and rather that investment goes hand in hand with growth.

There is a link between high-quality infrastructure and GDP per capita

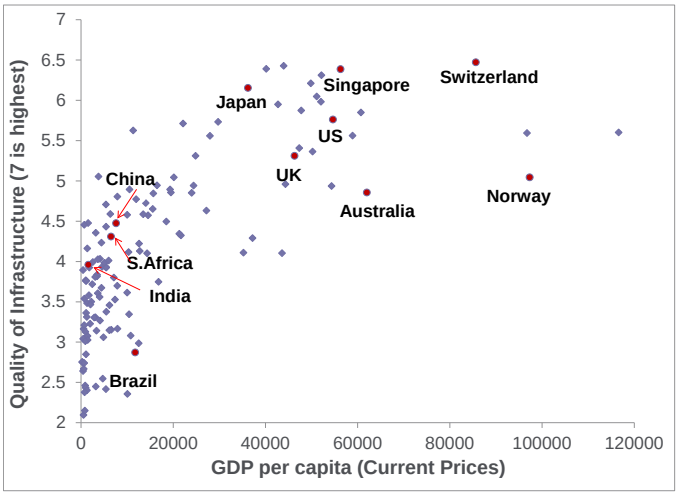
Despite all of these caveats, one thing is clear — high-quality infrastructure and levels of wealth (as measured by GDP per capita) certainly go hand in hand, as shown in Figure 19. While the data will once again be affected by, for example, the country's fortuitous (or otherwise) level of natural resources such as oil or petrochemicals, there is a clear correlation and one certainly can't achieve high levels of GDP per capita with poor infrastructure.

Figure 18. Ranking of Quality of Infrastructure in Different Countries

Country	Overall Rank (out of 144)	Score 1-7
Switzerland	1	6.5
UAE	2	6.4
Hong Kong	3	6.4
Singapore	4	6.4
Netherlands	5	6.3
Finland	6	6.2
Japan	7	6.2
Australia	8	6.0
Iceland	9	6.0
France	10	5.9
US	13	5.8
UK	24	5.3
China	51	4.5
S. Africa	59	4.3
India	74	3.96
Brazil	123	2.90

Source: World Economic Forum[7], Citi Research

Figure 19. Quality of Infrastructure Against GDP per Capita



Source: World Economic Forum[7], World Bank Citi Research

We believe there is a strong case for boosting infrastructure investment given the potential economic and social benefits

The previous caveats over output gaps etc. notwithstanding, if used effectively, infrastructure investment can clearly be used to boost GDP growth, or to look at it another way, one cannot achieve GDP growth beyond a point without investing in infrastructure. Hence with global growth stuttering, and with the current monetary policy medicine seeming to have little effect, we believe that there is a very strong case for boosting infrastructure investment given the potential economic benefits and the undoubted social benefits.

[7] World Economic Forum, The Global Competitiveness Index Historical Dataset 2005-2015

The Scale of the Opportunity

It is estimated that infrastructure spending for emerging markets alone will need to increase from $0.8 trillion to $2 trillion per year to maintain growth

So how do we assess what the global infrastructure gap is, and what the scale of the opportunity is? It is notoriously tricky to quantify what the world's infrastructure shortage is. A common complaint of economists trying to study these issues is the lack of good data on the world's stock of infrastructure, and on the rate of return on infrastructure spending in the past. These difficulties haven't, however, stopped economists from trying to estimate what needs to be spent. A typical approach can be found in a 2012 paper by Bhattacharya, Romani and Stern[8], who believe that infrastructure spending for emerging economies alone will need to increase from around $0.8 trillion per year to around $2 trillion to maintain growth. This $1.2 trillion increase amounts to roughly 5% of the respective countries' GDP.

These are described as 'conservative numbers' and, critically, don't account for maintenance and depreciation. Including these would 'approximately double' what's needed. A more recent World Bank paper, by contrast, has a lower estimate, arguing instead for an increase in investment of $0.8 trillion for emerging economies *including* maintenance and depreciation[9].

Infrastructure spending needs to increase from $2.5 trillion to $3.6 trillion per year

The world today spends approximately $2.5 trillion a year on infrastructure (water, power, transportation, and telecommunications) which is approximately 3.5% of global GDP. According to McKinsey[10], this is not enough and spending needs to increase to approximately $3.6 trillion per year from 2016 through to 2030, with the largest investment needed in the power sector ($1.1 trillion per year), followed by roads ($0.9 trillion per year). Over 60% of this investment is required in emerging economies. The authors assume a global GDP growth rate of 3.3%.

Our analysis using the 'capital stock' methodology outlined earlier shows that in order to return to their respective long-term average stock of public capital as a share of GDP by 2035, emerging economies would on average have to spend around 9% of GDP per year. This would amount to a total of $65 trillion over the next 20 years. However, if they were to increase their efficiency, e.g. to the level of Chile, the financing need would on average drop to around 5% of GDP or a total of approximately $40 trillion across emerging markets. Advanced economies stand to benefit from increased efficiency in public spending as well, albeit to a lesser degree. We estimate that around $45 trillion of investment will be needed across advanced markets in order to return to their respective long-term average stock of public capital. Increasing efficiency to the level of Singapore would reduce this number by almost $10 trillion and could save the average advanced economy approximately 1% of GDP in public expenditure.

However, as before, the public capital stock includes all sorts of capital formation, including inventories etc., and hence may not be the 'purest' measure of infrastructure.

What is the investment needed to achieve current forecast levels of growth?

Perhaps a more informative methodology is to use the relationship derived from our previous dataset to ascertain the amount of investment needed to achieve current forecast levels of growth, as shown in Figure 20.

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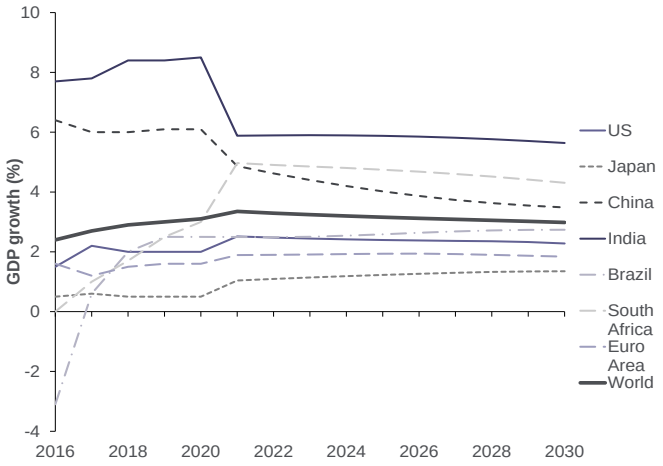
[8] '*Infrastructure for development: meeting the challenge*', Amar Bhattacharya, Mattia Romani and Nicholas Stern, June 2012. http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/03/PP-infrastructure-for-development-meeting-the-challenge.pdf

[9] '*Infrastructure investment demands in emerging markets and developing economies*', Fernanda Ruiz-Nunez and Zichao Wei, September 2015. http://documents.worldbank.org/curated/en/141021468190774181/pdf/WPS7414.pdf

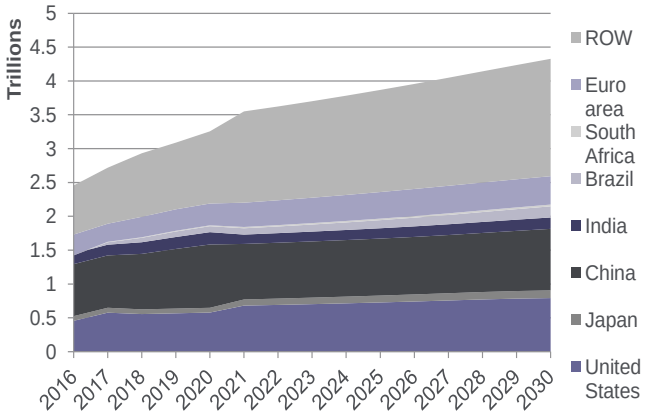
[10] McKinsey Global Institute, Bridging Global Infrastructure Gaps, June 2016

Figure 20. Forecast Global GDP Growth Rates



Source: Citi Research (to 2020), OECD (post 2020)

Figure 21. Implied Infrastructure Spend to Meet Current Growth Forecasts

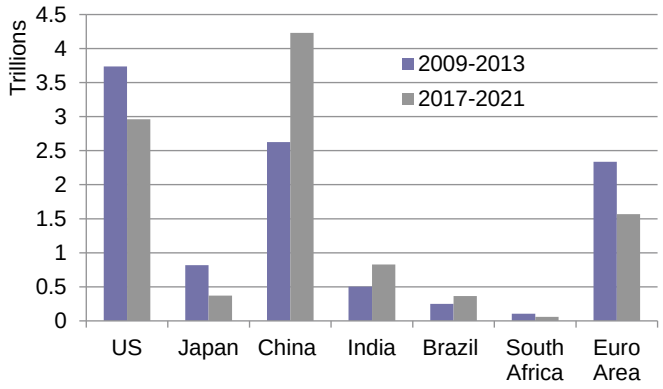


Source: Citi Research

This derives the total global spend as shown in Figure 21, showing that global investment in infrastructure will have to increase from current levels of around $2.5 trillion per year to around $4.3 trillion by 2030, with effectively all of that growth in investment coming from emerging markets. This implies a total global spend over the next 15 years of some $53.7 trillion.

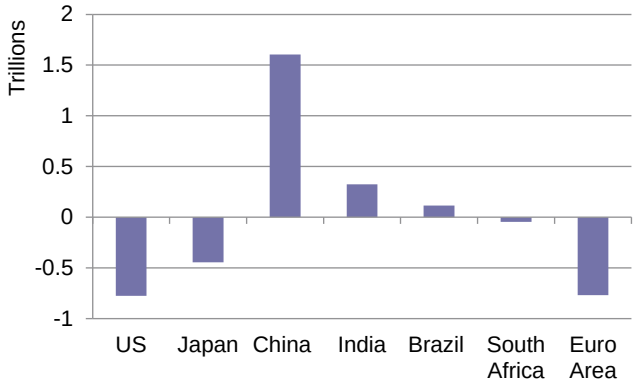
It is also informative to look at the implied delta in investment between historic levels of spend (2000-2015) and our forecast period of 2016-2030, the results being shown in Figure 22 and Figure 23.

Figure 22. Comparison Between Historic Spend and Implied Future Spend



Source: Citi Research

Figure 23. Delta in Investment Between Historic and Future Levels



Source: Citi Research

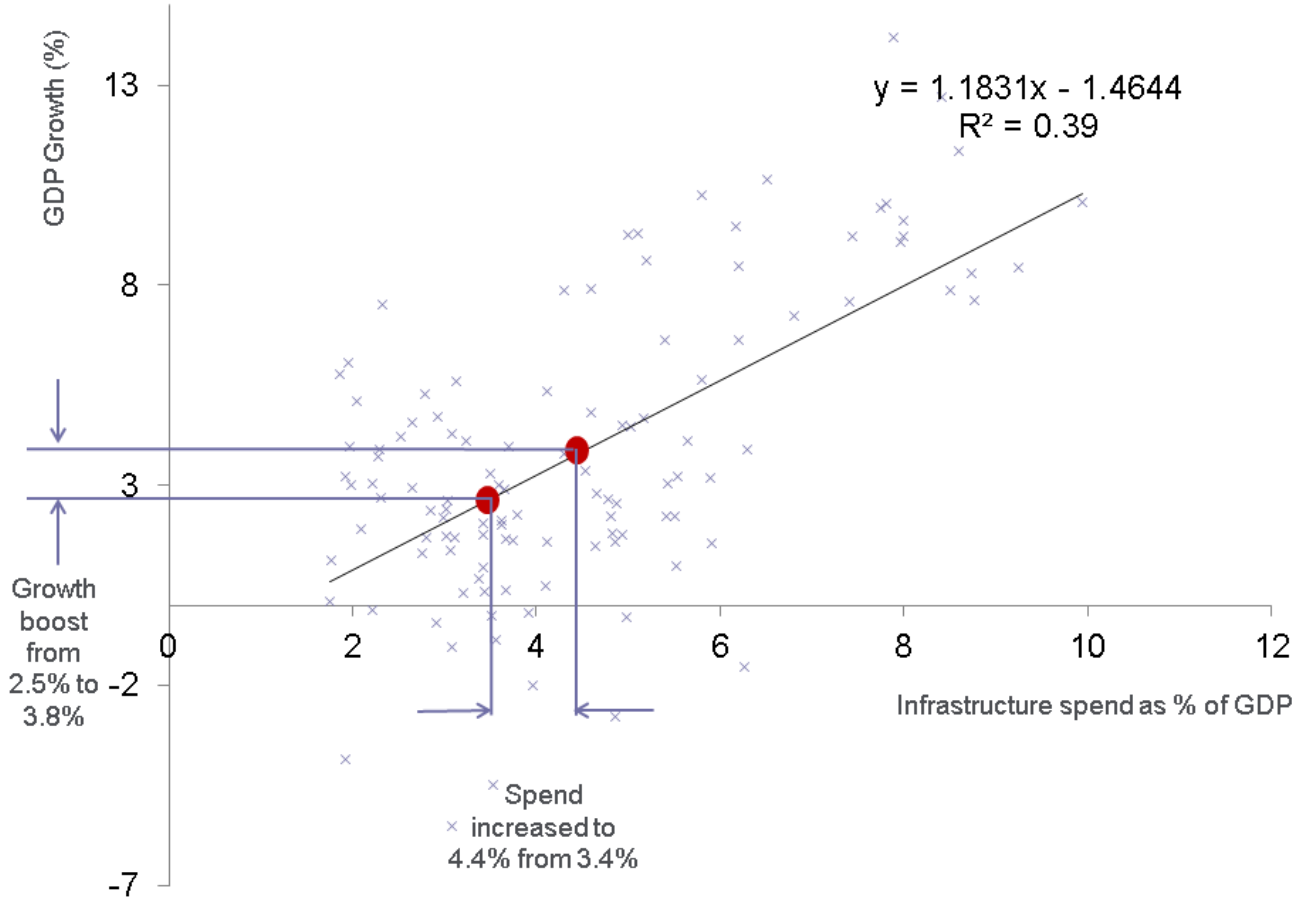
How much should we invest to get to desired levels of global growth?

However, Figure 23 highlights the flaws in this approach, most notably with implied Euro Area investment actually falling versus recent history. This is because this approach derives the spend 'commensurate' with a rate of growth, and forecast growth rates for various economies such as the Euro Area or Japan are rather anemic (exactly the problem we are trying to resolve), hence implying low levels of future investment. What we should really be interested in, is how much *should* we be investing to get global growth out of the doldrums and back to the levels which we desire?

The (Citi) GDP growth projections used in Figure 20 above imply a compound average growth rate (CAGR) in GDP from 2016-2020 of 2.9%. Examining the required level of infrastructure spend of course involves choosing a desired growth rate (within reason!), and we have chosen for the sake of example to use the OECD's previous (2014) forecasts for growth from 2016-2020, which imply a CAGR of 3.6% over the same period.

Using Citi's 2015 global GDP growth figure of 2.5% as a baseline, to boost this growth rate to the OECD's previous global GDP growth figure 3.8% in 2017 (much higher than Citi's current forecast for 2017 of 2.7%) would imply an increase in investment in infrastructure from 3.4% of global GDP to 4.4%, i.e. an extra 1% of GDP, representing an increase in investment of around $800 billion, as highlighted in Figure 24. Clearly this is 'theoretical', as it would be almost impossible to mobilize that extra investment within the next 12 months – the comparison is merely chosen to explain the methodology, and to give an idea of the levels of extra investment to which we should aspire, if we desire more robust global growth.

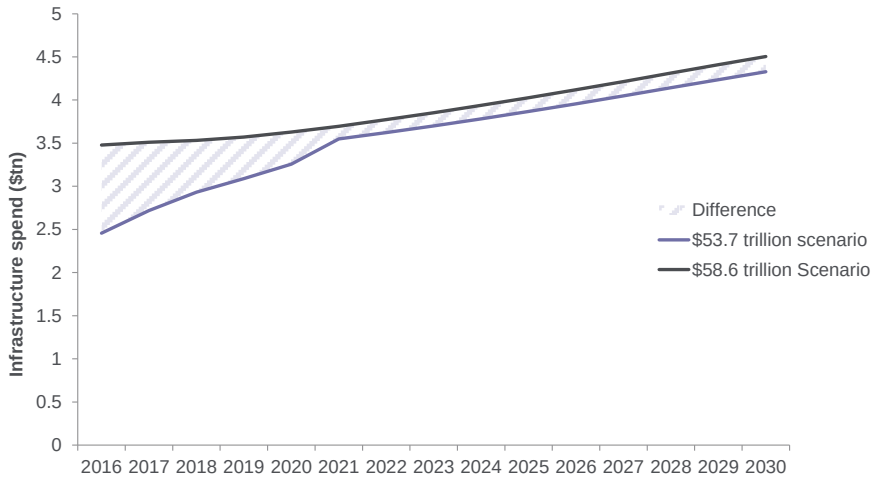
Figure 24. Implied Increase in Investment to Achieve Previous Growth Forecasts



Source: Citi Research

If we apply this differential methodology across a multi-year period, we achieve a spend 'differential' between current growth forecasts and higher 'desired' growth forecasts as shown in Figure 25.

Figure 25. Spend Differential Between the $53.7 Trillion and $58.6 Trillion Scenarios



Source: Citi Research

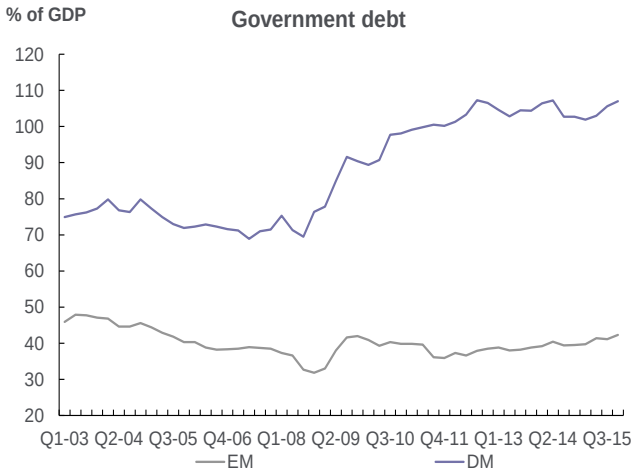
Infrastructure spend would need to reach $58.6 trillion from 2016 to 2030

As Figure 25 shows, using these figures would imply an increase in global spend from a 2013 level of around $2.5 trillion, to an average across the 2016-2020 period of $3.5 trillion, an initial increase of $1 trillion or 40%, although the gap narrows over time. Cumulatively this would boost the total investment in infrastructure to 2030 to $58.6 trillion (vs. our previous figure of $53.7trn), the bulk of the difference being in the early years.

The bulk of growth in investment will come from emerging markets

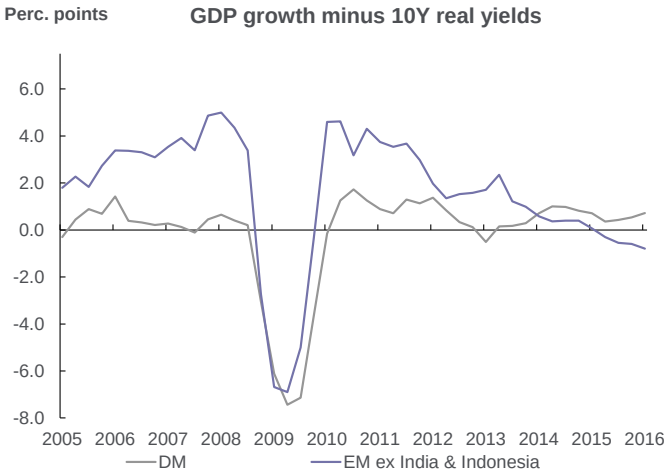
As discussed, the bulk of the growth in investment in future years will come from emerging markets, by virtue of their faster growth rates. However, if developed markets wish to kick start their growth beyond the effect implied purely by reinvigorated EM demand, they too have the opportunity to boost infrastructure investment. There are however stark differences between advanced and emerging economies in terms of their ability to boost investment. Advanced economies have rather high public debt/GDP ratios, exceeding 100% on average, while emerging economies have rather low ones, closer to 40% (Figure 26). Does this mean that there is more space for infrastructure investment in EMs than in DMs?

Figure 26. Low Public Debt Stocks in Emerging Economies Don't Necessarily Give EMs the Space to Spend on Infrastructure…



Source: Citi Research

Figure 27. …and in Advanced Economies the Cost of Borrowing is Lower than the Growth Rate, Providing Space for Fiscal Expansion



Source: Citi Research

Not quite. Although public debt/GDP ratios in EMs are low, they are low for a reason: namely, private capital markets have relatively little tolerance for rising public debt burdens in these countries, since more debt would threaten these countries' sovereign creditworthiness. By contrast, advanced economies have a significant advantage in boosting infrastructure spending relative to emerging economies: borrowing is so cheap. This is illustrated in Figure 27, which shows the difference between the real growth rate and the real cost of borrowing. Since this gap is positive, there is space for advanced economies to run higher fiscal deficits without any disturbing consequences for public debt dynamics. In EMs, by contrast, the difference between GDP growth and real government bond yields has been declining since 2009. This constrains the fiscal space of governments, since they need to run higher primary surpluses in order to avoid rapid increases in public debt levels.

One possible explanation for the difference between the two groups might be that advanced economies are more service-heavy, and thus potentially less infrastructure-dependent per unit of GDP. Another could be related to the efficiency with which infrastructure capital is deployed. Once the capital stocks are adjusted for the efficiency of government expenditure (using the World Governance Indicator for "government effectiveness"), capital stocks seem more similar across the two groups of countries, with emerging economies falling even slightly below the level of advanced economies. If governments target a certain level of functionality, it might be that countries with less efficient public institutions allocate comparatively more resources to infrastructure in order to obtain the desired outcome.

We see little reason why the private sector can't step up to the plate and plug the infrastructure gap

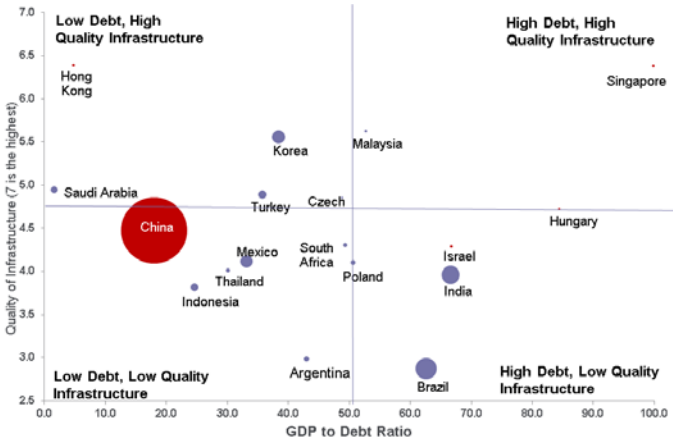
It isn't all about public investment though. While the reality is that the vast bulk of infrastructure has historically tended to be an endeavor of the public sector — due to enormous upfront costs, long payback periods, assets may not be initially economically viable, and returns that are generated by an infrastructure project which don't necessarily accrue only to the investor, but to society as a whole — this is less likely to be the case going forwards. In developed markets where demand is established, sufficient, and affordable, a significant portion of infrastructure is now privately owned and operated — think electricity companies, water companies, telecoms networks, railways operators, bus companies, and airports — while those performing a more specific 'social good' with less obvious immediate economic

benefits, such as schools and hospitals, tend to remain the preserve of public investment. We see little reason why, with the need for investment to fill the infrastructure deficit, and with private capital desperate for longer term returns, the private sector can't step up to the plate to plug the gap.

Countries with lower-quality infrastructure and high public debt could provide the greater opportunity for private capital infrastructure investment

So where are the best opportunities around the world? Figure 28 and Figure 29 show, for emerging and developed markets respectively, the quality of infrastructure versus the public debt-to-GDP ratio. Simplistically, countries with lower-quality infrastructure clearly have a greater need for investment, and if this is combined with high levels of public debt, then there should be a greater opportunity for private capital to step in and fill that gap.

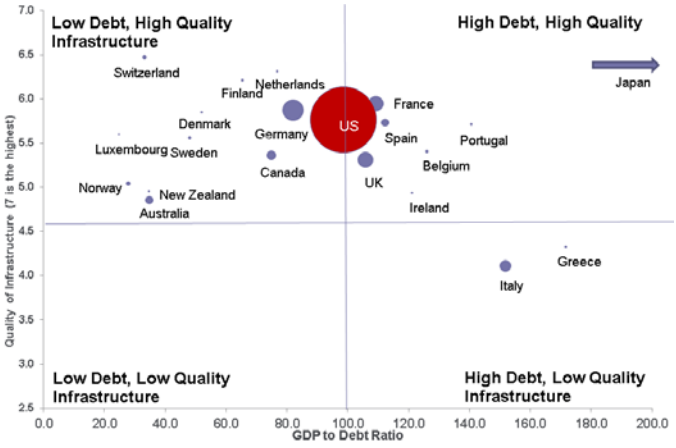
Figure 28. Emerging Market Infrastructure Quality vs. Public Debt (bubble size represents relative GDP, China=100)



Source: Citi Research

Data on quality of infrastructure was obtained from World Economic Forum[7]

Figure 29. Developed Market Infrastructure Quality vs. Public Debt (bubble size represents relative GDP, US=100)



Source: Citi Research

In emerging markets we can see that, while China dwarfs its neighbors in terms of the scale of the opportunity, its infrastructure is in a relative sense reasonably good on a relative basis, with the low debt levels showing a relatively small private opportunity, and given its nature as a command economy. Most attractive would appear to be Brazil, given its low infrastructure quality, relatively high debt, and as we saw earlier, what have been very low levels of investment in infrastructure vs. GDP. India represents perhaps the greatest opportunity, with a large market, relatively low quality infrastructure/high debt, but with relatively well-established markets and a history of inward investment – not to mention a fast-growing population and economy.

In developed markets, the UK stands out as a significant opportunity given its size, debt levels and legal stability

In developed markets, as seen in Figure 29, the picture is less clear. Italy and Greece stand out, the former clearly being a significantly larger market, though current economic and banking woes may raise perceived risk levels creating barriers to large-scale investment. The same is true for much of the Euro Area, in that, while asset quality is higher, debt levels are high, and infrastructure investment offers one obvious route out of the economic malaise by which the region is beset. While public debt levels are relatively low in Australia, its size and stability offer significant attractions given a relatively lower quality of infrastructure versus other developed markets. The UK also stands out as a significant opportunity, given its size, debt levels, and 'legal' stability, combined with large and liquid financial markets, and a likelihood that following 'Brexit', infrastructure investment may be a

good way to avoid (or mitigate) any economic slowdown that potentially materializes as Britain leaves the European Union. The US is notable by its enormous scale and relatively high debt levels, and while it shows up reasonably well here on infrastructure quality, the American Association of Civil Engineers offers a less rosy interpretation, with the aforementioned 'D+' and 'poor' rating which it awarded to US infrastructure.

Summary

So we end up with something of a paradoxical conclusion. The biggest global infrastructure needs are to be found in emerging economies, but these are the countries least able to afford the fiscal expansion required to get infrastructure going. In spite of their higher debt/GDP ratios, it is advanced economies that seem most likely to agree that there is fiscal space to allow a rise in infrastructure spending. Moreover, those developed markets can now borrow at unprecedented low rates, for enormously long durations, and are typically more efficient at deploying that capital.

One solution would be for advanced economies to take on debt to pay for infrastructure in emerging economies. Politics is likely to keep this idea in the realm of a thought-experiment — although the UN's $100 billion climate fund does show that it is possible to mobilize capital between DMs and EMs. A more realistic solution might be a heavier infusion of equity and debt capital from bilateral sources, like China, or from multilateral sources or regional development banks. However, mobilizing this kind of funding on a scale that could be described as game-changing would be challenging. So even if the case for infrastructure spending is water-tight, funding it remains a topic of perpetual uncertainty.

Conversely, private capital is starved of income and yield, and pension funds and insurers in particular are desperate for longer-term, stable cashflow and income streams, which infrastructure assets are uniquely well-placed to provide. While private capital markets have historically been wary of lending more to EM, we believe that there are opportunities to link the need for investment with the desire to invest through various mechanisms, the topic of a later chapter. Having examined the high level attractiveness of various EM and DM economies around the world, the next sections take a closer look at several of those key economies.

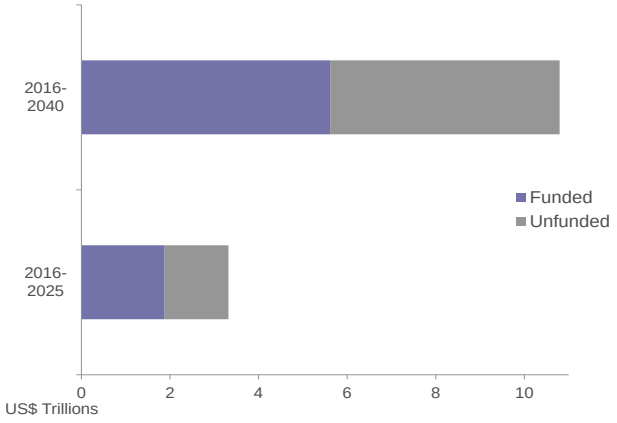
Infrastructure Around the World

US

Total infrastructure investment needs in the US are estimated at $3.3 trillion from 2016-2025, with a funding gap of $1.4 trillion.

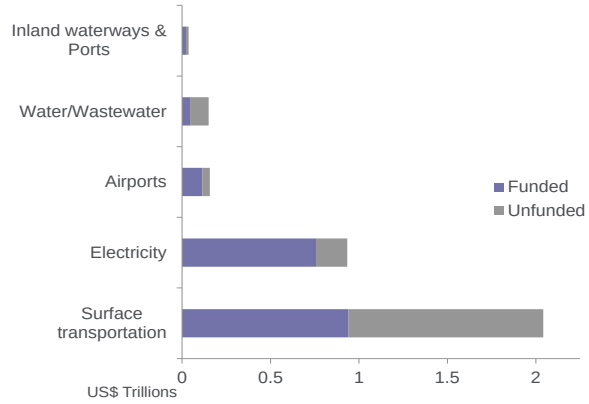
In the years after World War II, the US built an interstate highway system, water networks, hundreds of airports and port facilities and other important infrastructure that boosted the US economy over time. Much of this infrastructure is in desperate need of repair. However despite this, neither federal nor state governments have not been investing in these improvements. The American Society of Civil Engineers (ASCE) estimate total infrastructure needs from 2016 to 2025 at $3.3 trillion, with a funding gap close to $1.4 trillion. This increases to $10.7 trillion from 2016-2040 (Figure 30). The majority of investment is needed in surface transportation which is more than 50% unfunded. According to their report 'Failure to Act - Closing the Infrastructure Investment Gap for America's Economic Future', if none of the infrastructure gaps are properly addressed, the US is expected to lose nearly $4 trillion in GDP by 2025.[11]

Figure 30. Investment Funding Gap



Source: ASCE (2016)[11], Citi Research

Figure 31. Investment Funding Gap by Sector 2016-2025



Source: ASCE (2016)[11], Citi Research

The US is currently in an election year with two very different candidates, who, while poles apart on many issues, agree on one point — that there needs to be an increase in infrastructure investment. The Democratic candidate, Hillary Clinton, has proposed $275 billion in direct spending on infrastructure over five years, plus $225 billion in loans and loan-guarantee programs.[12] It is also likely that she would try to reinstate the Build America Bond Program (BAB) which expired at the end of 2010 albeit at a lower subsidy rate. While this falls short of the infrastructure investment needed as described above, it is considered to be a step in the right direction. The Republican candidate, Donald J Trump, has supported infrastructure investment from the beginning of his campaign, and has surprised many by stating that he would at least double Clinton's infrastructure investment proposals, though it is currently unclear how he intends to do this. S&P estimate that an increase in spend of 1% of GDP, spread over four quarters would boost US economic output by $270 billion over a three-year period. They also state that such an increase could add as many as 730,000 jobs to the US economy in a one year period — an average monthly job gain of 61,000.[13]

[11] ASCE (2016), Failure to Act

[12] The Atlantic, Donald Trump's Big Spending Infrastructure Data, August 6th 2016

[13] Standard and Poor (2015), Global Infrastructure Investment: Timing is Everything (And Now is the Time), January 13, 2015

UK

The UK government has committed to invest over £100 billion by 2020-2021 in infrastructure. Investment in infrastructure can not only grow the UK's economy but can create additional job opportunities

In the UK, there is a significant backlog of infrastructure projects which are critical in driving economic growth and job creation. However in the wake of the financial crisis, the capital to support some of these projects has been in short supply. According to Arcadis, the UK is behind all G7 members on built asset wealth per capita, and has a flat trajectory on investment share of GDP for several years since the 2008 financial crisis.[14] The UK generally ranks poorly for a Western European country with regards to overall quality of infrastructure (24th) compared with France (10th) and Germany (11th). Since 2011, the government has set out its infrastructure policies in the annual National Infrastructure Delivery Plans and publishes an annual updated infrastructure pipeline as shown in Figure 32. Infrastructure UK was also established in June 2010 to enable greater private sector investment in infrastructure and improve the government's long-term planning; it now forms part of the new Infrastructure and Projects Authority. The UK government has committed to invest over £100 billion by 2020-2021 as part of the £239 billion project pipeline up to this time period. The rest is estimated to come from the private sector.

Figure 32. National Infrastructure Pipeline (constant 2014/15 prices)

	2016/17	2017/18	2018/19	2019/20	2020/21	Total
	(£ bn)	(£ bn)	(£ bn)	(£ bn)	(£ bn)	(£ bn)
Communications	2.8	2.2	0.4	0.3	0.2	6.0
Energy	24.8	26.7	26.0	20.1	19.9	117.4
Flood	0.5	0.6	0.6	0.5	0.5	2.7
Science and Research	1.1	1.1	1.1	1.1	1.1	5.5
Transport	17.6	17.0	16.6	18.5	18.8	88.4
Waste	0.4	0.1	0.0	0.0	0.0	0.5
Water	5.0	5.0	4.7	4.0	0.5	19.2
Total Economic Infrastructure	52.2	52.7	49.2	44.5	41.0	239.7
Total Social Infrastructure						57.6

Source: HM Treasury and Infrastructure and Projects Authority (2016),[15] Citi Research

It is expected that the government will increase public investment following Brexit. The Bank of England is ensuring low borrowing costs and the new Prime Minister has pledged Treasury backing for new projects and the launch of infrastructure (government) bonds. Prime Minister May also promised support for the 'Northern Powerhouse' project, backing proposals for a new trans-Pennine road tunnel linking Manchester and Sheffield. However, while plans for the new nuclear plant at Hinckley Point seem finally to be sorted, the expansion at Heathrow or Gatwick airport continues to be a hotly debated issue with no decision in sight. The Chancellor of the Exchequer has also promised a 'fiscal reset' for the construction companies hoping for an increase in public investment in proposed infrastructure projects. Investment in infrastructure can help not only grow the UK economy but also create additional job opportunities in different regions. For example the HS2 railway from London to the West Midlands (phase 1) and then from the West Midlands to Leeds and Manchester (phase 2) is estimated to create between 24,600 and 50,000 new jobs during the construction phase. In addition, at a national level the overall benefits to the UK economy could be over £53 billion (present value 2011 prices).[16] The expansion to Heathrow airport (proposed NorthWest Runway) is estimated to generate up to 78,000 jobs by 2050 and £19.3 billion of direct economic benefits of such an expansion (PV, 2014 prices).[17]

[14] Arcadis, Global Built Asset Wealth Index 2015
[15] HM Treasury & Infrastructure and Projects Authority (2016), National Infrastructure Pipeline Spring 2016
[16] Department for Transport (2013), The Strategic case for HS2
[17] Airports Commission: Final Report, July 2015

China

China's infrastructure needs

China's infrastructure spending has been amongst the highest in the world in recent years, at an average of 8.5% of GDP. However, in terms of infrastructure quality, it ranked 51st out of 144 countries, far behind developed Asia countries such as Japan (7th), and Singapore (4th). According to Bhattacharyya et al (2010), China's infrastructure needs from 2010 to 2020 have reached $4.3 trillion, accounting for 53.1% of total Asian investment needs.

Figure 33. National Infrastructure Investment Needs in Asia: 2010-2020

Country / Sub region	% of Total Asian Investment Needs	Estimated Investment Needs ($ millions)	New Capacity	Maintenance	Total Investment Per Year	Total Investment Per Capita ($)	2008 GDP Per Capita (Constant 2000 $)
Central Asia	**4.544%**	**373,657**	**54%**	**46%**	**33,969**	**1,403**	**753**
Afghanistan	0.318%	26,142	57%	43%	2,377	901	-
Armenia	0.051%	4,179	41%	59%	380	1,358	1,520
Azerbaijan	0.344%	28,317	64%	36%	2,574	3,262	2,131
Georgia	0.060%	4,901	24%	76%	446	1,138	1,268
Kazakhstan	0.846%	69,538	61%	39%	6,322	4,436	2,378
Kyrgyz Rep.	0.107%	8,789	38%	62%	799	1,665	376
Pakistan	2.172%	178,558	53%	47%	16,233	1,075	650
Tajikstan	0.139%	11,468	47%	53%	1,043	1,678	245
Uzbekistan	0.508%	41,764	48%	52%	3,797	1,529	840
East and Southeast Asia	**66.553%**	**5,472,327**	**71%**	**29%**	**497,484**	**2,886**	**1,765**
Cambodia	0.163%	13,364	51%	49%	1,215	918	511
PRC	53.118%	4,367,642	72%	28%	397,058	3,297	1,965
Indonesia	5.476%	450,304	70%	30%	40,937	1,981	1,087
Lao PDR	0.138%	11,375	56%	44%	1,034	1,833	475
Malaysia	2.287%	188,084	79%	21%	17,099	6,962	5,151
Mongolia	0.122%	10,069	37%	63%	915	3,812	735
Myanmar	0.264%	21,698	56%	44%	1,973	438	-
Philippines	1.546%	127,122	53%	47%	11,557	1,407	1,225
Thailand	2.103%	172,907	72%	28%	15,719	2,566	2,640
Viet Nam	1.335%	109,761	53%	47%	9,978	1,273	647
South Asia	**28.829%**	**2,370,497**	**63%**	**37%**	**215,500**	**1,756**	**685**
Bangladesh	1.762%	144,903	54%	46%	13,173	906	462
Bhutan	0.011%	886	30%	70%	81	1,291	1,247
India	26.421%	2,172,469	64%	36%	197,497	1,906	718
Nepal	0.174%	14,330	50%	50%	1,303	497	254
Sri Lanka	0.461%	37,908	52%	48%	3,446	1,881	1,199
The Pacific	**0.073%**	**6,023**	**30%**	**70%**	**548**	**625**	**840**
Fiji	0.008%	667	15%	85%	61	790	2,181
Kiribati	0.001%	82	10%	90%	7	846	826
PNG	0.051%	4,214	34%	66%	383	641	676
Samoa	0.003%	242	13%	87%	22	1,351	1,739
Solomon Is.	0.004%	336	33%	67%	31	657	1,136
Timor-Leste	0.001%	71	35%	65%	6	65	329
Tonga	0.001%	106	13%	87%	10	1,022	1,666
Vanuatu	0.004%	306	40%	60%	28	1,309	1,339
Total Asia	**100%**	**8,222,503**	**68%**	**32%**	**747,500**	**2,335**	**1,272**

Source: ABDI Working Paper,[18] Centennial, Citi Research

[18] Bhattacharyay, B. 2010. Estimating Demand for Infrastructure in Energy, Transport, Telecommunications, Water and Sanitation in Asia and the Pacific: 2010-2020. ADBI Working Paper 248. Tokyo: Asian Development Bank Institute. Available: http://www.adbi.org/working-paper/2010/09/09/4062.infrastructure.demand.asia.pacific/

The public sector has financed the majority of infrastructure investment

Almost all Chinese infrastructure finance has been undertaken by the public sector, with private sector financing as a proportion of GDP close to zero. China has placed considerable emphasis on infrastructure in previous national five-year plans, with its 11th Five Year Plan (2006-2010) listing key transport infrastructure projects, whilst the 12th Five Year Plan (2011-2015) set ambitious targets for the extent of high-speed railway and road networks to be built. Responsibility for financing infrastructure projects typically lies with local governments, although the central government does provide funding to local governments to help. Local governments have also made use of other financing options such as selling up land rights and borrowing through local government financial vehicles.

Infrastructure construction in China is still far behind developed countries – there are regional differences between the quality and availability of infrastructure in the eastern and western areas of the country

Infrastructure construction in China is still far behind developed countries like the US, Euro Area, and Japan. The regional difference between the eastern and western areas of China is also tremendous — infrastructure demand for railways and roads in the western areas of the country is far from being sufficient. In addition, given significant downside risks to economic growth, the government needs more investment in infrastructure to boost the economy. China's fixed asset investment (FAI) was 43% of GDP, contributing 2.9 percentage points of GDP growth. If the current pace of FAI slowdown continues, China's growth could have been reduced by 0.8 percentage points alone in 2016. Against a backdrop of slowing manufacturing and real estate growth, infrastructure investment is the main driver to support FAI. We estimate that infrastructure investment growth would have to accelerate to 28% year-on-year (YoY) in order for the government to meet its 10.5% FAI growth target in 2016; hence we expect infrastructure investment growth at above 20% YoY in the second half of 2016.

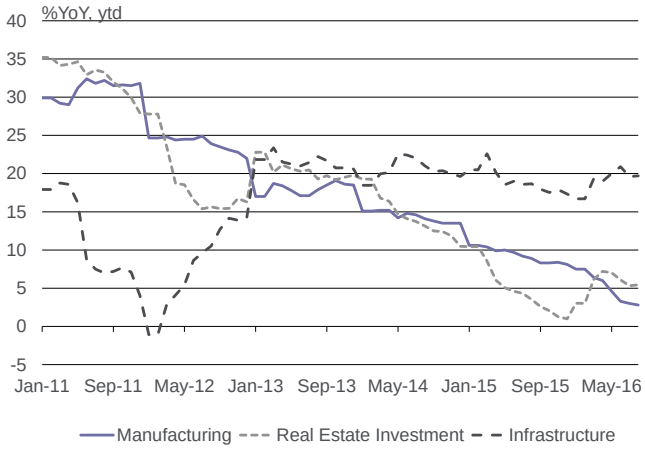
Investment growth needs to be maintained at 7.9% YoY if China intends to maintain a growth rate of 6.5%

Alternatively, if China intends to maintain a growth rate of 6.5% until 2020, investment growth would have to maintain a 7.9% YoY rate, assuming the current trend of consumption and net export growth continues (versus 6.7% YoY in the second quarter 2016). Assuming the investment growth were to be maintained at 7.9% YoY, the total amount of investment would be RMB175.1 trillion ($26trn) in the next five years (real price, 2010 level). Using the share of infrastructure investment in total investment of 33.5% in 2015, the infrastructure investment in the next five years would reach RMB58.7 trillion ($8.7trn). Based on the historical relationship between investment growth and fixed asset investment growth, as well as our investment growth estimate of 7.9% YoY in 2020, the fixed asset investment growth would reach 18.1% in 2020.

Central government debt remains low however local governments have suffered from high leverage in recent years

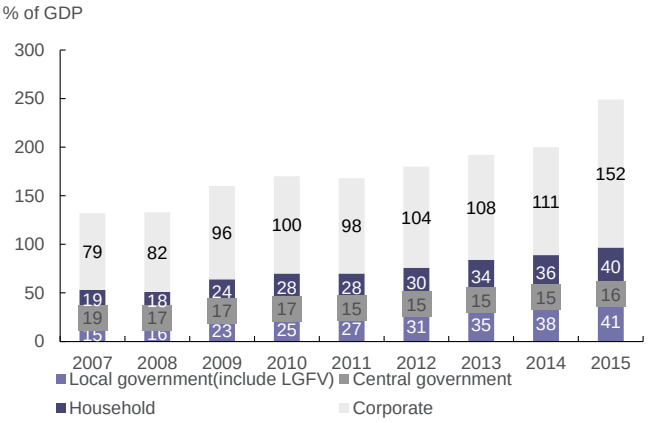
In terms of public debt, China's central government debt remains low; however, local governments have suffered from higher leverage in recent years. This debt issue is eased by the Ministry of Finance's debt swap program (up to RMB15 trillion in debt from 2015 to 2017). In addition, the introduction of Public-Private-Partnerships (PPP) could also provide financing support for infrastructure; so far we do not think China's infrastructure investment has created an alarming number of white elephants.

Figure 34. Fixed Asset Investment Breakdown



Source: CEIC and Citi Research

Figure 35. Debt Structure



Source: CEIC and Citi Research

The influence of infrastructure investment on job opportunities has both short- and long-term effects; in the short term jobs are created during the infrastructure construction, whilst in the longer-term jobs are created for the operation of the infrastructure. However in China, the Large Scale Development Strategy for the Western Regions which started in 2001 did not produce many job opportunities, due to the absence of private investment in production facilities. Therefore to create job opportunities, it is not sufficient to invest purely in infrastructure; other private investment in production facilities is also important.

China's new Silk Road investment plan

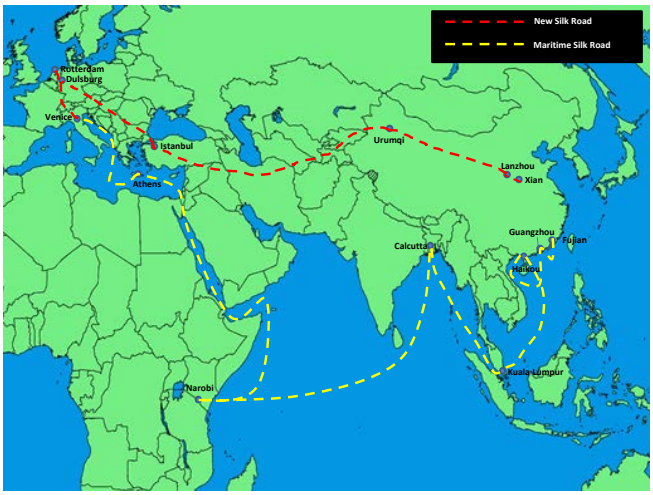
The New Silk Road Plan aims to connect China, Asia, Africa and Europe via land and maritime routes.

President Xi first introduced the "One Belt and One Road" Plan (OBOR) in Kazakhstan on September 7, 2013, which is essentially the New Silk Road connecting China, Asia, Africa, and Europe via land and maritime routes. The land-based belt is planned to cover Central Asia, the Middle East, West Asia, and parts of Europe, whilst the maritime route will cover Southeast Asia, South Asia, the Persian Gulf, the Red Sea, and the Indian Ocean coast (Figure 36).[19] Xi had previously announced the establishment of funds from the Asia Infrastructure Investment Bank ($100bn) and Silk Road ($40bn) to underpin this plan. There are three main objectives of the Silk Road plan (1) an increase in infrastructure construction projects, which would benefit railway construction, construction materials, and other transport sectors; (2) to boost inter-trade with China; and (3) to facilitate all other kinds of trade including utilities, financial cooperation, environmental issues etc.[19]

Citi's Chinese analysts in their report 'Surveying ASEAN's infrastructure' highlighted the importance of OBOR and the Asia Infrastructure Investment Bank (AIIB) in helping to finance the infrastructure needs in other ASEAN countries, estimated at over $100 billion per year over the next 10-15 years. The majority of the investment needs in these countries which include Indonesia, Thailand, Malaysia, and the Philippines are in the power and transport sectors.

[19] Lau E, Niu S, Tao V, Shang J, Gong P, China Industrials Sector, Investment Exploration on the New Silk Road, Citi Research, 17th November 2014

Figure 36. Map of New Silk Road, Also Known as One Belt, One Road



Source: Citi Research

Figure 37. Summary of Chinese Investment Fund

Name of Fund	Total Commitment (US$ bn)
AIIB	29.8
NDB- New Development Bank BRICS	41
Silk Road Fund	40
China-Africa Development Fund (CAD Fund)	10
CDB/EX-Im Bank Loans to Latin America (Since 2005)	125

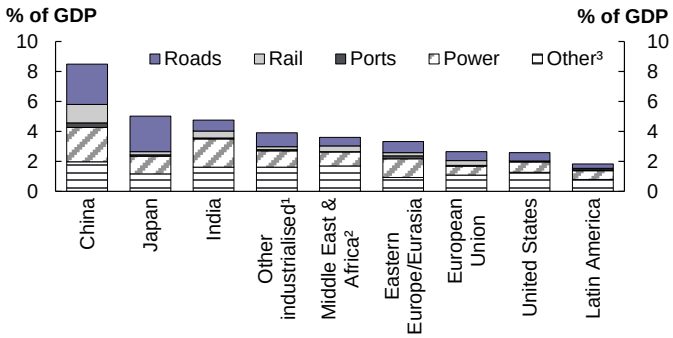
Source: Citi Research

India

Per capita investment on infrastructure in India was at a par with China until the 1990s. However over the years China has increased its investment immensely when compared to India

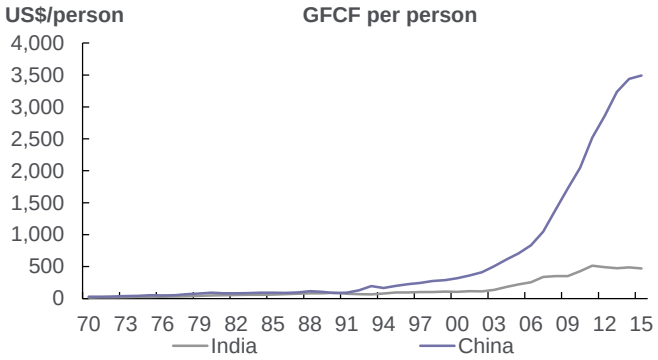
Over the years India has increased its infrastructure investment, though has spent less than other countries such as China (see Figure 38). The per capita investment was similar for China and India up until the 1990s, however China's increase was dramatic when compared to India's following this period. On a population adjusted basis, India would have needed to have spent $2.3 trillion in fiscal year 2015 to match China's per capita spend. On average from 1999-2011 India spent 4.75% of its GDP on infrastructure investment, while China during the same period spent 8.5%. Three key factors that impacted India's infrastructure spending versus China were the following: (1) stretched government finances for central and state governments; (2) onerous land acquisition laws; and (3) stringent environmental clearances. In fact, while output market reforms progressed well in India, efforts to reform the input markets were rather tardy. These factors led to delays and cost over-runs at different stages of project completion, thus impacting the viability/returns on existing and new investments. In addition, availability of crucial inputs (coal, steel etc.) and high interest rates could also be considered as dampeners.

Figure 38. Average Spent on Infrastructure 1999-2011



Source: OECD (2014)[20], Citi Research

Figure 39. The Evolution of Investment in India and China



Source: Citi Research

India ranks 74th out of 144 countries for the overall quality of infrastructure

The World Economic Forum ranked India 74th out 144 countries for the overall quality of infrastructure. Two-thirds of freight and about 80% of passengers in India are still transported by the road network, whilst India's per capita power consumption is estimated at 1,010 kWh in 2015; this is four times less than in China, where per capita power consumption is estimated at 4,000 kWh. In context, developed nations average around 15,000 kWh per capita. Over 7,800 villages still do not have access to electricity and even if there is power, it is far from being satisfactory. China also has 30 times the port capacity of India and three times India's coastal GDP. India's turnaround time at major ports is 84 hours vs only 7 hours in Hong Kong and Singapore. Trucks in India drive just one-third the distance of the trucks in US (280km vs 800 km) as only 40% of the time is spent driving. Logistics costs are higher than the wage bill or the cost of power and 3-4 times international benchmarks (Leemput, 2014). McKinsey estimates that an increase in infrastructure investment equivalent to one per cent of GDP would translate into an additional 3.4 million direct and indirect jobs in India.

[20] OECD (2014), OECD Economic Surveys: India 2014, OECD Publishing. http://dx.doi.org/10.1787/eco_surveys-ind-2014-en

The government has recognized the importance of infrastructure investment- it has stated that in order to attain a 9% real GDP growth rate, infrastructure investment should average nearly 10% of GDP

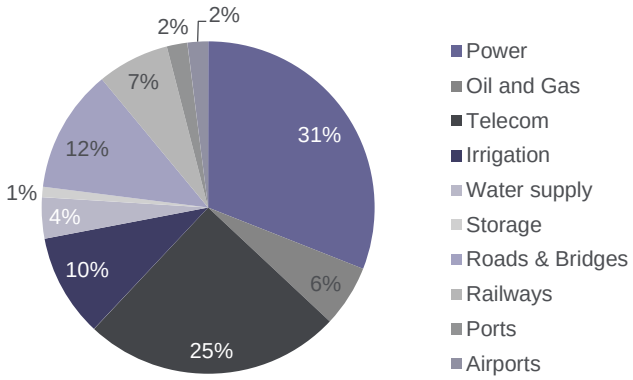
The government has recognized the importance of infrastructure investment and in its 12th Five Year Plan called for $1 trillion in infrastructure spending in the five years to 2017. The government has stated that in order to attain a 9% real GDP growth rate, infrastructure investment should be on average almost 10% of GDP during the 12th Five Year Plan.[21] In the past the government has funded the majority of India's infrastructure development; however it doesn't have the financial resources to meet the nation's needs for infrastructure and is therefore aiming to attract half of this targeted investment through the private sector, up from almost 37% during the 11th Five Year Plan.[22]

The private sector contributes around 40% of the infrastructure investment with the rest coming from the government/public sector. The government has been looking at different variants to the PPP model including engineering, procurement and construction (EPC), built operate transfer (BOT) and hybrid annuity model (HAM). For instance under the hybrid annuity model, the government shares the capital cost of a project and also helps reduce cash flow risk from the project. Over last three years, the share of BOT awards have dropped substantially from over 90% of total road projects in the period fiscal year 2012-14 to around 20% in fiscal year 2014-16 as per National Highway Authority of India (NHAI) data. With regards to financing, the government has also proposed a National Investment and Infrastructure Fund (NIIF) which will have an equity corpus of INR 200 billion ($3bn), and with additional debt resources it could become a strong financing vehicle for commercially viable infrastructure projects. With average infrastructure spend at around 8.2% of GDP in the fiscal year 2012-15 period, the government has met almost 80% of its targeted spend i.e., 10% of GDP in the 12th Five Year Plan.

Figure 40. Historic Private and Public Investment in Infrastructure

Source: Planning Commission India, Citi Research

Figure 41. Projected Sectorial Spend in 12th Five Year Plan



Source: Planning Commission India, Citi Research

Barriers to private investment

There are a number of barriers to private investment that could be summarized as the 3 'D's: demand, debt, and default. A still moderate level of capacity utilization of ~75% suggests sluggish demand conditions. Corporates, especially in the infrastructure sector, are highly geared and debt servicing remains a headwind. Lastly, public sector banks which have been the key source of credit financing are

[21] Working Sub-Group on Infrastructure, Infrastructure Funding Requirements and its sources over the implementation of the Twelfth Five Year Plan (2012-2017)
[22] PWC, India: a snapshot

also struggling with non-performing assets (NPAs) reaching cyclical highs, crimping their lending ability.

Future plans and projects

The planning commission has been replaced by the National Institution for Transforming India (NITI) Aayog which is currently working on the 15-year development agenda as well as a shorter seven-year action plan. However, the government of Prime Minister Modi is continuing with some of its flagship infrastructure projects with targets for 2022 including:

1. Housing for all which aims to provide 20 million houses in urban areas and 40 million houses in rural areas;
2. Rural electrification of 20,000 villages of which 6,000 are already completed;
3. Urban infrastructure that includes developing 100 smart cities.

Some of the key projects being implemented include the Delhi Mumbai Industrial Corridor, the Dedicated Freight Corridor (DFC), and a high speed railway (bullet train) among others. The dedicated railway freight corridor, which is being constructed on the Eastern-side (Ludhiana to Dankuni-1856 km) and Western-side (Mumbai to Dadri-1504 km) is scheduled to be completed by 2019. The development of the Delhi Mumbai Industrial Corridor (DMIC) along the Western DFC is also expected to provide impetus to industrialization and planned urbanization. The DMIC is being implemented under the memorandum of understanding (MoU) signed between the Indian and Japanese governments and spans six major states. In addition to the DMIC and DFC, the government is also aiming to develop a diamond quadrilateral of high speed rail networks (bullet trains) with the Mumbai-Ahmedabad corridor set to be implemented using Shinkansen technology.

Job opportunities and multiplier effect

A 1% of GDP increase in infrastructure investment would translate into an additional 3.4 million jobs in India

With average infrastructure spend at around 8.2% of GDP in the fiscal year 2012-15 period, the government has met almost 80% of its targeted spend i.e. 10% of GDP in the 12th Five Year Plan. McKinsey estimates that an increase in infrastructure investment equivalent to one per cent of GDP would translate into an additional 3.4 million direct and indirect jobs in India. Investment into Indian railways has significant forward (i.e. sectors which use railway services as input) and backward (sectors which provide input to railways) linkages. The total benefits to other sectors from increases in the output of railway services can be to the tune of five times the increase in the railway output. Furthermore, this multiplier effect has been increasing over a period of time.

Brazil

Brazil has invested very little over the years in infrastructure, averaging 2.25% of GDP over the last 20 years

Infrastructure investment in Brazil has dropped from an average of 5.2% of GDP in the early 1980s to an average of 2.25% of GDP over the last 2 decades.[23] Compared to other countries such as China and India, Brazil has invested very little over the years in infrastructure investment (see Figure 5). Even though there is a lack of transparency in investment figures, there are consistent explanations backing this evidence including: (1) a low level of domestic saving (historically below 20% of GDP) which constrains the overall level of investment; (2) the historical weak fiscal position of the public sector (except between 2004-2008) combined with the reluctant government position in privatizing those companies; (3) the weak regulatory framework, deterring the private sector from investing in long-term projects; and (4) the absence of long-term financing, with this gap being filled by the public sector/Brazilian Development Bank (BNDES).

It is estimated that a yearly investment of at least 5% of GDP will be required to close Brazil's infrastructure gap

The country also scores low on overall infrastructure quality as shown Figure 18 - ranking 123 out of 144 countries that were surveyed by the World Economic Forum. It is estimated that a yearly investment of at least 5% of GDP will be required over the long run to close Brazil's infrastructure gap.[24] Current and previous governments have acknowledged the country's urgent need to invest in overall infrastructure. In fact, Dilma Rousseff launched an Infrastructure program which aimed for a combined government and private investment of R$500 billion ($156bn) over the next decade (see Figure 42), with an annual investment in infrastructure increasing from an average of 2% of GDP to just under 3% of GDP. However since her suspension from office, it is not clear whether any of these plans will materialize.

Figure 42. Planned Investments (Combined Government and Private Investment) Under Dilma Rousseff's Government

Program	Cost (R$ billion)
Highway Program	42.1
Ports	54.7
High speed train	35.7
Oil and Gas	80
Railroad	91.1
Urban mobility (e.g. subway)	81.4
Energy	148.1
Airport	18.6
Total	551.7

Source: Wagner et al. (2014)[24], Citi Research

The current government has recently announced a new round of concessions for infrastructure investment under a project called Crescer (i.e. to grow). There seems to be a considerable overlap between Crescer and Dilma Rousseff's prior plans, but not much information has yet been released. The Finance Minister announced in an interview that the investment in infrastructure could reach $269 billion across sectors, however up until the publication of this report there has only been official information with regards to a total of Rs$20-30 billion ($6-10 billion) being spent for 11 projects in transportation.

[23] Garcia- Escribano M, Goes C, Karpowicz I, (2015), Filling the Gap: Infrastructure Investment in Brazil, IMF Working Paper WP/15/180

[24] Wagner M, Bertol G, Murphy A, (2014), Enhancing private infrastructure investment in Brazil, Oliver Wyman

Making It Happen – Unlocking Global Infrastructure Investment

The Funding Anomaly

As interest rates in many places around the globe approach zero, or indeed go negative in real terms, the scope for further monetary policy actions of cutting rates is limited. Quantitative easing (QE) deployment is already widespread, and there may be limited scope to push this further, given growing question-marks over its effectiveness, as well as issues such as asset bubbles that it appears to be causing.

Coordinated monetary and fiscal policy would be much more effective — however, the latter is constrained by excessive leverage rates in both advanced and emerging economies. Conversely, private sector investment is facing exactly the opposite; it has capital to spare, and is desperately seeking long-dated cashflow and income streams, but is faced with a lack of viable investment options.

We estimate that $58.6 trillion of infrastructure investment is needed over the next 15 years to facilitate stronger global economic growth

Alongside this, the world has an enormous infrastructure investment deficit; yet infrastructure spend as a percentage of GDP has fallen to around 3.3% of GDP, and we estimate that this figure would need to grow to 4.1% by 2020, equating to $58.6 trillion of investment over the next decade and a half to facilitate stronger global growth.

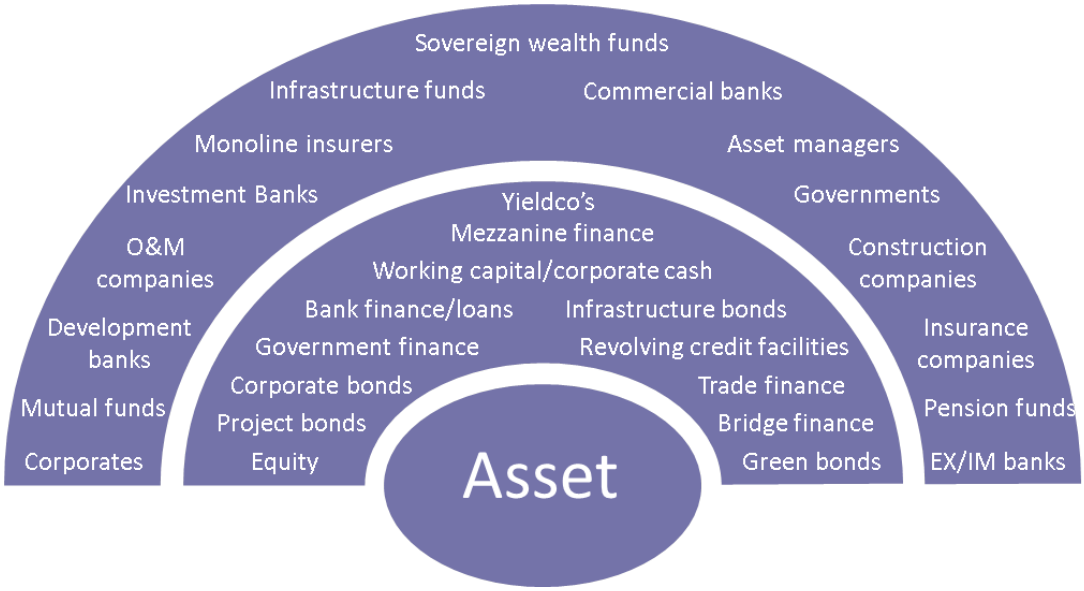
Furthermore, with large elements of the globe's population still lacking access to the basic necessities of clean water, electricity, and sanitation, not to mention the distant dreams of mobile networks, broadband, education, health, and mobility, it is clear that there is also a huge social need for infrastructure investment. The same holds true for upgrading (and updating) the vast amounts of aging infrastructure in advanced economies.

So given the need for investment, the desire to invest, and the undoubted economic and social benefits, why hasn't it happened?

The Infrastructure Orchestra – Understanding the Players and the Instruments

We should start by recognizing the many different types of finance involved in infrastructure, and the sources of those funds.

Figure 43. An Inexhaustive Look at Some of the Players and Instruments Involved in Infrastructure Finance



Source: Citi Research

The players

While Figure 43 is far from exhaustive, it begins to show the number of differing players and instruments involved purely in the financing of infrastructure.

Some are perfectly suited to infrastructure finance, such as pension or insurance companies, who have long-dated liabilities, and wish to link them with equally long-lived investments, which offer a stable and secure income stream with a relatively limited risk of not getting their capital back at the end of the period.

However, many players have either disappeared, or had their ability to participate in infrastructure financing curtailed by Global Financial Crisis-related events; the monoline insurers have largely disappeared, banks find themselves held back by Basel III implications on their need to maintain higher levels of capital, while insurers are often constrained by their inability to 'count' infrastructure assets under Solvency II limitations.

The instruments

Debt finance seems to suit infrastructure investment as assets tend to be expensive to build, but once operational they have limited operating costs

Most infrastructure assets tend by definition to be expensive to build, but once operational typically have limited operating costs and variability of operation, which lends them perfectly to debt finance. Assets are typically (if there is a typical project) around 70% debt financed, with equity only providing 30%.

This debt finance, however, can take a myriad of different forms, from recourse or non-recourse, to corporate debt (where the risk is spread across a company's portfolio of projects), to project-specific debt. The debt can be either public or private; private can offer advantages such as certainty of cost and staggered draw-downs to reduce negative carry (whereas public requires the equivalent of an

auction at listing), but although public is more expensive given listing requirements, reporting etc., it provides greater liquidity, and is potentially seen as lower risk given that disclosure, published credit ratings, and greater market scrutiny and knowledge.

Beyond that, there are specialist types of bonds, such as green bonds where the use of proceeds is specifically earmarked for sustainable/environmentally beneficial projects (see our Energy Darwinism II GPS for a more detailed discussion).

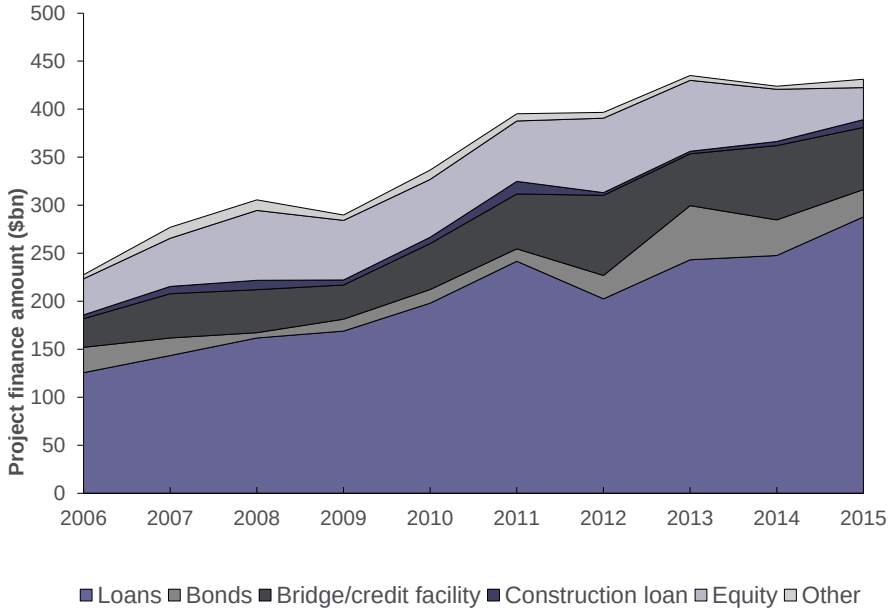
Equity traditionally provides 'first loss support' to credit investors, but requires higher returns commensurate with this higher risk. Hybrid vehicles such as yieldco's, which are listed equity vehicles which hold highly levered assets, also exist and pay out sizeable dividend streams (typically 90% of cash available for distribution), retaining a buffer for operational volatility. These vehicles are often listed with 'spare' balance sheet capacity to allow investment in new projects, thereby adding a growth element to the total return argument. However, this new type of vehicle has had limited success, more due to individual asset issues (inability to raise finance on an asset) rather than the model itself. Moreover, markets have proved slightly 'greedy' – in wanting income and growth, and wanting to value both – which is fine in principle, so long as one understands the source of the cash, limitations to that growth, and risks involved. While yieldco's have had a somewhat stuttering start, we expect to see many more similar vehicles going forwards; they provide a perfect exit for developers to crystallize value based on income streams, value which is unlikely to be reflected in the combined SOTP approach to valuing a construction company with stakes in assets which it has developed.

These various instruments are often issued via a special purpose vehicle (SPV) which is a self-contained entity created to hold the assets, and manage the associated liabilities, often without recourse to parents or sponsors.

Just as confusing as the types of finance, are the types of structure, such as PPP, BOT, PFI, or BOOT, a veritable jungle of acronyms. Without going into detail on each here, they generally relate to who sponsors the project, and who builds, owns, operates, and ultimately ends up with the assets at the end of any concession period.

It is also informative to examine the relative scale of those types of finance, to highlight the scale of the opportunity in drawing in greater levels of private investment.

Figure 44. Project Finance Volumes by Type Over the Last Decade



Source: Dealogic, Citi Research

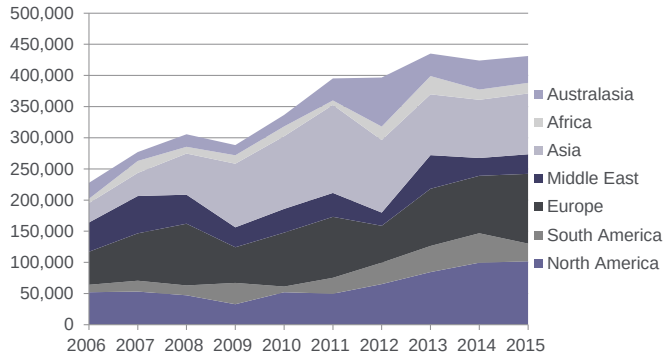
Even though the volume of project finance has grown steadily over the years, it still only amounts to $430 billion

As Figure 44 shows, while the 'volume' of global project finance has growth steadily, it still only amounts to around $430 billion, less than 20% of the $2.5 billion infrastructure investment calculated earlier. This implies that some 80% of investment is still being accounted for by other means, the vast bulk of which being public sector investment. In reality, that public figure is even greater, as much of the 'private' sector investment captured using project finance as a proxy is in reality conducted either by state-owned banks such as KfW in Germany, or equity from state-controlled companies.

If we compare these project finance amounts to the scale of the global equity market of around $70 trillion, or even more extreme, a global credit market of $130 trillion, the sums pale into insignificance. Even if we were to compare the average 'required' annual investment in infrastructure calculated earlier of around $3.9 trillion per annum, private capital markets clearly have the capacity (not to mention the desire) to finance a large part of that investment. As well as viewing the 'extra' capital as a way to boost total amounts of infrastructure investment, the other way of looking at this is that it effectively ameliorates the burden for cash-strapped governments, and in some markets could free up capacity for public debt reduction; austerity and investment all rolled into one.

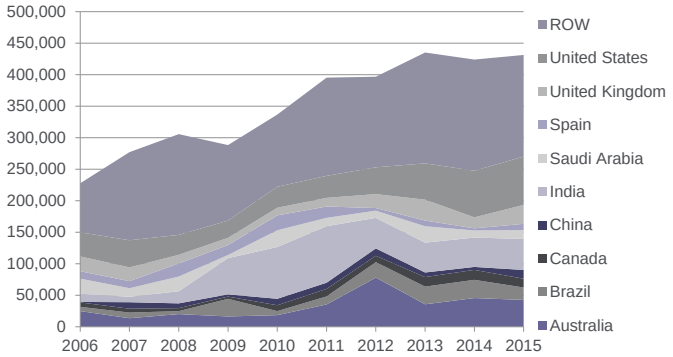
Another corollary of this is if much more investment into infrastructure is to be undertaken by the private sector, this will have (over time) a significant effect on the stock of public assets. This topic of 'national balance sheets' is covered in significant detail in another GPS report, The Wealth of Nations. The report also makes the argument that significant portions of assets could be moved into either private or PPP hands.

Figure 45. Project Finance Volumes by Continent



Source: Dealogic, Citi Research

Figure 46. Project Finance Volumes by Country



Source: Dealogic, Citi Research

The volume of project finance is distributed with a focus on developed markets, however delving deeper into country analysis showing some interesting peculiarities

As Figure 45 shows, limited as the volume of project finance may be, it is distributed around the world, with a focus on developed markets such as North America, Europe, and Australasia. However, delving deeper by country does highlight some interesting peculiarities. On the positive side, it is interesting to note that despite economic difficulties, Brazil has been a relatively large market, with Saudi Arabia and particularly India notable by their scale. The latter is especially interesting in comparison to China, which remains tiny – perhaps a corollary of a state-controlled command economy where state finance remains key. It is also notable that of the developed economies Japan is very small (too small in fact to feature on the chart). Perhaps most noteworthy though is Spain; Spain had a healthy and growing project finance market (much of it in energy) even through the Great Financial Crisis, which has all but dried up following retrospective regulatory changes in the energy market. This highlights an important lesson that we revisit later in terms of 'making it happen' – political and regulatory stability is key, and once markets perceive risks to have gone up, particularly via the taboo of retrospective legislation, it is extremely hard to reopen those markets up to private finance.

The vast majority of historical infrastructure investment has historically been public.

As the previous series of charts show, the vast bulk of infrastructure investment (around 80%) has historically been public, for very good reason. Private financing sources can only really be used where there is a financial justification to do so, that is, the asset will produce some form of revenue stream (or one is provided by government) which will allow a return on that investment. Accordingly, much of our basic infrastructure such as normal 'streets' is inappropriate for private finance, as (generally) are social housing, education, or hospitals for example. Government borrowing has historically been much cheaper than corporate financing, which again has allowed a lower total spend. Offsetting this is the traditional 'inefficiency' associated with government funded schemes, which for a variety of bureaucratic reasons often means that state investments lack the financial rigor and urgency which private investment can bring.

The assets

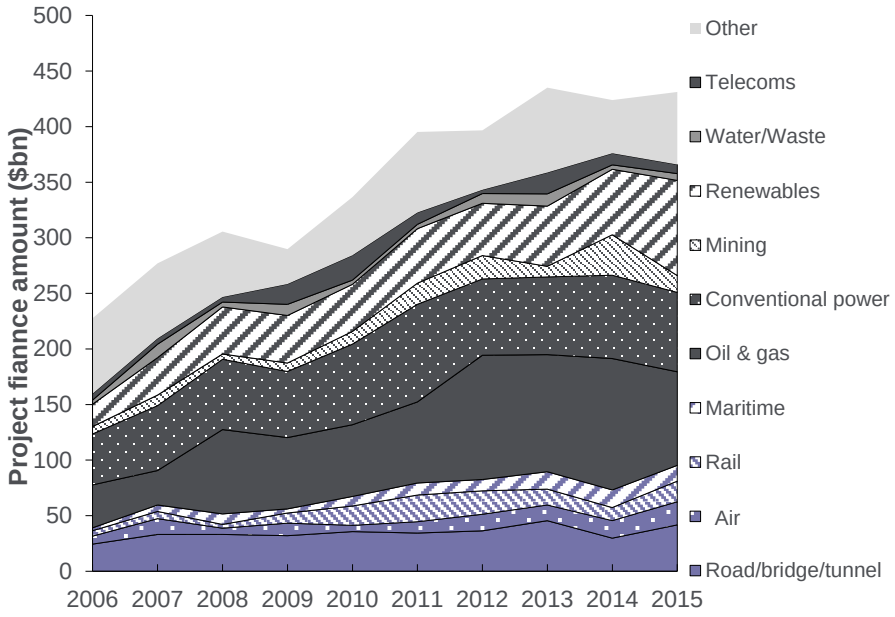
However, assets such as motorways, broadband & telecom networks, mass-transit systems, airports, and energy networks all lend themselves well to private finance as we tend to pay as we use them. In reality we pay for everything, even our local streets, through local or central taxation and hence it is hard to think of an asset class which couldn't be funded privately, if the financing and structure were imaginative enough and a revenue stream was provided (e.g. by elements of road tax being given to a concessionaire to maintain roads in a certain area). Nevertheless it is those assets which perform a 'social good' rather than an overtly

economic good which are harder to finance privately. Even assets which have not historically been profitable (given the desire to keep prices low for consumers) such as urban railways (subways/tubes/metros), can be made to work if enough imagination is used. A good example of this is the Hong Kong Metro, where the developer was granted property rights around the stations; clearly as the stations were developed, the real estate in close proximity appreciated in value. By combining the metro operation and real estate aspects has allowed the business to be profitable, while maintaining a low cost to use, and facilitating private investment and infrastructure development.

The majority of the project finance is in the energy space (approximately 60%)

As Figure 47 shows, the vast bulk of this project finance (almost 60% in fact) is in the energy space, with transport a distant second at 22%, with water/waste and telecoms on just 1% and 2%, respectively.

Figure 47. Split of Project Finance by Sector

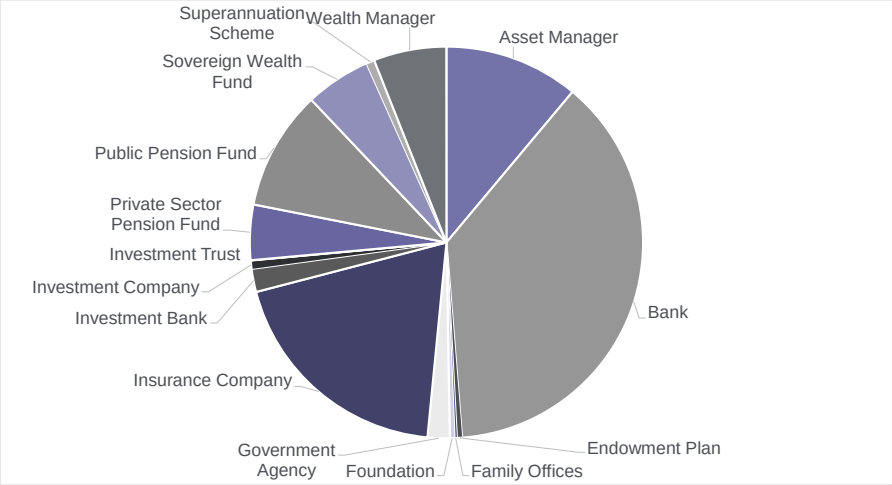


Source: Dealogic, Citi Research

Banks are the largest players in private finance markets (estimated at 40%)

The key players in the private infrastructure finance markets are shown in Figure 48, which highlights the continuing dominance of banks on nearly 40%, public and private pension funds on 15% and insurance companies on 20%, though with various types of asset managers and investors playing taking a much smaller role. Moreover, we should remember that this private exposure is still relatively limited when compared to public investment.

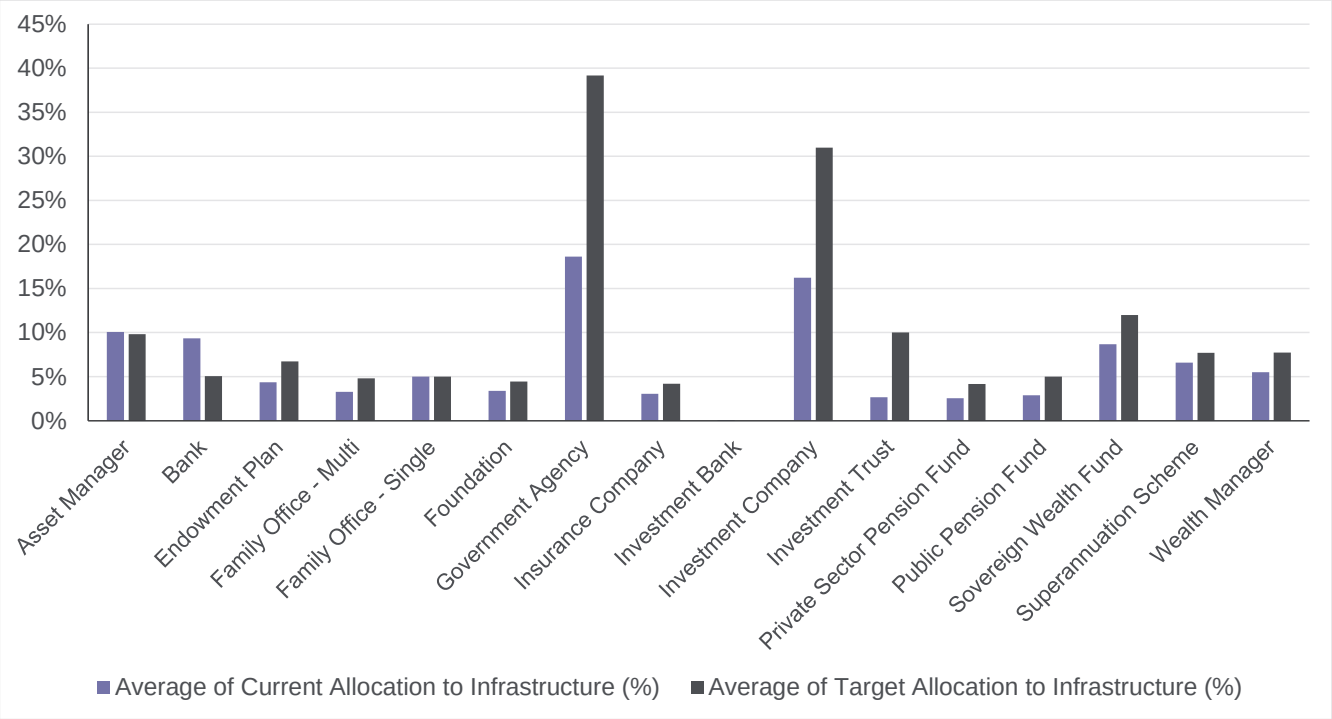
Figure 48. Breakdown of Institutional Investors Active in Infrastructure by Type and Total AUM



Source: Preqin Infrastructure

Yet private investors still only allocate a fraction of their assets under management to infrastructure investments, as shown in Figure 49. This seems odd, given the perfect match of longer-dated liabilities of insurance companies and pension funds, against long-dated assets. Moreover, the income provided offers obvious attractions, and, as highlighted elsewhere, default rates are actually lower than for corporate bonds, with significantly higher recovery rates in the event that default does occur.

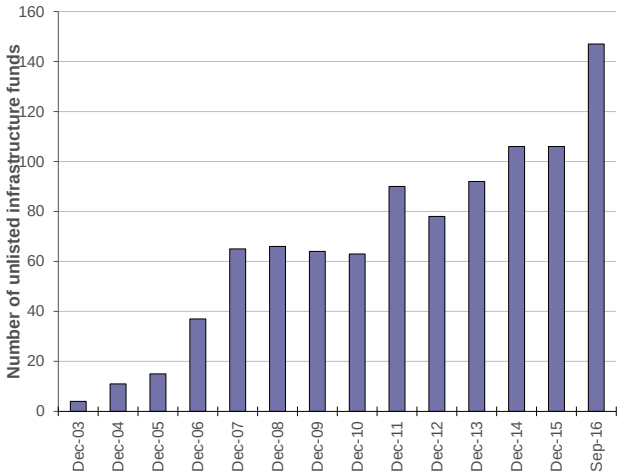
Figure 49. Breakdown of Average Current/Target Allocation to Infrastructure by Investor Type



Source: Preqin Infrastructure

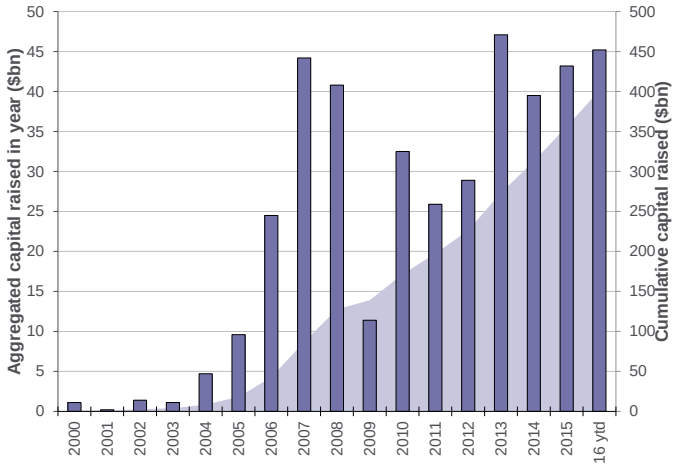
While the percentages allocated to infrastructure may still be small, Figure 49 does highlight the opportunity in building a new and more liquid infrastructure asset class, given the broad appetite for a greater level of exposure to infrastructure. Moreover, while still small, the number of unlisted infrastructure funds, and the capital which they have raised, has increased steadily and dramatically since 2000, as shown in Figure 50 and Figure 51. However, in terms of current infrastructure spend of $2.5 billion per year, let alone the $3.5 trillion that we believe infrastructure investment needs to be boosted to in the short term, it remains a drop in the ocean.

Figure 50. Number in Unlisted Infrastructure Funds



Source: Preqin Infrastructure

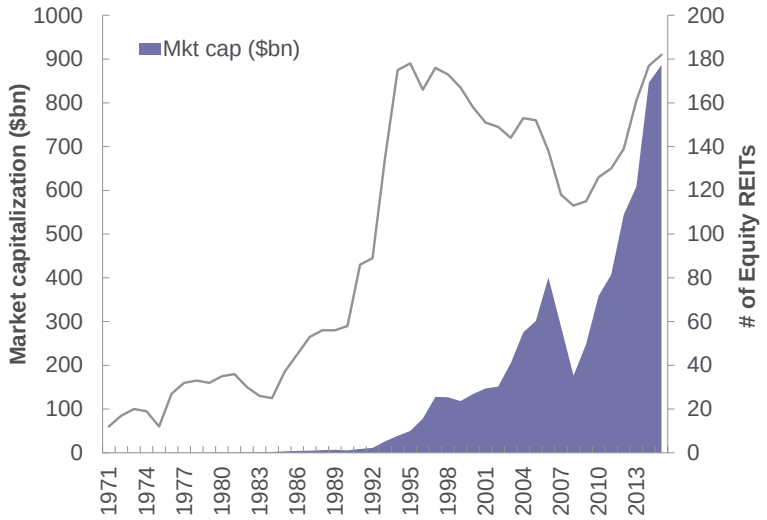
Figure 51. Capital Raised by Infrastructure Funds by Year/Cumulative



Source: Preqin Infrastructure

With the right level of financial ingenuity, structuring and incentives, it is possible to create new asset classes, and for them to become liquid. Figure 52 below shows the evolution of the Real Estate Investment Trust (REIT) market, demonstrating that the market capitalization of equity REIT's has grown in the last 20 years from a negligible level to around $900 billion of market cap (with a levered effect of course much higher).

Figure 52. Growth in the REIT Market



Source: Citi Research

This expansion has seen REITs grow to represent between 10% and 15% of the total real estate market, but perhaps more importantly, about 4% of the US public equity market, and REITs are now being recognized as a top line sector in their own right under the Global Industry Classification Standard (GICS)).

The lack of bankable projects is the reason why infrastructure investment by private investors is not higher

So why, if the need for the spend is clear, and the desire and the assets under management to invest are there, isn't infrastructure investment higher? In our view, the simple answer is a lack of bankable projects. To put that more specifically, there is an impasse between the stability of projects, the regimes in which they operate, and the 'allowed' returns on offer. Hence, the answer must simply lie in aligning those risks and rewards to the satisfaction of both sides – and once agreed, sticking to them.

An Appropriate Level of Return

Getting it right involves matching returns with risks and adjusting those risks via available instruments such as insurance or risk-sharing mechanisms

So what is an appropriate level of return? The answer is it varies, depending on the type of project, its duration, and the structure. Moreover, levels of return available/granted will vary within a project, depending on the type of financing and their stage of entry. Getting it right involves matching returns with risks, and adjusting those risks via various insurance or risk sharing mechanisms.

Simplistically, a project can be broken down into three key stages, each with very different levels of capital intensity and associated risk:

- **Design & Planning** (including tendering etc.) – This element is time-consuming, and can take several years, but requires relatively little in the way of capital input. It involves the initial project description, scope, and hence design, and will also require consortia to be put together (including the financing partners), and the tendering and contract award. While physical inputs are likely to be relatively limited, it is likely to involve site testing, surveying etc., and hence will involve some deployment of capital, as well as of course corporate and staff costs. This is likely to be corporate working capital (i.e., cash) financed. While the risks are relatively low given limited capital deployment, there is of course the risk of sunk costs if the project does not progress, or is awarded to another party.

- **Construction** – This is the most capital-intensive and highest-risk part of the lifespan. Risks are high, as it involves coordination with many parties, such as construction and contracting teams (often from multiple companies), suppliers/procurement, as well as partner organizations. Delays and cost overruns are not infrequent, either through poor planning, but also due to uncontrollable externalities such as weather having an impact. Some projects are dogged by design and specification changes, late deliveries, poorly performing or wrongly specified equipment, as well as changes to concession grantors (including ruling political parties/local governments). The risks are exacerbated by the often enormous scale of the projects, sometimes multi-billion in dollar terms. Moreover, construction/contracting/EPC earnings before interest, tax, depreciation and amortization (EBITDA)margins tend to be relatively low, from low-single-digit for 'simple' projects, up to just into double figures for more complex technical facilities. Hence small changes to costs can have adverse impacts on profitability, and ability to service interim capital. This stage of a project tends to be equity financed, alongside either revolving working capital facilities/bridge finance/bank loans/revolving facilities, and possibly the drawdown of project bonds (potentially with financing charges being capitalized).

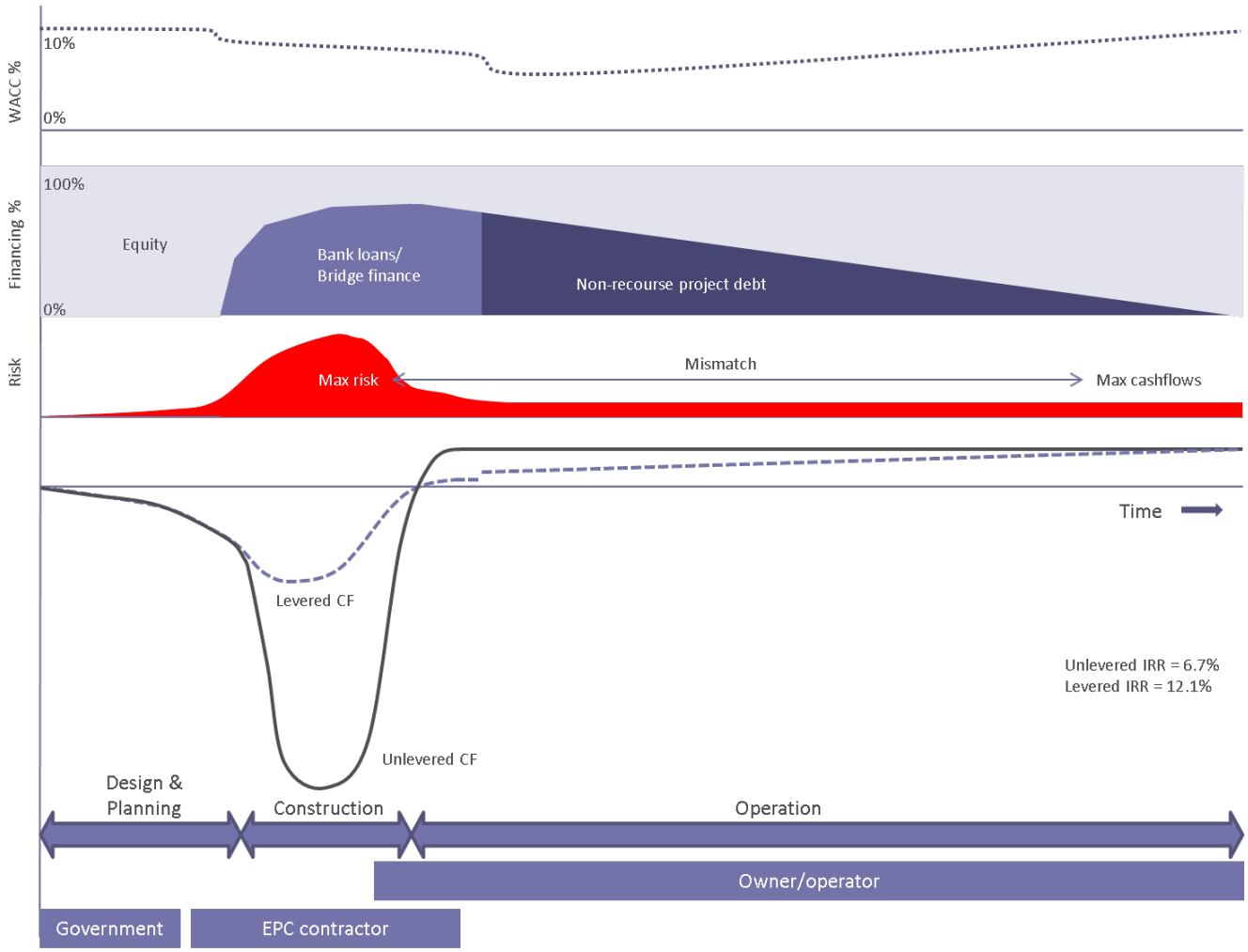
- **Operation** – Infrastructure assets often have a very long operating life, with some concessions being 40 years or more. Many, if not most infrastructure assets, have highly predictable revenue and limited operating cost bases, a wind farm being a good example. Given these stable operating characteristics, projects are often highly leveraged, potentially up to 75%. Once a project has a demonstrable EBITDA generation track record, it will be considerably easier to arrange long-term debt finance, potentially non-recourse and secured on the asset, at a much lower rate than would be available either before or during construction. The remaining equity buffer shields debt investors from operating fluctuations, as well as providing a safety net on the capital value should the asset 'fail' and have to be sold as a distressed asset. It is possible for debt finance to take various forms, and there may be a debt hierarchy, with senior and subordinated debt providing differing levels of risk.

At every stage, insurance can be taken out, though of course the cost of this may offset the potential benefit in risk/reward terms. Moreover, removing the majority of risk might reduce returns which make the investment inappropriate for certain investors with a higher risk/reward appetite.

One of the biggest issues is that risk does not correlate to cashflow

One of the biggest issues, as highlighted in Figure 53, is that risk does not correlate to cashflow – there are considerable cash outflows at the beginning with no income, when risks are highest, and it is only later that cash flows and returns materialize, when investment and risks are very low.

Figure 53. Comparison of Cashflows, Financing, Cost of Capital and Risk Across a Generic Project Lifecycle

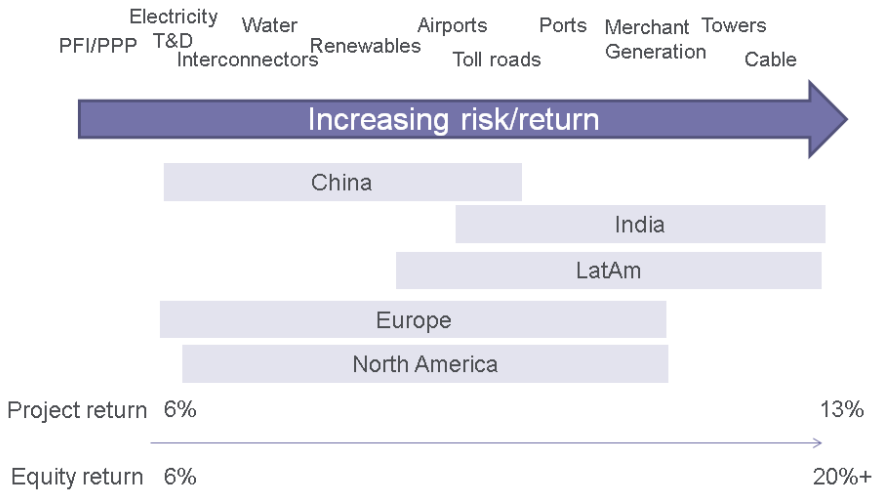


Source: Citi Research

Given the enormous variation of projects and their structures, it's not possible to put a single number on what an appropriate level of return is. However, ranges can be informative. Credit clearly varies significantly by region, but simplistically is likely to require a margin of potentially 100-200 basis points over the risk-free rate for the country in question – obviously higher-risk projects or structures may require much more. It is also worth highlighting that while in some markets risk-free rates remain very low, other markets are still seen as risky, with not inconsiderable levels of risk of default, and hence risk-free rates as a starting point are much higher.

Equity tends to be harder to judge, but as a 'mid-point' it is useful to think of infrastructure internal rates of returns in the high single/low double digits, with the caveats again that much higher-risk projects and or jurisdictions might get closer to 20% (or even beyond), with very stable projects potentially being at the lower end. Clearly the financing structure, level of risk mitigation/insurance, whether the government is invested, industry, geography, politics, regulation etc. will all make a significant difference to the allowed returns.

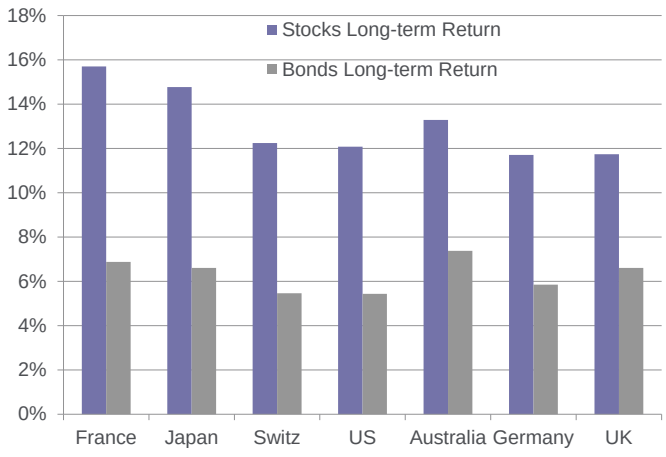
Figure 54. Relative Risk and Return Ranking by Industry and Region



Source: Citi Research

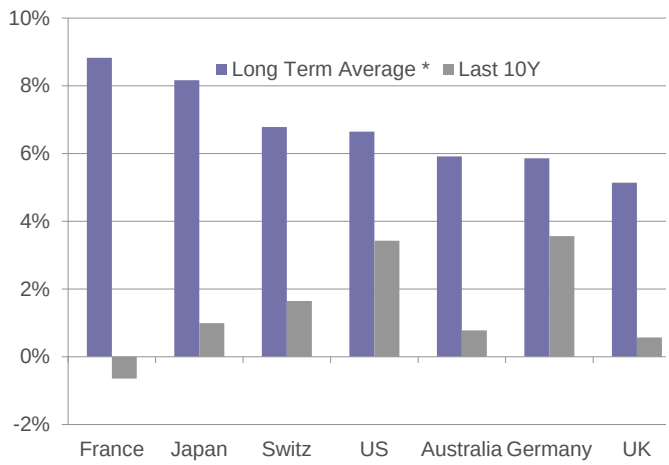
Comparing these to longer- term rates of return in equity and debt markets might not make them seem that attractive, as highlighted in Figure 55.

Figure 55. Long-Term Annual Returns by Country



Source: Citi Research, Global Financial Data. Annual data used for the US, UK, France, Aust since 1915, Germany since 1927, Japan since 1921, Switz since 1980

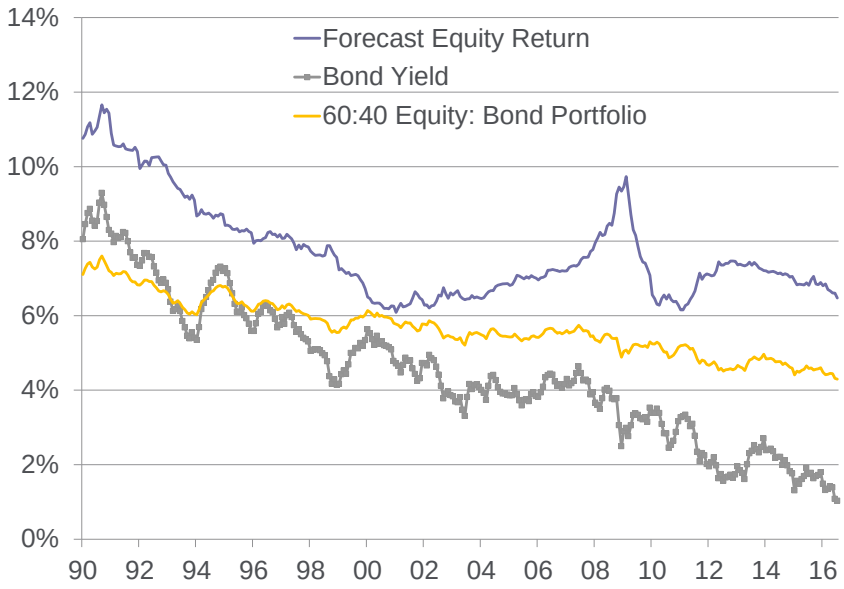
Figure 56. Annual Equity Returns Over Bonds



Source: Citi Research, Global Financial Data. Annual data used for the US, UK, France, Aust since 1915, Germany since 1927, Japan since 1921, Switz since 1980

However, as Figure 57 highlights, equity returns versus bonds have been significantly lower in recent years. Combined with dramatically lower bond yields, the outlook for returns on both equities and debt is significantly lower than historically.

Figure 57. Expected Returns

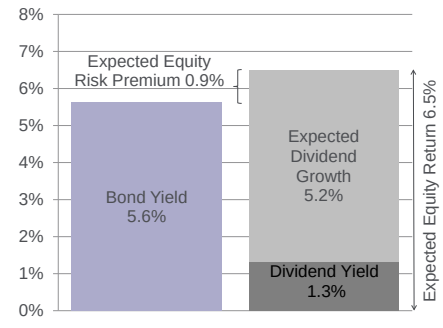


Source: Citi Research, Datastream

At 6.5% per year currently, the expected equity return is well below the 10% on offer to those brave enough to buy in 2009 or the early 1990s, and well below the 100-year data shown in Figure 55and Figure 56.

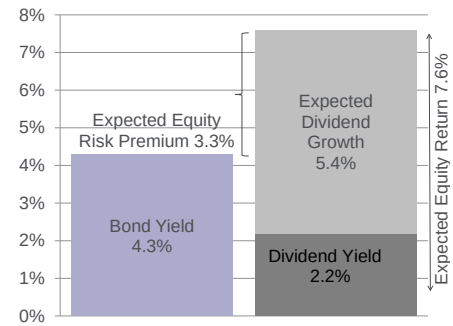
What has actually happened is that, while bond yields have dropped dramatically, expected equity returns have not moved that much in recent years, implying a dramatic widening in the equity risk premium, as shown in Figure 58 to Figure 60.

Figure 58. Global Ex-Ante ERP in Jan 2000



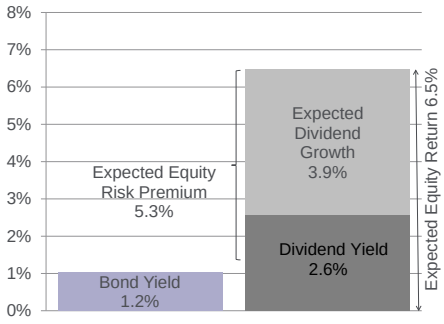
Source: Citi Research, Datastream

Figure 59. Global Ex-Ante ERP in Sep 2007



Source: Citi Research, Datastream

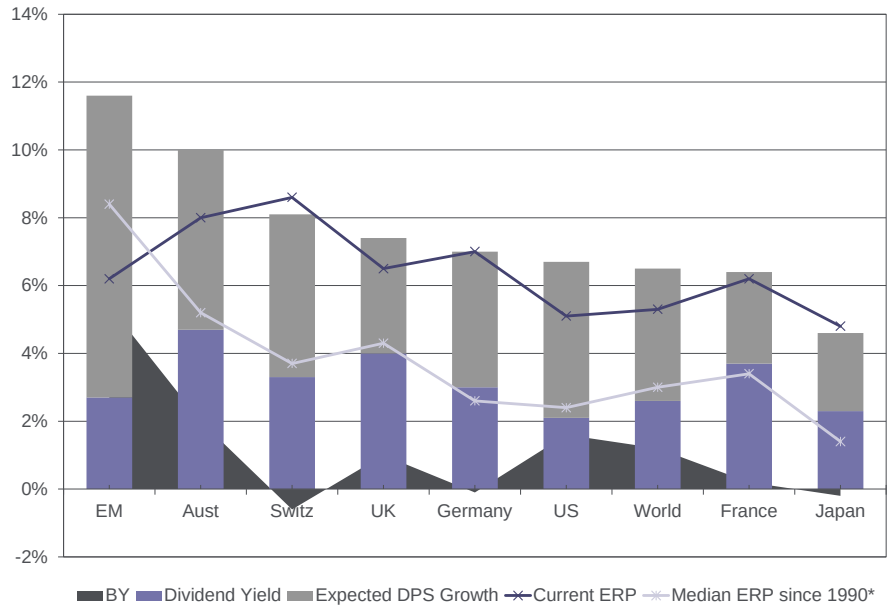
Figure 60. Global Ex-Ante ERP in July 2016



Source: Citi Research, Datastream

This is an effect which we can examine in more granularity around the world, as highlighted in Figure 61.

Figure 61. Bond Yields vs. Equity Total Returns Around the World



Source: Citi Research

Figure 61 shows the split of expected equity returns around the world by income and growth, and compares them to the woefully low bond yields on offer. What it also highlights is the huge disparity between emerging and developed markets, given different perceptions of risk.

Against this backdrop of lackluster market returns, infrastructure investing begins to look even more attractive.

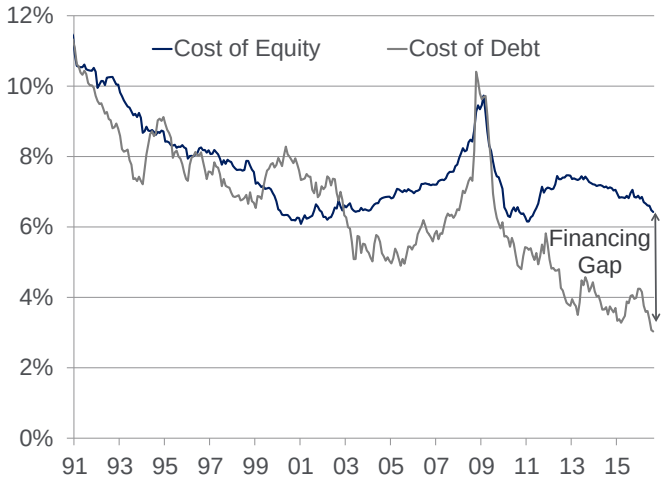
Against this backdrop of lackluster market returns, infrastructure investing begins to look even more attractive. However, while these returns might sound high at first glance in the context of markets, and given our earlier comments about 'low risk assets', we should remember that equity investors have had their fingers burned many times in infrastructure, in both developed and emerging markets. Spain's retrospective regulatory review in power markets led to enormous write-offs (in the billions of dollars) for investors, and in Brazil, the reduction of lending capacity on projects by the BNDES led to developers having to 'find' several hundred million dollars of extra equity investment on projects which had already broken ground – indeed this led to some very high-profile cases of companies entering bankruptcy protection.

This highlights an important point; while projects which are working tend to be stable, when a project 'goes wrong' the results can be catastrophic, and can lead to a total loss of equity, and while debt is normally more secure, write-downs/offs do happen.

If infrastructure evolves as an asset class, the liquidity premium could start to reduce as exiting an infrastructure investment could become easier

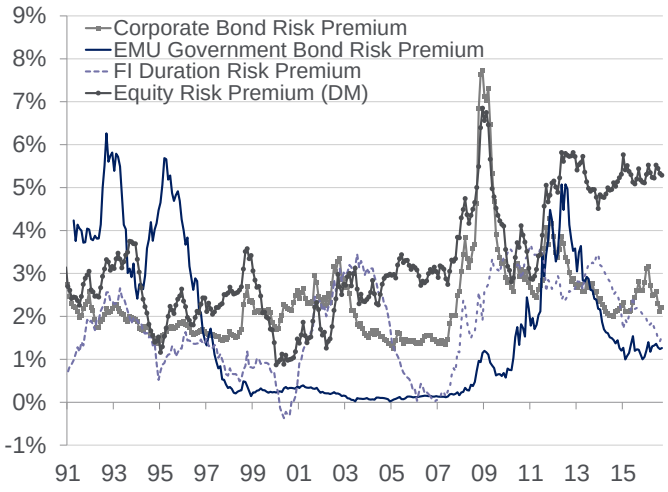
Moreover, infrastructure investing does deserve a premium return based on a lack of liquidity. There is as yet a limited 'secondary market' in infrastructure assets, with many owners having been the original investors, but if infrastructure evolves as an asset class as we expect, the liquidity premium could start to reduce, as exiting an infrastructure investment should become easier.

Figure 62. Long-Term Costs of Equity and Debt



Source: Citi Research

Figure 63. Global Risk Premia Across Fixed Income and Equities



Source: Citi Research

Despite the higher rates of return available in infrastructure investing, loss levels are relatively low. Standard and Poor's noted (in 2014) that over a 15-year period the average annual default rate for project finance debt was 1.5%, vs 1.8% for corporate bonds. Moreover, recovering rates post default tend to be higher, averaging around 75% versus rates closer to 50% in the cases of corporate default.[25] Just as interesting is the fact that infrastructure investments held up well, with no significant change in default rates through the financial crisis. In our view this resilience and lack of volatility are a significant relative attraction versus equities and corporate (and indeed government) credit.

The returns of infrastructure investment when compared to equity and credit markets are attractive

So, while infrastructure projects and investing might be 'dull' given ultra-long investment lives and very limited operating variability (the construction phase can be anything but dull…) compared to equity and credit markets where returns are at historic lows, the returns in context are attractive, particularly from an income perspective. While this is partly reflective of the low levels of liquidity, it provides yet another reason as to why now is the right time to be investing in infrastructure.

Mechanisms and Making it Happen

So, we have identified a social need for infrastructure investment, a macro need for infrastructure investment to boost global growth, attractive relative returns, lower defaults, the desire and availability of private capital to invest, alongside historically low borrowing costs for governments.

So what else do we need to do to make it happen? The way we have approached this is to think about what success looks like, by asking, "What would be the elements of a large and liquid global market for infrastructure investments, with a significant number of players?"

[25] "Global Infrastructure: How to Fill a $500 Billion Hole", S&P, 2014

If we are serious about building and growing a new global asset class, we need to improve the availability of infrastructure data

1. **A lack of data** – Writing a report such as this highlights the first hurdle – there is no central source of data on infrastructure. If you want to write a report on energy, you have the International Energy Agency (IEA) and various other sources to use. However, in infrastructure, there is no such resource. Historic data is patchy at best, varies enormously by country, region, and industry and is often collated on different bases (and isn't clear as to what is public, private etc.). While it sounds basic, if we are serious about building and growing a new global asset class with liquid markets which facilitate investment and efficiency, data is a fundamental tenet. Whether this is UN, World Bank, OECD etc. coordinated is not our call to make, but there must be a central source of data if a large, liquid, and transparent market is to evolve.

Information on the future is also lacking. Delays and uncertainty on projects do nothing to encourage investors to invest in much-needed infrastructure

2. **A lack of bankable projects and a visible pipeline** – Information on the future is equally patchy. Governments and local authorities need to have detailed and thorough long-term infrastructure investment plans. India and China have their five- or seven- year investment plans which are a help, and more countries are following suit, with potentially even longer time horizons (even if speculative), which could help provide positive investment signals to investors and companies to allocate more resources to the sector. Even developed markets suffer from a lack of clarity, and excessively long lead times. Taking just the UK as an example, how long have we heard discussions about a third runway at Heathrow, or a new airport in the Thames estuary, or whether HS2 should go ahead, or whether we should build a new nuclear plant at Hinckley or not, and who should build it? Delays and uncertainty do nothing to allay investors' fears, or to create a consistent backdrop against which to allocate resources and to invest for the long term. If the deadline is there and the desire and focus, projects can be completed on time and on budget, and be a resounding success – take the London 2012 Olympics as an example.

   The previous point – if we had a database of historic investment – would also help with planning and pipelines, in that it would provide a better understanding of the efficacy of projects, and we could learn more about risk and appropriate returns, hurdles, pitfalls, and lessons to be learned. While we are never likely to have 'standardized' projects or models given the inherent variations by project, a blueprint or template would be a good starting point which could then be adapted for purpose using the lessons of history.

Governments are often seen as the most significant area of risk.

3. **Political and regulatory stability** – Governments must wake up to the fact that they themselves are often seen as the most significant area of risk. While traffic volumes, power prices etc. can all to an extent be hedged out or insured against, what is much harder to offset is governments or concession-grantors 'moving the goalposts' once an asset has been built. The examples of this are (sadly) too numerous to mention, but the most common are competing assets being built (such as new roads being built in parallel to toll roads, or even slip roads being built that allow users to bypass toll booths) or allowed returns or feed-in tariffs on an asset being changed post construction, to name but two. This isn't just limited to emerging markets – we have seen developed markets (e.g. Spain) resort to the taboo of retrospective legislation in recent years, as governments grapple with the need for austerity post the Great Financial Crisis.

   Governments often seem to offer asymmetric risk – if you make supernormal returns, regulation will cut those returns, whereas if it doesn't work out as planned, it is much harder to get compensation from the government. Governments or concession grantors must accept that returns are obviously not commensurate with the risks perceived by investors and financial markets – the one thing which is certain is that in the highly competitive capital markets,

competition would drive returns on projects down to the lowest acceptable rate, if it was even worth tendering for projects on the basis of the returns available. Often it is political or regulatory risks where the differential in perceived risks occurs.

Following on from the previous point, changes of administration that may result in projects being shelved or goalposts being moved are a significant factor in deterring investment. If governments vacillate before a project is even built, it is hardly surprising if investors are wary about a change of administration moving the goalposts once an asset is half-built, let alone at some point in a 30-year concession life. Examples are again too numerous to mention, though the ultimate of course remains the renationalization of privatized assets.

Regulatory stability is equally important. The creation of genuinely independent, non-politically controlled/motivated regulatory bodies, with clear and transparent return methodologies, is key to success. There are many examples of success, such as the independent regulatory bodies such as the Water Services Regulation Authority (Ofwat) in the UK and the transparent 'regulatory asset base (RAB)' mechanism which has facilitated dramatic increases in service levels, reduced leakage, and allowed enormous investment in networks while removing the liability from government balance sheets, at the same time as providing attractive returns and income for investors over the last quarter century.

Governments should set out commercially minded bodies to manage infrastructure pipelines

4. **Planning/infrastructure bodies** – Following on from our comments on pipeline visibility, governments should set up commercially-minded bodies to manage these pipelines, and to liaise with private investors, owners, operators, and contractors to enable these projects to progress as quickly and efficiently as possible.

   These institutions could take the form of the infrastructure bodies which are appearing around the world, such as the Asian Infrastructure Investment Bank, created with a view to facilitating the One Belt One Road project, tasked with creating a modern equivalent of the Silk Road via an overground and maritime trade route around Asia. In Europe the European Commission and the European Investment Bank (EIB) have created the European Fund for Strategic Investments (EFSI) which by mobilizing private investment could leverage a centralized seed of €21 billion ($23bn) into a €315 billion ($347bn) fund for infrastructure or strategic investments. In the US, about the only thing Republicans and Democrats seem to agree on is that there should be an infrastructure investment boost, with suggestions of a national infrastructure investment bank, and the re-launching of Build America Bonds.

   The creation of these bodies, and their correct engagement with private entities, would help to eliminate the infamous 'white elephant' projects which have dogged the industry – enormous, impressive, and very high-profile projects which serve no purpose or offer no return or are a financial millstone in their operation and ownership.

Corporates and investors should not expect premium returns to be handed to them on a plate

5. **Financial expertise and allocation of resources** – By the same token, corporates and investors should not expect premium returns to be handed to them on a plate. The lack of a liquid, diverse, and efficient market in infrastructure investment vehicles can also be laid partly at the door of investors, some of whom have not yet allocated the resources in terms of qualified personnel to conduct due diligence on investment opportunities, thereby creating a large enough market. Admittedly difficult when the pipeline of projects isn't there, but the greater volume of projects won't be there unless there becomes a greater level of competition for assets, leading to greater transparency, knowledge, and market liquidity.

   So, this is the usual case of chicken and egg; or in this case, a standoff between 'if you build it, they will come' and 'if you come, they will build it'.

Public private partnerships need to evolve further

6. **Structural and financial innovation** – While public private partnerships are hardly new, having effectively been around for millennia (albeit under different names), they do need to evolve further. All parties have different skills and attributes to bring, whether it is the cheap financing available to governments, to the technical expertise of designers and EPC contractors, or the financial rigor of investors, to the practical knowledge of operations and maintenance companies, all have a key role to play in the creation and operation of a infrastructure consortium. End users/customers/consumers should also be represented, as the more fit for purpose an asset is, the greater its likely utilization, and hence potential return (or reduced risk of lower usage). The structure of this consortium and how it evolves over time can also be critical to the success of a project.

   For example, if a government provides low-cost financing initially and potentially guarantees, but retains 'skin in the game' financially, this can provide greater security to private investors regarding regulatory and political stability, given a (relatively) low likelihood that a government will shoot itself in the foot.

   If done correctly, the right measure of risk sharing (upside and downside), via caps, collars, banding mechanisms, first loss structures, credit enhancement, and other mechanisms can reduce risk and overall cost. Moreover, as risk metrics and expertise requirements change through the life of an asset, it is appropriate for financing structures, ownership and risk-sharing metrics to evolve as the project does. For example, an airport might need to be built by public money, it could be 'sold' once operational, but there is no reason why private expertise couldn't be involved initially, in return for (for example) preferential rights at sale, discounts, risk-sharing mechanisms. They may even want to be involved at the outset, if the public entity takes enough volume (for example) risk – risk which they would be taking anyway. Compensation mechanisms are also important, with a pre-defined independent arbitrator to settle any disputes which may arise.

   Players and central institutions then need to get creative about how risk is spread, via for example securitization of multiple project investments, thereby creating a portfolio effect. Government or supranational bodies can also offer forms of credit enhancement such as the EIB project bond credit enhancement program (PBCE).

   On the equity side, pain and gain sharing mechanisms can reduce risk, as can usage guarantees.

Beyond the obvious financial structuring, there are much more innovative approaches to aligning risk and returns. Building an infrastructure asset should deliver either a social and/or economic benefit (otherwise why bother), which itself is likely to have many resulting effects. The aforementioned Hong Kong Mass Transit Railroad provides an excellent example here, where the operator benefits from the appreciation of land values around stations on the network. This allows the entity to be profitable while maintaining low fares, and also facilitates further development of infrastructure around stations.

Companies should be clear about (1) what they do, (2) how they finance it and (3) where their risk exposure lies

7. **Industrial & financial evolution** – Given the range of risk profiles through an investment's life, a lack of clarity over expertise can cause problems of perceptions of greater risks. In recent years, EPC companies have started taking larger stakes in projects which they construct themselves. The justification for this is that gaining operational data creates a positive learning loop for new projects, and exposes them to greater levels of upside/return on the asset which they have built. (The reality may be more due to a lack of financing availability during the credit crunch.) While in principle this is fine, it requires significant rigor (and importantly transparency) over structure and financing. For example, while an operational concession might be 75% levered, a construction company certainly won't be, and investors need to be clear about where debt is and where cash is, and who has recourse to what. Moreover, the (traditional) usage of negative working capital to construct projects (i.e. the sponsor pays, then you build it) can work fine, so long as the cash and liquidity are retained, providing flexibility in the event that financial circumstances change – individual projects can easily be large enough to bring down a whole company, resulting in a domino effect and distressed sale of other operational assets which should have been lower risk. This effect can be exacerbated where there is extensive usage of factoring and reverse factoring (and a lack of transparency over the utilization of such facilities) as a financial situation becomes even more opaque. So, it is important that companies are clear about WHAT they do, HOW they finance it, and WHERE their risk exposures lie. It may be that in many cases companies are better off sticking to one thing – either building it, or owning and operating it, but not both. By not investing in projects themselves, EPC contractors could also reduce the risk of pushing out potential other investors, and holding back further the creation of a liquid market for investors.

Greater financial transparency would attract more players, which would improve liquidity, and even though it would reduce returns, it would also reduce overall financing costs

8. **Financial transparency** – Infrastructure investing has been dominated either by governments, and even where investment is from other sources this has often been 'private', i.e., it has been conducted behind closed doors, and not via a public process (such as a debt auction). While the latter can be more expensive and cause issues with timing of drawdown etc., the greater levels of disclosure etc. required in prospectuses help to reduce risk and theoretically the overall financing cost, as well as potentially providing easier exit routes.

   Greater transparency would attract in more players, which would improve liquidity, and, while it would inevitably reduce returns (as it has done recently) via greater competition, this would effectively reduce financing costs overall, theoretically enabling more projects (as well as making money go further). While many existing players might not welcome greater levels of competition for assets, and greater disclosure given 'commercial sensitivity', they cannot then complain about the lack of bankable projects – surely it would be better to have more opportunities to choose from, even if the average returns were slightly lower.

A great example of the power of communication and greater transparency comes from the Crossrail project in London, currently Europe's largest infrastructure project with budget of some £14.8 billion ($18.1bn), due for completion in 2018. As well as all parties devoting staff to centralized cross-fertilization of ideas during planning and construction (the so-called 'Innovate 18' program), the Crossrail learning legacy framework aims to share best practices across 12 main areas from project management to innovation, and is available to all.

Forms of credit guarantees which could turn EM credit into investment grade are of great interest

9. **Turning EM into investment-grade** – As discussed, much of the infrastructure requirements of the coming decades will be in emerging markets, driven by population growth, increasing wealth levels, and by themes such as urbanization. However, most EM credit markets are sub-investment grade, which effectively excludes them from access to much of the global credit market and investors. While EM governments have lower levels of debt/GDP than DMs, they are wary of exposing themselves too much to international credit markets in case these 'turn against them' given the volatility of EM markets. Hence forms of credit enhancement or guarantees which could effectively turn EM credit into investment grade are of enormous interest. While still relatively new, we have seen interesting developments in some fields such as renewable energy, with emission credits being guaranteed in terms of a price floor, which effectively makes EM projects much more stable and marketable and elevates credit quality. If international institutions could guarantee elements or provide first loss support (with international collateral provided locally, for example), this could be enough to open the log jam and start to boost investment in emerging markets, restoring growth, which would in turn drive demand for products from developed markets, and so on and so forth. Given the global focus of infrastructure needs in EMs, this is perhaps the single most important step in the evolution of infrastructure markets which the financial (and government and supranational) community could make.

The complexity of infrastructure accounting can itself be a hurdle for the financial community

10. **Accounting transparency** – While accounting might seem like an odd inclusion here, the complexity of infrastructure accounting is itself a hurdle to transparency for the financial community. Without going into inappropriate levels of detail here, concession assets can be accounted for under two wildly differing financial models, namely the financial asset model, where the (e.g.) 40-year concession is booked as a financial asset, and is treated as a loan on which financial income is earned by the concession owner operator. This leads to limited EBITDA, but significant net income. Conversely a concession where the operator has the right to collect usage revenues itself direct from the consumer (rather than direct form the government or concession grantor) will be booked as an intangible asset, which will earn often very high levels of EBITDA, which are then offset by very high financing charges from the cost of building the concession asset/leverage on the asset. Hence the same asset could have massively differing levels of EBITDA generation depending on its accounting treatment – while cash is the same, it is enormously complex. While specialist investors understand, generalists typically do not – and companies do not help the situation by not being transparent (and potentially making use of the impenetrability). Where it becomes even more complex is where the company built the asset and booked the EBITDA from building it, again a treatment which is allowed under the intangible asset model. How these assets are then booked on the balance sheet, and at what level, once again provides enormous layers of complexity, leading to a lack of transparency.

Greater levels of disclosure on what are in most cases monopoly assets anyway, can only be a good thing, with an end to the obfuscation facilitated by the mantra of 'commercial sensitivity'.

Education and ensuring the customer experience is positive could make a significant change to the perception of the industry

11. **Industry transparency and customer engagements** – Infrastructure remains an opaque and not widely understood sector, and the industry could benefit from rectifying this. We all use infrastructure every day, but most of us rarely stop to think about how it got there, who built it, and what the realities of operating it are – but we get very upset when it doesn't work.

    Building infrastructure assets, be it a power station, water network, road, bridge, or telecoms network can cost billions of dollars. However, the marginal costs of operation — e.g. the cost per car on a motorway — are in many cases close to zero. This leads to very high EBITDA margins (which are necessary to cover the financing costs on the initial investment) but which may be politically unpopular and smack of profiteering, especially on a monopoly asset. We've all seen media reports of X company making Y hundred million dollars of 'profit' on an asset and neglecting to mention that net profit post financing was negative, and that cashflow was minimal due to the investment requirements. Education and ensuring the customer experience is positive (rather than purely functional) could make a significant change to the perception of the industry, which in turn could help to change government attitudes towards what they see as private company 'profiteering'. With many infrastructure assets being by definition monopoly assets, the expertise of companies is often in efficient delivery, rather than of 'commerciality' in industries where customers have a choice. Learning from customer-focused tech companies, or real estate companies who have turned shopping malls into experience destinations etc., could help not just in perception, but also in building a 'better' asset which would in turn be used more and hence offer better financials.

12. **Industry consolidation** – Despite the size and obvious attractions of the industry, it remains enormously fragmented. Take as an example the world's largest construction company by revenue, ACS. While ACS has €35 billion ($39bn) of global revenues, this still only accounts for <1.5% of global infrastructure investment. While the industry titans such as ACS or Vinci might in some minds be big enough already, what surely must be inefficient is the vast tail of dramatically smaller companies which build and operate infrastructure assets all over the world. This level of fragmentation serves as a significant barrier to best practice cross-fertilization in the industry.

    While it might seem inconceivable to have a construction company or series of companies so large that the market could be called mature (a typical definition of maturity being, say, seven players representing the bulk of the market), we have seen levels of scale in other industries which would previously have been inconceivable (technology, pharmaceuticals, or oil & gas, for example). While the physical nature of infrastructure might mean that these analogies are somewhat inappropriate, the current levels of fragmentation surely cannot be efficient.

Conclusions and Recommendations

Infrastructure is all around us and a basic part of our everyday lives, from the water system that provided the water for your shower this morning, to the energy which moves the train that got you to work today, and the broadband network which probably delivered you this report.

Yet in both developed and emerging markets, we are spending less relatively on infrastructure than we used to, and this is evidenced by aging infrastructure or a lack of access. There is an enormous social need for infrastructure, with billions of people around the world still lacking access to electricity, clean water and sanitation, a situation which will only get worse as we struggle to accommodate a further 1.5 billion people, most of them in infrastructure-heavy cities, over the next 20 years.

There is also a strong economic justification for infrastructure investment. With monetary policy all but exhausted with close to zero or negative real rates and widespread QE, fiscal policy in the form of infrastructure investment offers a potential solution to sluggish economic growth. While debates about causality continue, our data shows a clear linkage between infrastructure investment and GDP growth, alongside an equally undeniable link between GDP per capita and the quality of infrastructure. One thing is certain; key infrastructure is either aging, or doesn't even exist yet, and you certainly can't have growth without the necessary infrastructure.

At the same time, the ~$200 trillion of equity and credit markets are struggling to find returns, with returns for both over the last decade pitifully low versus their long run histories. Hence investors are desperate for yield and for long-term income streams to match against liabilities. Infrastructure projects can provide those returns; in fact, they provide higher returns, with long durations, and with typically lower default rates than their traditional investment alternatives.

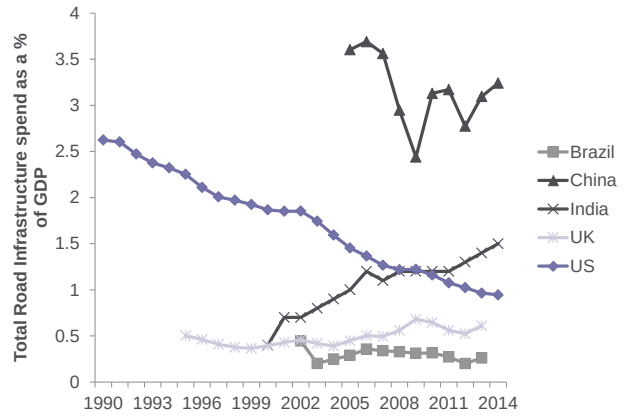
So with a $58.6 trillion need for infrastructure investment and $200 trillion in capital markets with a desperate desire to invest in instruments with the characteristics that the former can provide, why is there only a fractional overlap between the two?

The main reason is a lack of bankable projects, or more specifically a mismatch of risk perceptions and an immature, fragmented, and relatively disorganized industry. These problems, while not easy to overcome, are far from insurmountable given a coordinated approach. Without reproducing the list in full here, we believe that some of the key building blocks for the future must be regulatory and political stability, collation and availability of data, transparency, specialized institutions, and financial and structural innovation. All are key to developing a large and liquid global market for infrastructure investment vehicles.

Rarely do the planets align to provide a multi-trillion dollar opportunity that aligns capital with a desire to invest with projects that need investment, in a venture that offers the scope to kick start the global economy, and deliver enormous social good for the world. That opportunity is here now – it is up to us to seize it.

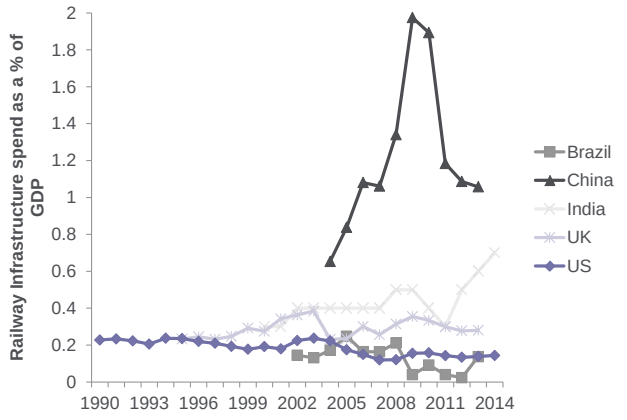
Transportation Infrastructure

Figure 64. Total Road Infrastructure Spend as a % of GDP



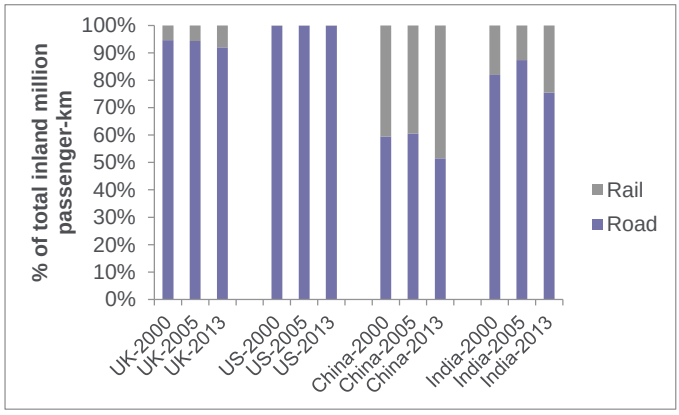
Source: OECD, Citi Research

Figure 65. Total Rail Infrastructure Spend as a % of GDP



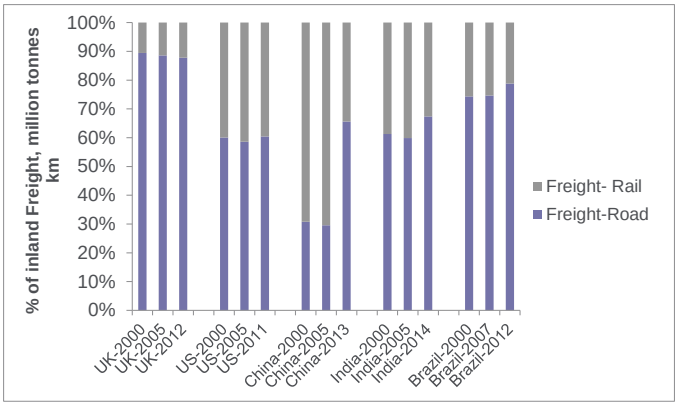
Source: OECD, Citi Research

Figure 66. Model Split of Inland Passenger Transport (Road and Rail) (% of Inland Passenger-km)



Source: OECD, Citi Research

Figure 67. Model Split of Inland Freight Transport (Road and Rail) (% of Inland Tonnes-km)



Source: OECD, Citi Research

Figure 68. Quality of Road Infrastructure

Country	Quality of Roads - Rank	Score 1-7
UAE	1	6.6
Netherlands	2	6.2
Singapore	3	6.2
Portugal	4	6.2
Hong Kong	5	6.2
Austria	6	6.1
France	7	6.1
Japan	8	6.0
Switzerland	9	5.9
Taiwan	10	5.8
US	**14**	**5.7**
UK	**29**	**5.2**
China	**42**	**4.7**
India	**61**	**4.1**
Brazil	**121**	**2.7**

Source: World Economic Forum[26],Citi Research

Figure 69. Quality of Rail Infrastructure

Country	Quality of Rail - Rank	Score 1-7
Japan	1	6.7
Switzerland	2	6.6
Hong Kong	3	6.4
Spain	4	5.9
Finland	5	5.8
France	6	5.8
Netherlands	7	5.7
Singapore	8	5.7
Germany	9	5.6
Korea	10	5.6
US	**15**	**5.0**
China	**16**	**5.0**
UK	**18**	**4.8**
India	**29**	**4.1**
Brazil	**98**	**1.7**

Source: World Economic Forum, Citi Research

[26] World Economic Forum, The Global Competitiveness Index Historical Dataset 2005-2015

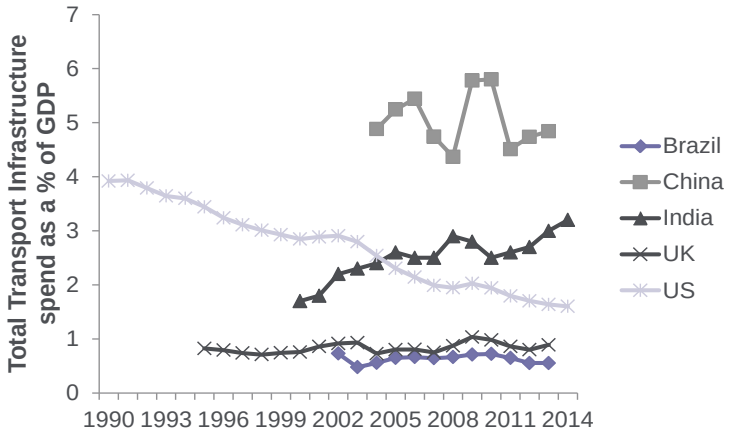
Moving People and Goods Around the World

Transportation infrastructure covers an incredibly wide range of assets but can essentially be broken down into road, rail, air, and maritime, though each of those has its own subsets of infrastructure. We should also remember that transport includes freight and passenger, the latter being divided between business and leisure.

$1.15 trillion was spend on transport infrastructure in 2013, with spend levels varying in different countries

In 2013, the world spent $1.15 trillion on transport infrastructure, with spend levels varying around the world, from ~5% of GDP in China to <1% in Brazil.

Figure 70. Total Transport Infrastructure Spend as a % of GDP



Source: OECD, Citi Research

Developed markets have not been spending enough on the maintenance of transportation assets

While spend is naturally higher in emerging markets, we can be forgiven for assuming that it is 'OK' for developed markets to have much lower spend as the infrastructure already exists. However, transportation infrastructure is perhaps the most 'visible' of the four key areas of infrastructure, and one only has to travel from the tired airports via deteriorating roads to some of the world's greatest capital cities, to realize that developed markets have not been spending enough on the maintenance of transportation assets. Part of this is the assets' age – the US embarked on a massive roadbuilding program in the 1950s, and the railway networks in mature markets such as the UK and US are considerably older. This is borne out in the quality of infrastructure around the world, with the US and UK both outside the top 10 in both road and rail infrastructure, as shown in Figure 68 and Figure 69. Conversely, Japanese and Swiss railroads are the stuff of legend in terms of efficiency and being able to set your watch by them, and the statistics appear to bear this out. So, while it is easy to think of high-profile new projects such as Crossrail in the UK, the Gotthard Base tunnel in Switzerland, or One Belt, One Road in Asia, when we think of transportation infrastructure spend, we should also remember that maintenance spend is just as important, and perhaps has not been given the attention it deserves.

Going forward, the way we travel is likely to change dramatically. Population growth and wealth improvements are likely to increase leisure travel, and trade growth will inevitably drive infrastructure demand. However, disruptions such as virtual reality could have significant longer-term impacts on both business (and leisure travel), as could drones on commercial transportation, to name but two.

Disruptive Transportation Innovations

Transport infrastructure has to be future-proof, which requires understanding of future demand, how we will travel and the innovation that is happening in this area

Transport infrastructure networks have a very long lifetime, typically 50 to 100 years or more.[27] Therefore decisions today will ultimately have an effect on mobility patterns extending beyond 2050. Transport infrastructure networks have to be future-proof, which requires an understanding of future demand, how we will travel, and of the innovation that is happening in this area.

Autonomous vehicles and driving habits

Transport innovation such as driverless cars has an impact on the landscape of the city and the way cars are used in the future

Our GPS report (Car of the future II) highlighted some of these innovative systems, including how tomorrow's cars could be built, powered, equipped, and serviced. The report also mentions mobility as a service, where companies like Uber and Lyft could potentially change the way consumers plan for getting from A to B. Driverless cars were relatively recently thought to be something in the distant future, but the technology is improving at a very fast pace, with some models now featuring the technology. Singapore has just launched a self-driving taxi service: the trial service run by Singapore's nuTonomy founded by two researchers from MIT is using a Renault Zoe and Mitsubishi i-MiEV electric car and testing the free-taxi service in a small district in Singapore. Uber is not far behind, and is expected to start using driverless cars to carry passengers around the city of Pittsburgh. The ride service will use Ford Fusions equipped with self-driving technology; drivers will still be needed at this point, as a safety measure, to take control of a vehicle if needed. In the UK, the city of Milton Keynes is testing out a completely autonomous vehicle pod vehicle using the Lutz Pathfinder. Created by RDM Group in collaboration with the University of Oxford's Mobile Robotics Group and Transport Systems Catapult, the two-person vehicle uses a number of sensors and cameras to monitor its surroundings and drive on the road network without human interference.[28]

Even though the extensive roll-out of fully autonomous cars could be a decade away, their impact on the landscape of the city and the way people will use cars in the future should be taken into consideration when planning transport networks, especially in urban areas. UK Autodrive Project Director Tim Armitage believes that driverless cars will lead to fewer cars in the city – "Public transport will be integrated and very accessible, people will walk, cycle, use pods, and use buses seamlessly. They will be billed for the services they use from a citywide mobility provider. No cars will be parked in the city for extended periods of time, they will simply return to car storage areas on the outskirts of the city when not in use. Fewer people will own a passenger car, instead cars will be hired when needed." Driverless cars could also drive in narrower lanes, potentially requiring less road space and therefore being able to divide the existing space into a greater number of lanes. Smart roads could also be better managed and controlled. For example a connected Wi-Fi road could see cars and infrastructure wirelessly connected, with drivers receiving real-time news of congestion, making journeys more efficient.

[27] Zarli A, Bourdeau L, Segarra M (2016), REFINET: Rethinking Future Infrastructure NETworks, Transportation Research Procedia 12 (2016) 448-456

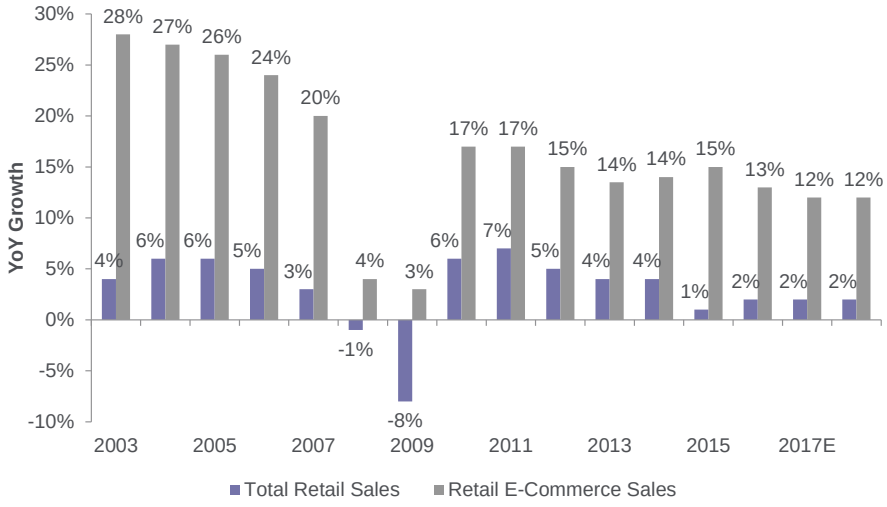
[28] Zipcar presents Transit Evolved (2016), UK City is Designing a Future of Fewer Cars-By Focusing on its Roads

Transport and e-commerce

New innovations such as drones could change the way e-commerce is delivered reducing the amount of small light good vans on the roads in cities

The rapid growth in e-commerce has greatly increased the transportation requirements to deliver goods from their production line to the end user in the shortest time possible. Our e-commerce analysts estimate that sales from e-commerce in the US grew 14.6% year-over-year in 2015, this compares with a 14.4% growth in 2014 and above their initial 14% forecast for 2015. Increases in urbanization especially in Asia and Africa will create more concentrated consumer markets similar to the US and Europe. Today, packages are delivered by 'men in vans', though e-commerce companies like Amazon believe that drones could reduce the direct and environmental costs of delivery and improve speed. The 'last mile' delivery is typically the most expensive, especially for small packages that made up 86% of e-commerce orders and 2 billion deliveries in 2015[29]. Drones will be able to carry these small packages and will be able to reach destinations in 30 minutes. It might seem like fiction at this point; however the company has invested significant sums in its Prime Air system and aims to roll out the technology by 2017. If this happens, maybe we will be living in a world where drones flying over cities would be as normal as seeing delivery vans on the road. The corollary is that vast numbers of small light-goods vehicles driving on the roads of London, New York, Beijing, and others delivering our goods to our door step wouldn't be needed any more.

Figure 71. Total Retail and E-Commerce Retail Year on Year Growth



Source: US Department of Commerce, Citi Research

Air travel and virtual reality

Our consumer electronics analysts have estimated that the Virtual and Augmented Reality market could reach $692 billion in 2025 (see Citi GPS Virtual & Augmented Reality). It is estimated that the initial major market would be the gaming sector, however over the years the technology would expand into other sectors including media, sports and music, phone and video calls, marketing etc.

So how does all this relate to travel and in particular infrastructure? The building and expansion of airports requires a detailed analysis on the future demand of the passengers traveling through different airport hubs. The International Air Transport Association has stated that passenger numbers are expected to reach seven billion

[29] Enders Analysis (2016), Amazon Prime Air pilots in the UK, 11th August, 2016

by 2034, with a 3.8% average annual growth rate. This is more than double the amount of people that flew in 2014. China, the US, India, and Brazil are expected to have the largest share in terms of additional passengers.

So could VR affect this market? While our analysts do not believe that VR will have a negative impact on actual travel in the short-to medium term, they do believe that there are questions to be answered for the longer term. While 'virtual holidays' might still belong in the realms of science fiction, augmented reality does offer potential alternatives to some elements of business travel.

Could augmented reality change the way we have face to face meetings, reducing business travel in the process?

Technologies such as Skype, WhatsApp and OpenExchange have allowed companies to have face-to-face meetings with clients, employees and counterparties at the click of a button. While these systems have been instrumental in changing the way we communicate with one another, they inevitably fall short of fully recreating the feeling of a one-to-one personal meeting. Augmented reality offers the potential to take this one stage further. For example Microsoft HoloLens may be able to project a hologram of your guests into your room and (you into theirs), and enable an environment which allows you a face-to-face meeting without leaving your work place. You might have to look at people using an AR headset, and while its impact might be at the margin in the short to medium term, the technology does offer the potential to replace some elements of business travel in the longer term, reducing corporate travel costs and CO_2 emissions in the process.

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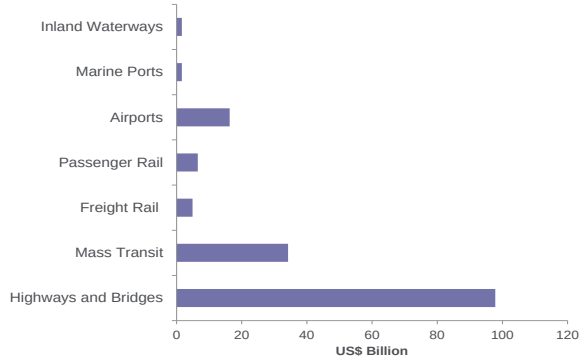
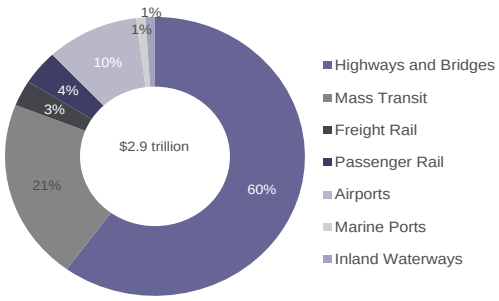
Transport in the US

Figure 72. Annual Average Capital Investment Needs



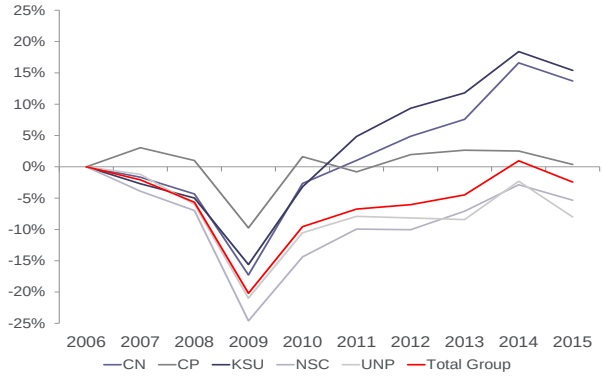
Source: US Chamber of Commerce (2013)[30], Citi Research

Figure 73. Aggregate Capital Investment Needs (2013-2030)



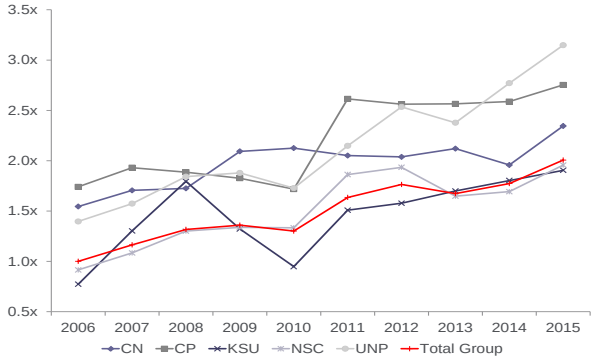
Source: US Chamber of Commerce (2013)[30], Citi Research

Figure 74. Industry Volumes Are Down from 2006 Peak Levels



Source: Citi Research and Company Reports

Figure 75. While Capex Has Essentially Doubled per CarLoad



Source: Citi Research

The ASCE gave the US a D+ for the overall quality of infrastructure. Failure to invest in infrastructure could cost the economy $4 trillion by 2025

In its most recent (national) report card for the US (2013),[31] the American Society of Civil Engineers (ASCE) gave the US a D+ overall for infrastructure, with transport components being roads (D), ports & bridges (C+), transit (D), rail (C+); and aviation (D), where C is classed as mediocre, and D as 'poor'. This far from resounding endorsement highlights many people's personal experiences, which suggest that maintenance spend in the US has been below levels necessary to maintain infrastructure at an appropriate level. In economic terms, the ASCE suggest that failure to invest at appropriate levels could cost the US economy $4 trillion by 2025, and a loss of 2.5 million jobs. They further believe that the funding gap over the next decade is $1.1trillion in surface transportation, and $42 billion in airports. US Chamber of Commerce figures give further granularity to the scale of the necessary investment in US transportation infrastructure.

Growth outlook

The US freight environment is currently just over a year into a contractionary period, but second derivative movements in industry data indicate that a soft inflection has started exiting the second quarter of 2016. Airfreight and Integrated Package

[30] US Chamber of Commerce (International Affairs), 2013, From International to Interstates: Assessing the Opportunity for Chinese Participation in U.S Infrastructure
[31] 2013 Report card for America's infrastructure, ASCE, www.infrastructurereportcard.org

Carriers have been less affected over the past 12+ months, thanks to exposure to secular e-commerce trends, while Rail and Trucking have been more affected in their relatively larger industrial and energy end-market exposures. Generally speaking, we expect a return to volume growth in 2017 across US freight networks, which should be supportive of pricing gains. Longer term, we expect volume growth correlated to real GDP growth and pricing growth above inflation. That said, we expect capital expenditure (capex) reductions in both the Rail and Trucking subsectors, but incremental increases in the Airfreight and Integrated Package Carrier subsector as companies with large business-to-consumer (B2C) exposures build out network capacity to meet the multi-year trend of secular e-commerce growth. In terms of Rail-specific infrastructure spending, we expect a reduction in capex spend from the Rail carriers over the next few years, reversing a trend of outsized spending growth since the 2009-2010 recession.

Major transport projects in the US

A 5-year $305 billion Federal highway spending bill was signed into law In December 2015- this legislation is important as it helps the intermediate outlook for transportation spending in the US

The FAST Act ("Fixing America's Surface Transportation" Act) — a 5-year $305 billion Federal highway spending bill— was signed into law in December of 2015. This legislation was particularly important as it helps the intermediate-term outlook for transportation project spending and creates a supportive framework within which are housed funding provisions for multiple freight and passenger transportation network initiatives, ending several years of annual stop-gap and provisional funding solutions. Of note, the law contains 18 separate provisions geared towards accelerating project delivery, which expedite timing and spend through such measures as environmental review exemptions for mid-century bridges and rail and transit lines and allowing for at-risk bridges to be replaced without delays, among others. The law also includes multiple highway-related freight funding provisions that encompass grant programs to state and local projects. Other major areas addressed by the law in programs are Highway Safety Improvement, Railway-Highway Crossings, Congestion Mitigation and Air Quality Improvement, Construction of Ferry Boats and Ferry Terminal Facilities, and the establishment of a designated Multimodal Freight Network. (Click here for more details on these and other programs: http://www.fhwa.dot.gov/fastact/factsheets/).

Multiple projects are under way to expand and improve East Coast port and highway infrastructure so as to handle increased import/export spurred by the Panama Canal expansion. Some of these projects are already under way, and include: the raising of the Bayonne Bridge in New Jersey, the expansion of the Port of Miami (Florida), and the dredging of the waterway at the Port of Savannah.

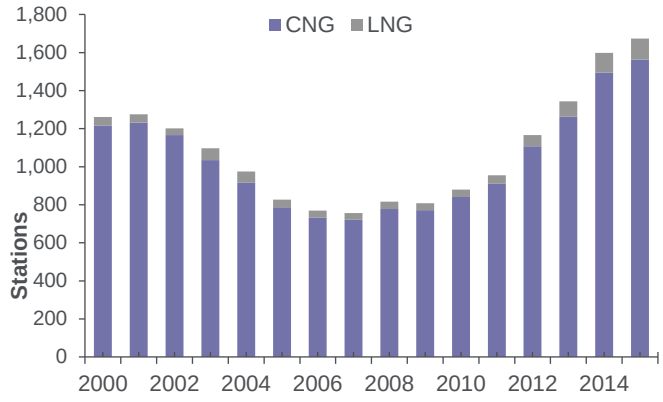
Rail network congestion issues surrounding Chicago have been a problem for years. The CREATE program is a partnership between the US Department of Transportation, the State of Illinois, City of Chicago, and passenger and freight rail carriers that is investing billions over 70 different projects to address these issues. Projects include 25 new roadway overpasses and underpasses, six new rail overpasses and underpasses, and 36 freight rail projects aimed at track, switching, and signal system upgrades

Barriers

The Highway Bill's passage puts to rest many outstanding questions on government support for infrastructure projects in the intermediate term. (Since 2005, no transportation funding bill had been enacted that lasted longer than 2 years). That said, the 5-year $305billion bill falls short of the 6-year $478 billion proposal which the President sent to Congress earlier in 2015, implying the need for substantial funding for additional infrastructure improvements which may hinge on election outcomes in November 2016 and in 2017.

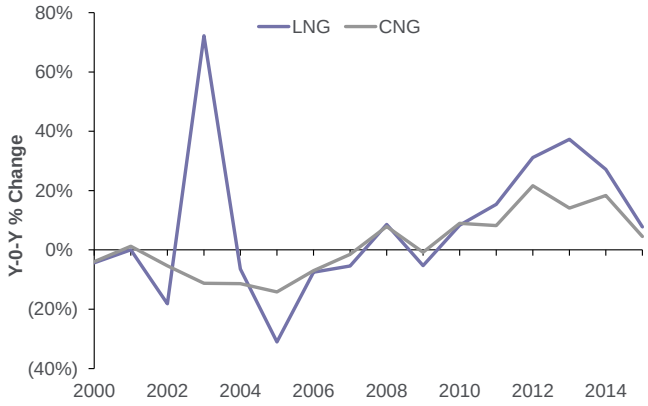
US Natural Gas Fueling Infrastructure

Figure 76. Natural Gas Fueling Stations Continue to Be Developed



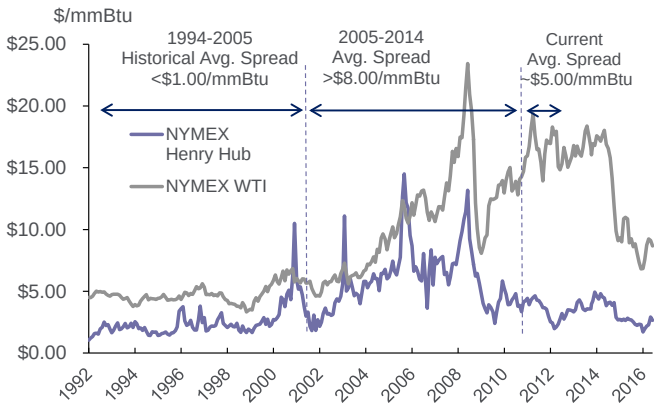
Source: US Department of Energy

Figure 77. Natural Gas Fueling Station Growth Has Slowed



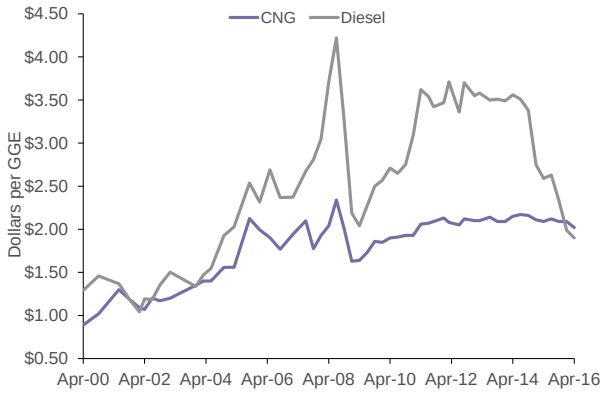
Source: US Department of Energy

Figure 78. Natural Gas Has Been Less Competitive vs. Oil



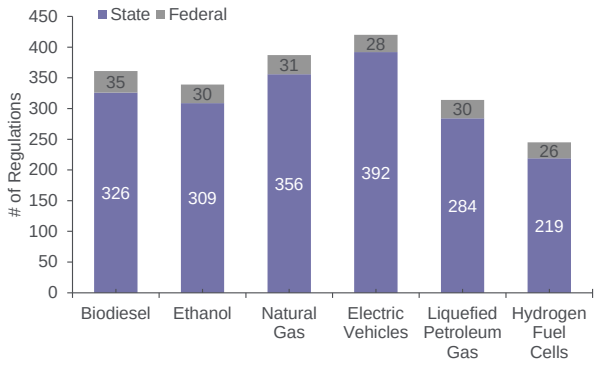
Source: Bloomberg and Citi Research

Figure 79. Retail CNG Prices Have Trended Above Diesel



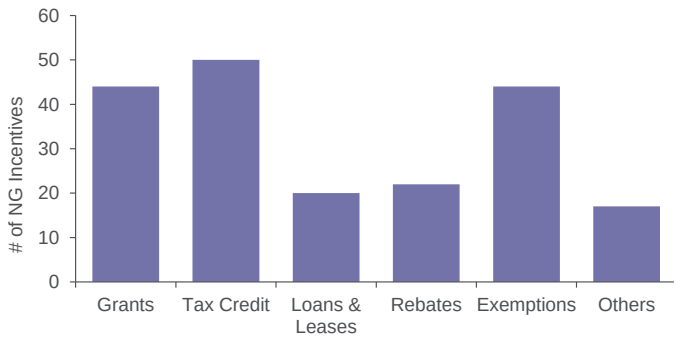
Source: US Department of Energy

Figure 80. Number of Laws and Incentives by Fuel Type



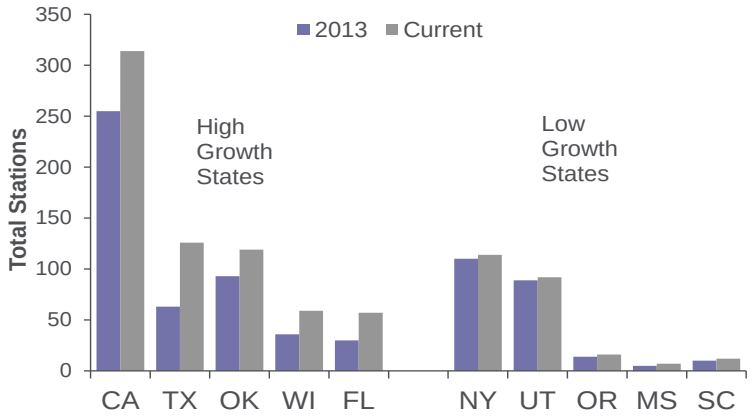
Source: US Department of Energy

Figure 81. Number of Natural Gas Incentives



Source: US Department of Energy Note: Includes both Federal and State incentives

Figure 82. Infrastructure Growth Continues at Targeted Locations



Source: US Department of Energy

The number of CNG fuelling stations grew ~14% annually from 2010-2014

The use of natural gas (NG) fueling for transportation is not necessarily a 'new' concept in the US as vocational vehicles, especially transit buses, have reaped the benefits of cheaper NG fueling since the early 1990s. However, as oil prices ballooned following the recession and technology advancements in natural gas drilling and production drove down NG prices, a wave of interest in Class 8 gas fueling developed. Based on data from the US Department of Energy (DOE), the number of compressed natural gas (CNG) fueling stations grew ~14% annually from 2010-2014 as rising diesel costs made the use of CNG/LNG (liquefied natural gas) alternatives increasingly compelling.

However, the collapse of oil prices in mid-2014 largely broke down the underlying economic catalysts that had been supporting the growth of natural gas fueling. Underlying conversion economics, from a fuel price spread, dropped from a 4-8x oil/NG range (diesel gallon equivalent adjusted) in late 2013, to the current 2-4x range. In some cases, this has resulted in negative CNG/diesel spreads at the pump, according to DOE data (although this likely does not take beneficial fueling contracts into account).

Due to a lack of scale and the relative newness of the equipment, Class 8 natural gas vehicles (NGVs) typically have a ~$50K premium vs. diesel to overcome. At mid-2014 prices, this translated into a < 2 year payback period, however, a recent estimate from Volvo stated NGV payback periods nearly doubled to 3-4 years (or longer) at current prices. While this shift is less likely to sway the vocational market – which often owns a vehicle for its entire life and comes with a much higher price tag compared to Class 8 tractors – an elongated return on investment is a major deterrent for a truckload operator that trades on a regular 4 year cycle. Echoing this, Class 8 NGV research and development has slowed across the major auto manufacturers in the current pricing environment.

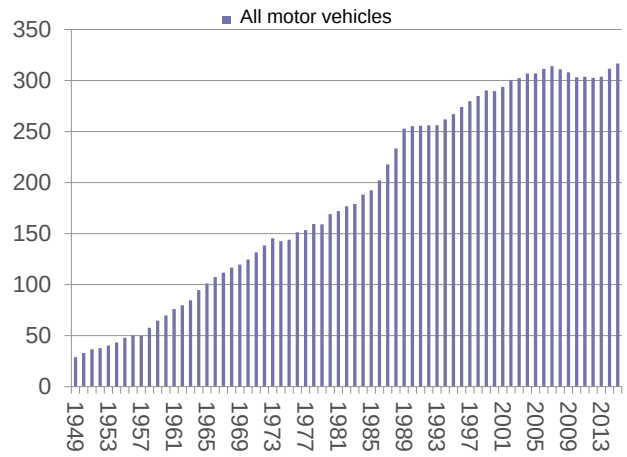
While fueling infrastructure has continued to forge on albeit at a more muted pace, US NGV sales have continued to decline, with NG truck sales down 24% year-to-date. It isn't just about economics, though, with increasingly stringent emissions standards placing pressure on vehicle fleets to adopt cleaner alternatives. The US government has provided vast support for renewable fuel development, with currently 31 federal and 356 state incentives for natural gas fueling alone, such as the Alternative Fuel Excise Tax Credit, the Corporate Average Fuel Economy (CAFE) standards, the Alternative Fuel Infrastructure Tax Credit, the Congestion Mitigation and Air Quality Improvement (CMAQ), as well as numerous state incentives.

Transport in the UK

Growth of 50% in motor vehicles was observed in the 1980s, 14% in 1990s and 6% in 2000s

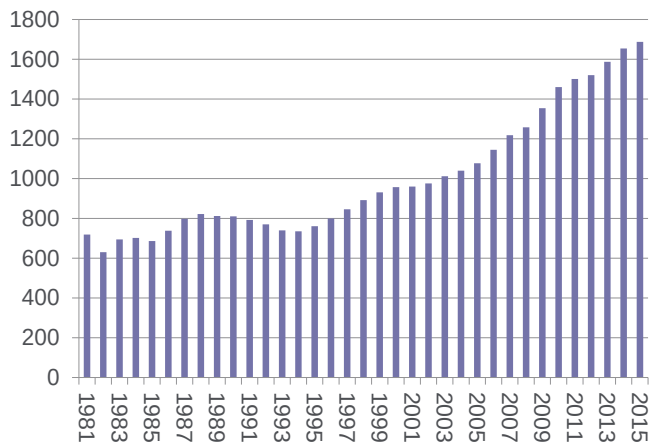
Figure 83 below presents the rapid growth of motor vehicles in UK since 1949 with growth of 50% was observed in the 1980s, 14% in 1990s and 6% in the 2000s. The UK Department for Transportation (DfT) report that motor cars accounted for 79% of vehicle miles traveled versus 44% in 1949. Figure 84 illustrates the post privatization growth from 1986 in travel by rail in the UK The combined effect of modest growth in travel by road and particularly rapid growth in travel by rail has given rise to a significant infrastructure need to accommodate current demand and future expected demand.

Figure 83. UK Road Traffic 1949-2015 (Vehicle Miles, Bn)



Source: DfT

Figure 84. Total UK Rail Passenger Journeys 1981-2015 (Bn)



Source: ORR

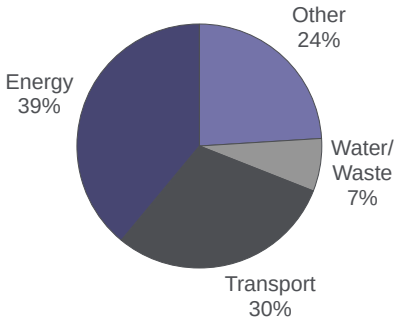
The UK has traditionally been at the forefront of innovation in infrastructure financing from the entirely private sector funding including public equity in the Channel Tunnel (1986) and the first major airport (1986) and port (1983) privatizations and to the ill-fated creation and privatization of Railtrack in 1994 (succeeded by Network Rail in 2002), the owner and operator of the UK heavy rail network. We believe the financial issues that led to the administration of Railtrack in 2002 and the financial restructuring of Eurotunnel in 2007 provide lessons on the issues that can arise with highly restrictive and long-term financial and regulatory arrangements when providing assets to serve markets that can change rapidly. Latterly the UK government has acted as a developer/incubator of major projects (such as HS1) where project planning and delivery is undertaken by the public sector and when commercial viability has been demonstrated the asset is sold to the private sector and the capital re-cycled to incubate another project.

The UK governments expects 85% of the transport projects in the NIDP to be publically finances: 100% of airports and ports and 0% of road and rail projects

The UK government expects 85% of transport projects in the National Infrastructure Delivery Plan (NIDP) to be publically financed. This is essentially 100% of airport and port projects and 0% of road and rail projects. Private sector funding mechanisms are well established for the private planning, delivery, and operation of airport and port assets in the UK. The public sector is the primary source of development finance for the provision of rail and road infrastructure with fairly limited exceptions of certain tolled bridges and roads. We believe the airport model best balances the interests of users, provides incentives for improved operational efficiency, and provides independent, stable, and transparent economic regulation to facilitate the financing of major capital projects such as the Terminal 5 at Heathrow Airport, which took around 20 years from conception to completion and cost £4 billion.

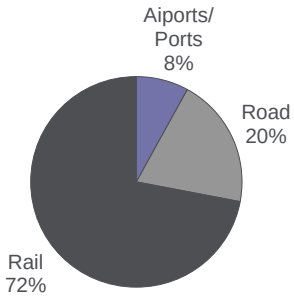
The NIDP 2016 identified a £483 billion ($591bn) pipeline of investments in over 600 projects of which transport was the second biggest contributor at £88.4 billion ($108bn). The UK government expects nearly £300 billion ($367bn) to be spent in 2016/17 to 2020/21 (see Figure 85) and around £64.2 billion ($79bn) on transport projects (see Figure 86). The NIDP includes both maintenance and enhancement investment.

Figure 85. UK Infrastructure Pipeline to 2020/21 (£bn)



Source: Company Reports

Figure 86. Transport in UK Infrastructure Pipeline to 2020/21 (£bn)



Source: Company Reports

Figure 87 below illustrates the UK infrastructure pipeline of major projects.

Figure 87. National Infrastructure in the Pipeline in the UK (£ billion)

Sub-sector	No. of projects & programs	total cumulative	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	Post 2020/2021
		£ Billion	£ Billion	£ Billion	£ Billion	£ Billion	£ Billion	£ Billion
Airports	10	5.1	1.3	1.1	1.3	0.5	0.5	0.4
High Speed Rail	1	53.7	0.8	1.6	2.7	4.4	4.3	40.0
LA Majors	84	11.8	2.6	2.3	2.2	2.3	2.3	0.0
London	36	12.4	2.4	2.6	2.5	2.4	2.5	0.0
Ports	3	0.7	0.3	0.2	0.1	0.1	0.0	0.0
Rail	95	38.2	8.4	6.9	5.4	6.2	5.6	5.7
Roads	91	12.5	1.8	2.2	2.4	2.6	3.5	0.0
Roads - LA Pinchpoints	9	0.0	0.03	0.0	0.0	0.0	0.0	0.0
Grand Total	329	134.5	17.6	17.0	16.6	18.5	18.8	46.1

Source: HM Treasury, Citi Research

The largest single transportation project under development is HS2, a new high speed rail line running from London to Birmingham, Manchester and Leeds, with a total cost of £56 billion

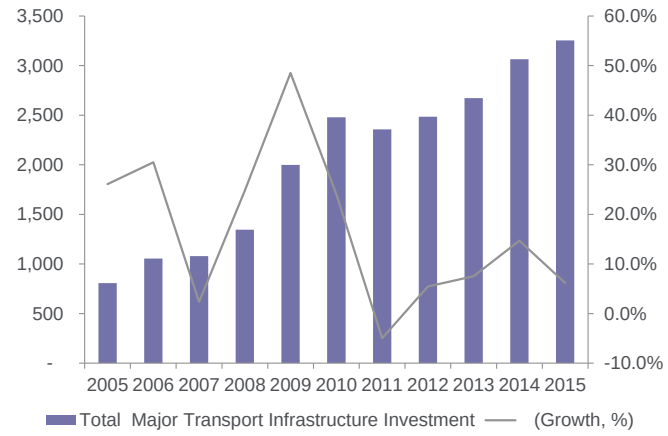
The UK investment requirement for infrastructure investment includes maintenance of the national and local highway networks, national rail network and the London underground. Most discussion concerns the provision on flagship projects such as Crossrail, Crossrail 2, HS2 and new runway capacity to serve London. The largest single project currently under development is HS2, a new high-speed rail line running from London to Birmingham, Manchester and Leeds (with stations in the East Midlands, Sheffield and Crewe) with a total project cost (including planning, compensation, land purchase, construction and rolling stock) of some £56 billion ($69bn).

Major projects beyond 2021 include HS3 to serve the Leeds-Manchester corridor and potentially a third runway at London Heathrow if the Government proceeds with the preferred option of the Airports Commission for a Northwest runway and a sixth terminal at an estimated cost of £19 billion ($23bn).

Transport in China – Rail and Road

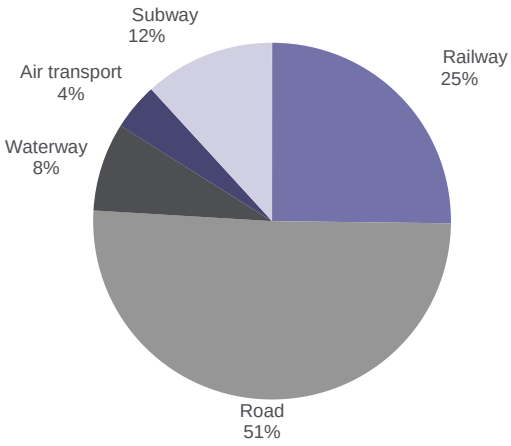
China is the largest infrastructure investor globally. After the economic stimulus package of 2008-2009, as part of the effort by government to minimize the impacts of the Global Financial Crisis, infrastructure investment growth rebounded to 49% in 2009 from 2% in 2007. In 2011, the growth was dragged by railway investment due to the Wenzhou High Speed Rail (HSR) collision in July 2011. During 2012-2015, the growth rebounded as infrastructure played an important role in achieving economic growth targets.

Figure 88. China Major Transport Infrastructure investment



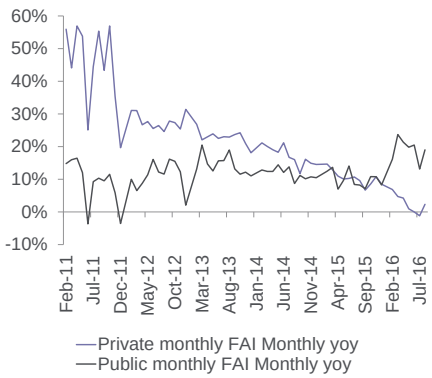
Source: NBS, MOT, Citi Research

Figure 89. Breakdown of China Major Transport Infra Investment



Source: NBS, MOT, Citi Research

Figure 90. China FAI Growth Breakdown by Private and Public



Source: NBS, Citi Research

Currently, due to little outlook confidence, most private names are unwilling to invest in capital goods despite low interest rates. Therefore, Chinese private fixes asset investment (FAI) growth has been on a consistent downtrend since 2012, and even worse, growth was slashed to single digit 6.9% for the first half of 2016 (vs. double digits in the past few years). It fell to a negative 1.2% for July, levels which we have not seen over the past decade. In contrast, China public FAI (mostly infrastructure investment) growth is relatively strong at 16-24% for the first eight months of 2016. Going forward, we believe transport infrastructure investment will show steady growth given its important role in countering the slowdown of economic growth, and the ambitious 13th Five Year Plan (FYP) released in March which consists of a steady plan for transport targets with key highlights as below.

- **Railway** – China targets a railway operating mileage of 150k km by 2020 from 121k km, representing a CAGR 4.3% from 2015-2020E, compared to 6% during 2010-2015. Of this, high-speed rail operating mileage is targeted at 30k km by 2020 and covering over 80% of major cities, representing a 9.6% CAGR during the period. In July 2016, NDRC rolled out the long-term plan for railways. Based on the current backbone of "4 horizontal and 4 vertical lines", China will build more regional inter-city railway networks to extend into "8 horizontal and 8 vertical lines" (see Figure 91 and Figure 92).

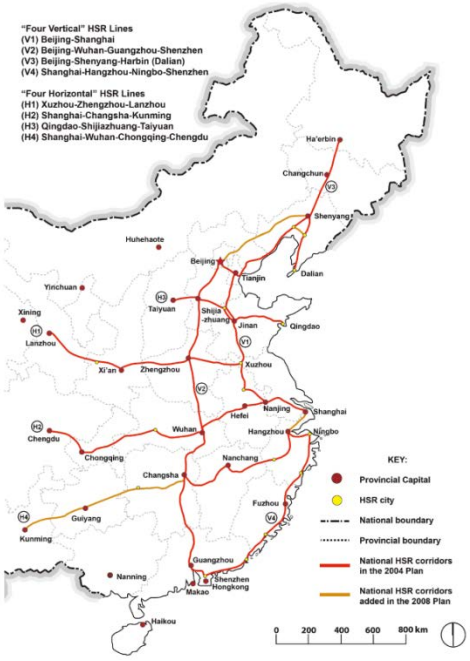
Figure 91. 4x4 to 8x8 Railway Network

4 Vertical Routes Extended to 8 Vertical Routes	
	Costal railway: Dalian - Shenzhen route
	Beijing - Fuzhou route: Completed
Beijing - Shanghai route	Beijing - Kowloon (Hong Kong)
Beijing - Hong Kong route	Beijing - Guangzhou route: Completed
Beijing - Harbin route	Beijing - Haikou route
Hangzhou - Shenzhen route	Baotou - Nanning route
	Yinchuan - Kunming route
	Urumqi - Lhasa

4 Horizontal Routes Extended to 8 Horizontal Routes	
	Tianjin - Yinchuan route
	Qingdao - Lanzhou route
Qingdao - Taiyuan route	Lianyuangang - Lanzhou route: partly cor
Shanghai - Chengdu route	Shanghai - Urumqi route: partly complete
Xuzhou - Urumqi route	Yancheng - Ruoqiang route
Shanghai - Urumqi route	Shanghai - Chengdu route
	Shanghai - Kunming route
	Guangzhou - Kunming route

Source: NDRC, Citi Research

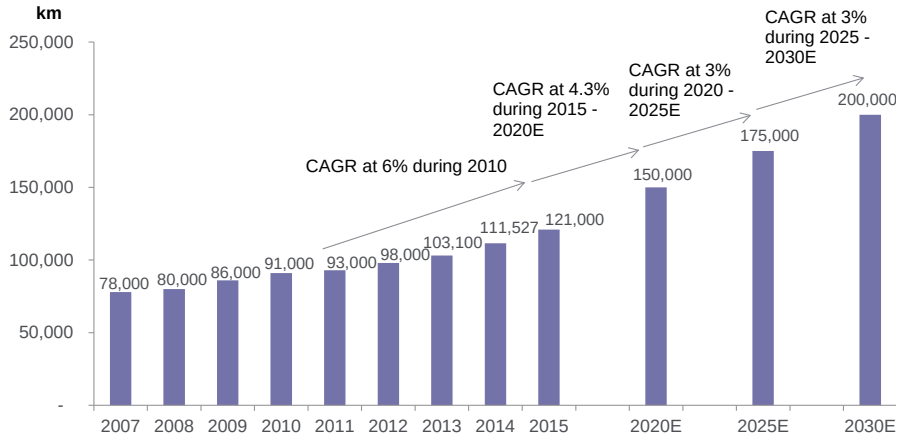
Figure 92. The Rail Network Backbone of "4 Vertical 4 Horizontal lines"



Source: High-Speed railway as a tool for (re-) making cities in China[32]

By 2030, China will have operating mileage of over 200K km compared with 121k km in 2015, or CAGR of 3.4%, and HSR operating mileage of 45k km, which will significantly shorten travelling time to 1-4 hours between neighboring provinces and 0.5-2 hours within a city. While this growth rate doesn't look enormous, China paints a stable growth picture over the coming decade at least. This assures rail construction will remain a core business for construction / equipment giants, which is critical given their enormous revenue base.

Figure 93. China Railway Operating Length



Source: CRC, MOT, Citi Research estimates

[32] Sun, Hong, "High-speed railway as a tool for (re-) making cities in China", RC21 International Conference, August 2015.

- **Roads** – China targets 30k km of new build/rebuild expressways and 200k km of roads in rural areas during 2015–2020. Although the amount looks lower than what China achieved during 2010-2015 the investment amount should be at similar level given much higher construction cost currently.

Figure 94. Details of China PPP Projects

PPP project type	Number of Projects
Energy	175
Transport	1,254
Water conservancy	475
Environmental protection	562
Agriculture	108
Forestry	13
Technology	117
Social housing	498
Healthcare	463
Elderly care	264
Education	515
Culture	298
Physical culture	200
Municipal	3,644
Govt's infra projects	144
Area development	638
Tourism	581
Social welfare	106
Others	258
Total	10,313

Source: MOF, Citi Research

Public-Private Partnerships (PPP) Mode to Solve Funding Issues

Given the huge amounts of investment required for the long-term infrastructure plan and the high debt levels of local governments in China, the central government rolled out PPP mode in 2014 and began promoting the mode heavily in 2016 to attract private capital to participate in infrastructure, mostly through build-operate-transfer agreements or other modes like franchise and build-own-operate. As of August 2016, there were cumulatively 10,313 PPP projects recorded in the government's project database with a total value of Rmb12.3 trillion ($1.8trn), approximately 28% of the total FAI budget. Amongst this, transport accounted for 12% of the total in terms of the number of projects, but the proportion should be much larger in terms of value since transport projects are usually much more capital-intensive than other projects. China views the PPP mode as a vital method to solve the funding issues for its mega infrastructure investment.

Accelerating Overseas Opportunities from One Belt, One Road (OBOR)

'One Belt One Road' and the creation of the associated Asian Infrastructure Investment Bank are key initiatives to drive Asian infrastructure investment

The plan was firstly introduced by President Xi Jinping in Kazakhstan on September 7, 2013. The plan consists of a land-based belt and a maritime route connecting China to Asia, Africa, and Europe to facilitate trade, investment and cooperation in finance, utilities, new energy, and environmental issues. The land-based belt is planned to cover Central Asia, the Middle East, West Asia, and parts of Europe while the maritime route will cover Southeast Asia, South Asia, the Persian Gulf, the Red Sea, and the Indian Ocean coast. The countries along the road are mostly emerging markets and developing countries with total population of 4.4 billion, or 63% of the global population. Those countries combined generate total GDP of $2.1 trillion, equivalent to 29% of the global economy, per the Minister of Commerce Mr. Gao Hucheng.

The major area covered by OBOR is Asia, which obviously has huge demand for infrastructure investment. Oxford Economics projected Asia-Pacific infrastructure investment could reach $5.3 trillion in 2025 from ~$2 trillion in 2013, while ADB estimated there could be an infrastructure deficit of ~$8 trillion in Asia during 2010-2020E.

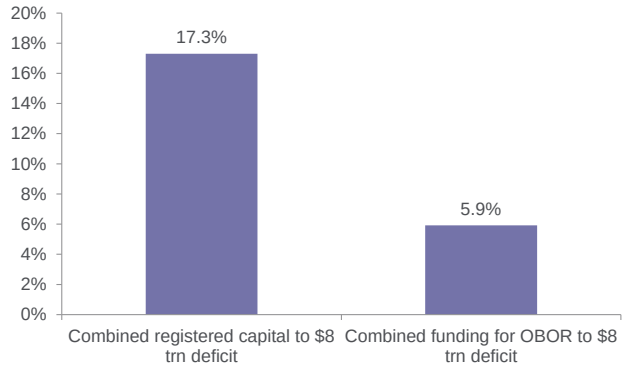
Following the Asian Infrastructure Investment Bank (AIIB) establishment this year, we expect an acceleration in emerging market infrastructure project launches, which will present more opportunities for Chinese constructors. The initial registered capital of AIIB is $100 billion, though, even if all of this money flowed into meeting Asian infrastructure demand, it would still constitute only 1-2% of the $8 trillion deficit estimated by ADB. However, we expect the funding size to be raised in the future to cope with the enormous demand.

Figure 95. Registered Capital for Different Global Financial Organizations

US$ bn	Registered Capital	Total Funding for Infra Investment in Countries Covered by OBOR
Asia Development Bank	165	56
IMF	755.7	9
AIIB	100	100
New Development Bank	100	100
New Silk Road Fund	40	40
Total	1160.7	305

Source: Xinhua, IMF, World Bank, ADB, Wiki, and Citi Research

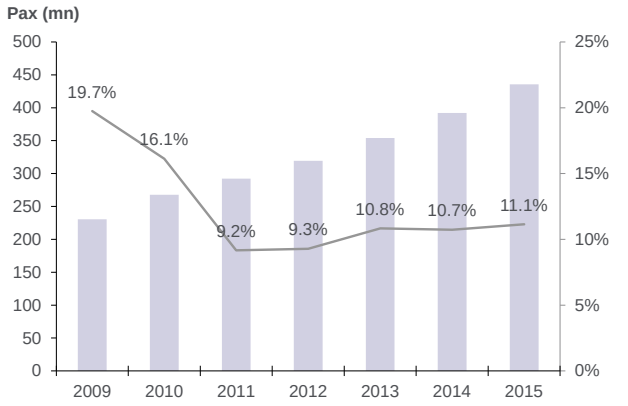
Figure 96. Funding Compared to $8 Trillion Deficit



Source: Xinhua, IMF, World Bank, ADB, Wiki, and Citi Research

Transport in China – Airport & Ports

Figure 97. China Air Travel Passenger Trend



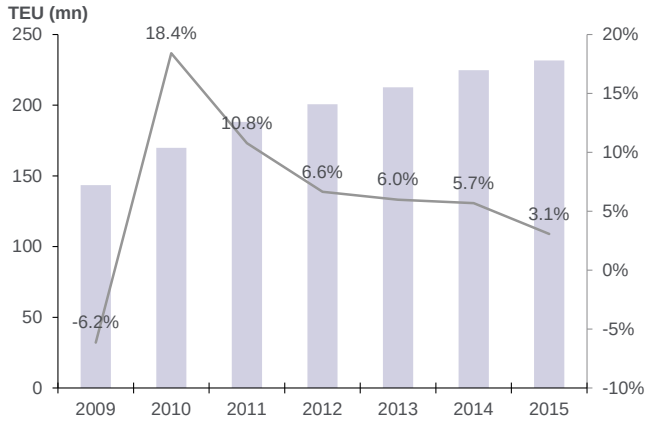
Source: CEIC, Citi Research

Figure 98. Major Airports' Recent Infrastructure Plans

	Capex	Fixed assets
Beijing Airport	Rmb80bn	Consists of 4 runways and a 700,000 sq.m. terminal with a designed capacity of 620,000 aircraft movements and 72 million passengers throughput
Shanghai Airport	Rmb20.2bn	525,000 sq.m satellite terminals with a handling capacity of 20mn passenger throughput; related airside asset includes apron, aircraft stands, taxiways; tram system connected the current terminals and satellite terminals
Shenzhen Airport	Rmb2-3bn	A new satellite terminal will be completed in 2020 which will improve current terminal capacity by 8mn annually.

Source: Company reports, Citi Research

Figure 99. Port Throughput Growth Turned to Low-Single-Digit



Source: Alphaliner, Citi Research

Figure 100. Map of New Silk Road, Also Known as One Belt, One Road

Source: Citi Research

Figure 101. CM Port & CS Ports Acquired Kumport (located in Ambarli)

Source: Google, Citi Research

Figure 102. CS Ports Acquired Interest in KPCT2 (located at Khalifa Port)

Source: Abu Dhabi Terminals, Citi Research

Air traffic growth stimulating airport expansions

Major growth in air passenger numbers….

Continuously supported by consumption upgrades and the booming trend of outbound traffic, the number of air travelers in China has increased by a CAGR of 10.3% from 2010 to 2015. Correspondingly, the number of airports in the country has also increased from 175 in 2010 to 210 in 2015. Major international gateways in the country have also started expansion projects in order to cater for the potential air traffic demand in the future.

…has driven demand for new airport infrastructure or expansions

With strong international traffic growth, Shanghai Pudong Airport is under a Rmb20.2 billion ($3bn) airport expansion project which mainly includes a 525,000 sq.m satellite terminal with a handling capacity of 20mn passenger throughput and other related airside assets. Conversely, Beijing Capital International Airport's capacity constraint is severe with terminal and runway utilization rates at 109.7% and 97.9%, respectively, in 2015. That said, the city is now undergoing an Rmb80 billion (~$12bn) new airport construction project which is scheduled to open in 2019 with four new runways and a 700,000 sq.m. terminal with designed capacities of 620,000 aircraft movements and 72 million passengers throughput, respectively. Lastly, Shenzhen Airport's Rmb2-3 billion satellite terminal construction project will be completed in 2020 to improve the current terminal capacity by 8 million, marking the airport with a better positioning in the Pearl River Delta (PRD) region to further develop its international market.

Overall, we believe that there will continue to be a demand for new airport infrastructure in line with increasing air traffic demand.

OBOR gives port operators overseas expansion targets

OBOR should reinvigorate slowing port throughput

With a marked slowdown, the throughput growth of Chinese ports has fallen to only low-single-digit levels of 3.1% in 2015, versus a 7.3% CAGR between 2010 and 2014. However, China will further increase its geopolitical presence and economic links with other Asian and European countries with the aforementioned "One Belt One Road" (OBOR) national initiative. This should directly benefit port operators via enhanced tradeflows and traffic flows, due to the closer relationships amongst the countries in the OBOR region.

Port acquisitions along the maritime OBOR route offer further growth opportunities

Moreover, overseas expansion along the OBOR route will also offer immediate catalysts for the business growth of the port operators. In September 2015, CM Port and CS Ports, together with CIC Capital, acquired 64.5% of the Turkeys' Kumport Terminal which is located at a gateway to the Black Sea, a strategic interchange between Europe and Asia and also a location along the 21st Maritime Silk Road. Recently, CS Ports also entered into a concession agreement for the construction, management, and operation of Khalifa Port Container Terminal 2 for 35 years with voting rights of 90%, marking another strategic move for CS Ports in its OBOR expansion strategy.

With the China's increasing commitment to its OBOR initiative, we expect further overseas expansions of a similar nature in the future.

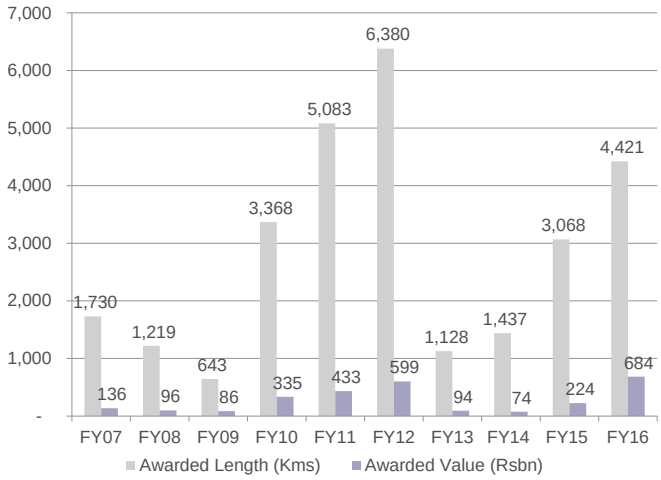
Transport in India - Roads

Figure 103. Breakdown of National Highways (km)

Length of NH under various phases of NHDP	48,428
Length of NH under SARDP - NE	5,562
Development of road in LWE	1,177
Length with NHIDCL	1,164
NHIIP (externally aided projects)	1,120
VGF/EPX scheme under NH(O)	1,730
Vijaywada Ranchi corridor	548
Balance length of NHS to be covered under NH(O)	40,900
Total length of NH network	100,475

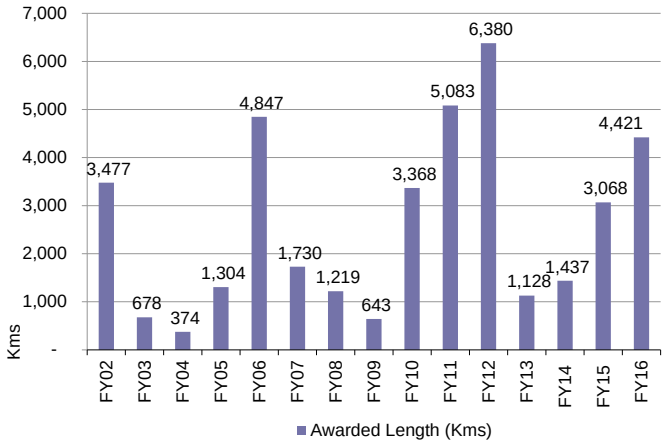
Source: Nhai and Citi Research

Figure 104. NHAI Road Awarding over FY07-FY16



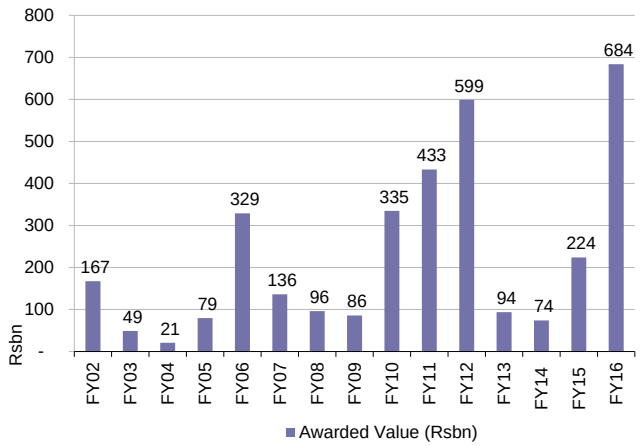
Source: NHAI and Citi Research

Figure 105. NHAI – Total Awards by km



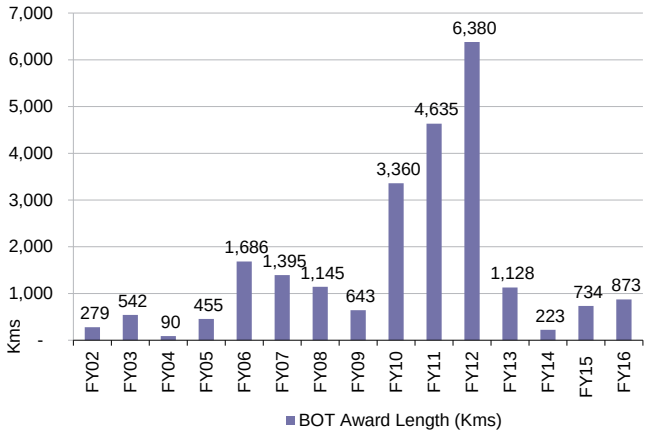
Source: Ministry of Road Transport and Highways, Citi Research

Figure 106. NHAI – Total Awards by Value (Rsbn)



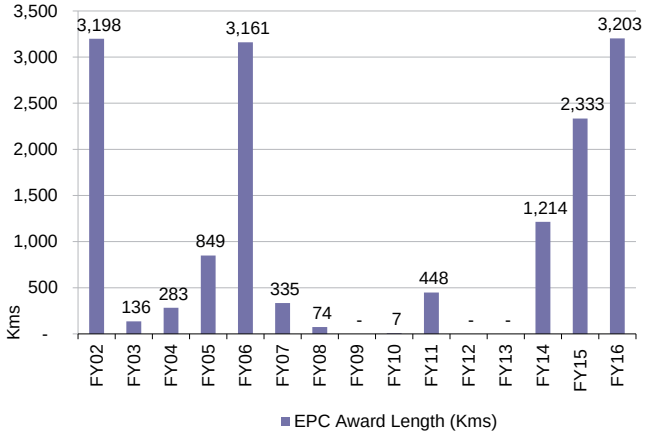
Source: Ministry of Road Transport and Highways, Citi Research

Figure 107. NHAI – BOT Awards



Source: Ministry of Road Transport and Highways, Citi Research

Figure 108. NHAI – EPC Awards



Source: Ministry of Road Transport and Highways , Citi Research

India has the 2nd-largest road network in the world which is the backbone of India, carrying over 65% of freight and 80% of passengers

India has the world's second-largest network of roads, which is the backbone of India, carrying 65% of total freight and 80% of total passenger traffic. Though the National Highways represent only 2% of India's total network, they carry 40% of India's traffic. The major road development programs that are currently under way are:

- The National Highways Development Program (NHDP);
- The Special Accelerated Road Development Programme for the North Eastern region (SARDP-NE); and
- Left Wing & Extremist affected areas (LWE).

After a weak 2013 and 2014, project awards picked up in 2015 and 2016. The government awarded total of 7,980 km of roads for 2015 (including 3,068 km from the National Highways Authority of India (NHAI)), a 120% YoY increase. Furthermore, momentum has improved in 2016. In 2016, 4,421 km of roads have been awarded – an increase of 44% year-on-year versus 2015.

In 2016, road projects worth Rs684 billion (~$10bn), +206% YoY, were awarded by the NHAI, following an equally strong 2015 where project award values increased by 203% YoY. The faster increase in the value of projects awarded versus the length of projects awarded is partially due to land price increases, but also possibly due to the fact that more complicated projects such as urban bypasses, flyovers, and projects near urban centers have been awarded.

The NHAI and the Ministry of Roads, Transport & Highway (MoRTH) have drawn up plans to construct 50,000 km of roads over the next 5 years. The NHAI's share of this target is 25,000 km, and it has started work on detailed project reports (DPR) for 7000 km of roads.

Transport in India – Railways

Figure 109 Railways Route Length (Km)

Region	Route Length (Kms)
US	224,792
Russia	128,000
China	112,000
India	64,460

Source: Citi Research

Figure 110. Indian Railways – Proposed Investment Plan (2015-2019)

	Rsbn	US$bn
Network Decongestion (Incl. DFC)	1,993	32.4
Network expansion (including electrification)	1,930	31.4
National Projects (North Eastern & J&K connectivity)	390	6.3
Safety (Track renewal, Signalling, Telecom)	1,270	20.7
IT and Research	50	0.8
Rolling stock	1,020	16.6
Passenger amenities	125	2
High speed rail and elevated corridor	650	10.6
Station redevelopment and logistics parks	1,000	16.3
Others	132	2.1
Total	8,560	139

Source: Highlights of Railway Budget Speech, Citi Research

Figure 111. Indian Railways – Backward and Forward Linkages

	1993-94	1998-99	2003-04	2007-08
Backward Linkage				
Agriculture	0.01	0.01	0.01	0.02
Industry	0.63	0.76	0.93	2.04
Services	1.28	1.32	1.24	1.23
Total Backward Linkage	1.92	2.09	2.18	3.29
Forward Linkage				
Agriculture	0.13	0.12	0.16	0.07
Industry	2.15	2.03	2.11	1.18
Services	1.13	1.13	1.16	1.19
Total Forward Linkage	3.41	3.28	3.43	2.44

Source: Economic Survey, CSO, Citi Research

India has the fourth-largest railway network in the world and runs approximately 21,000 trains per day. The railway carries more than 23 million passengers per day

India has the fourth-largest railway network in the world. Among the top 10 countries in the world, eight have nationalized railways, the US and Canada being the only exceptions. Indian Railways runs ~21,000 trains per day of which about 13,000 are passenger trains. Indian Railways carries more than 23 million passengers per day (roughly equal to entire population of Australia). Further, India is in a select group of four countries (the others being China, Russia, and the US) globally that carry more than 1bn tons of freight by rail each year.

Despite massive multiplier effects from investment in railways on other spheres of economic activity, less and less resource has been allocated to railways in recent decades. The share of railways has not only declined, but has stayed at less than 2% of total development expenditure of central and state governments.

Indian Railways has laid out an investment plan of US$140 billion from 2015 to 2019

Under the new government, Indian Railways has laid out an investment plan of Rs8.6 trillion (~$140bn) over 2015 to 2019. To achieve this total investment of Rs8.6 trillion, the rail budget has targeted capex of Rs1,210 billion ($15bn) in 2017 versus ~Rs822 billion ($12.3bn) in 2016 (revised estimates) and Rs658 billion ($10bn) in 2015. To put the investment of Rs8.6 trillion (~$130bn) and its impact on the economy in perspective, we note that the current nominal size of the Indian economy in 2015 was Rs125 trillion ($1.9trn); accordingly the investment represents around 7% of GDP.

Investment into Indian railways has significant forward (i.e., sectors which use railway services as an input) and backward (i.e., sectors which provide input to railways) linkages. The total benefits to other sectors from an increase in the output of railway services can be to the tune of 5x the increase in railway output. Furthermore, this multiplier effect has increased over time.

Assuming a factor of 5x of investment into railways, secondary benefits of investment into railways could be 30-40% of GDP over the next 5 years, if these investments are realized and are done so efficiently.

Dedicated Freight Corridor

The Dedicated Freight Corridor (DFC) consists of railway lines along the existing eastern and western trunk routes and is meant exclusively to carry freight traffic. A special purpose vehicle under the administrative control of Indian Railways, the Dedicated Freight Corridor Corporation of India (DFCCIL) was established in 2006 for the purposes of planning, development, mobilization of financial resources, construction, maintenance, and operation of the DFC.

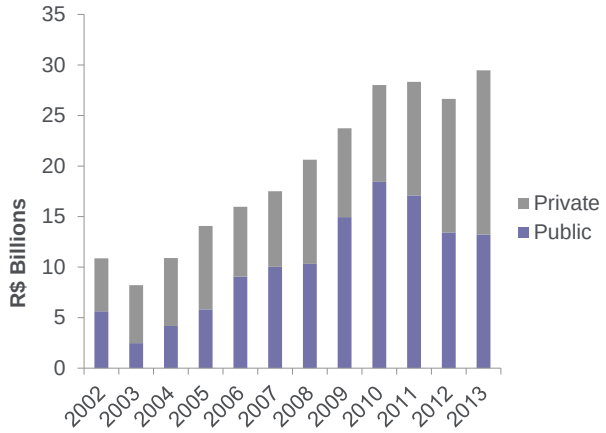
The freight corridor concept plan is 10,122km – the entire route length of the Golden Quadrilateral and its diagonals. At present, DFCCIL is constructing two dedicated freight corridors – the Western and the Eastern DFCs, spanning a total length of about 3,300 route km.

DFC is being constructed on the Eastern Side (Ludhiana to Dankuni -1856 km) and the Western side (Jawaharlal Nehru Port to Dadri -1504 km), and is scheduled to be completed by 2019, with the pace of execution accelerating recently.

Since the DFC is being constructed exclusively for freight movement, its carrying capacity will be significantly greater than the capacity of the existing railway lines. The DFC will be capable of transporting heavier loads at higher speeds with larger dimensions of rolling stock.

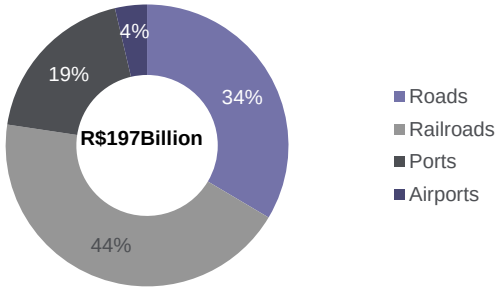
Transport in Brazil

Figure 112. Total Transport Investment in Brazil (2002-2013)



Source: BNDES, Citi Research

Figure 113. Proposed Aggregate Infrastructure Investment in Brazil (2015-2018)



Source: Brazilian governmental website[33] and Citi Research

In Brazil, current and previous administrations have acknowledged the country's urgent need to upgrade its transportation infrastructure. In 2013 and 2014, authorities successfully auctioned several toll roads and airports. These transactions included flagship assets, such as São Paulo's Guarulhos International airport and Rio de Janeiro's Galeão airport.

Brazilian interim president Temer has stated that he wants to use auctions as a means to upgrade the country's infrastructure.

Brazilian interim president Michel Temer has highlighted an important need to improve the country's roads, airports, ports, and rail infrastructure. Temer specifically stated that he wants to use auctions as a means to upgrade the country's infrastructure and to stimulate economic activity. To these objectives, Temer has said that he wants to use public-private partnerships in order to lure foreign investment in these projects. However, at this point, little is known regarding what sort of structure regulators might put in place, or what might be the range of potential returns.

Under the administration of Dilma Rousseff, Brazil had set benchmark real, unlevered internal rates of returns on toll road auctions at 9.2%. This had reflected a 200 basis point increase from 2013-2014 benchmark auction levels. At the same time, the government had also increased the Taxa de Juros de Longo Prazo (TJLP) lending rate on infrastructure projects by 200bps – to 7.5%. Of course, this move had helped maintain the spread between IRRs and underlying infrastructure project funding costs.

At present, there are very limited details regarding Brazil's infrastructure auction plans, so auction rules, benchmark IRRs, minimum bids, consortium requirements, etc. are not known at this time. The one modest exception to this rule are the planned auctions of the international airports in Fortaleza, Salvador, Porto Alegre and Florianópolis, for which regulators have already hosted public hearings on this process. Nevertheless, Citi sees a low likelihood of Brazil auctioning the above quartet of airports prior to the end of 2016.

[33] http://www.projetocrescer.gov.br/

Barriers to investment in Brazilian transport

Project funding remains one of the key constraints in infrastructure investment in Brazil.

Project funding remains one of the key constraints in Brazil. In the 2013 and 2014 toll road auctions, state-owned Brazilian development bank Banco Nacional de Desenvolvimento Econômico e Social (BNDES) had agreed to fund up to 70% of each toll road concession's financing needs. Under this previous regime, regulations had required toll road duplications to occur over the first five years of a concession contract. Therefore, auction bidders had been able to rely on BNDES providing cheap TJLP funding for the front-loaded capex requirements of these projects.

In light of Brazil's budgetary challenges, it seems very unlikely that BNDES will offer anything close to the levels of funding that are needed

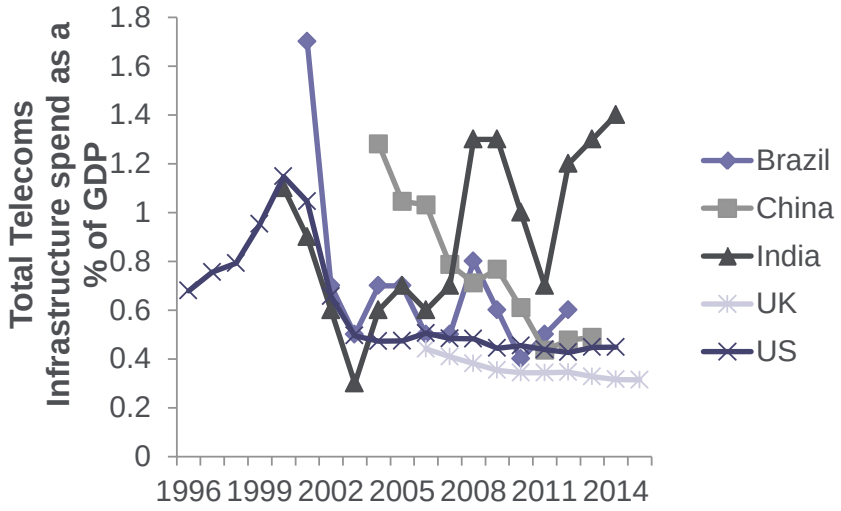
In light of Brazil's steep budgetary challenges, including the government's efforts to trim spending, it seems very unlikely that BNDES will offer anything close to the level of funding that it had provided in the previous auction rounds. Assuming that BNDES covers only 35% of new concessions' financing needs, these projects are likely to require more creative funding sources with such funding coming at a higher cost. On the other hand, it also remains to be seen whether authorities increase benchmark IRRs in response to potentially higher funding costs.

Potential political and legal intervention also remains problematic. For example, Brazilian toll road operator Ecorodovias won the BR-101 toll road auction in 2012. However, the company's launch of this project had gotten delayed for several quarters, as one of the losing contestants in the auction process took legal action in what had turned out to be an unsuccessful attempt to overturn this auction result. Separately, the state government of São Paulo appeared to have bowed to political pressure in mid-2014, when it suspended the annual inflation increase on state toll road tariffs. Although authorities had also compensated toll road operators by allowing them to levy tolls on vehicles' suspended axles, this action raised important concerns regarding whether the grantor was adhering to both the spirit and the letter of these contractual agreements.

Finally, economic developments in Brazil remain an important consideration. Although private vehicle traffic appears to be relatively inelastic, commercial toll road traffic can be highly sensitive to economic factors, such as fluctuations in agricultural prices and harvests. Air passenger flow has declined significantly in the last two years, as the country's carriers have cut costs during the economic crisis, and overall weak economic activity has hit cargo flow through Brazil's ports. As Brazil gradually recovers from its deepest recession in years, we remain concerned that the expected economic recovery should be softer than other cycles.

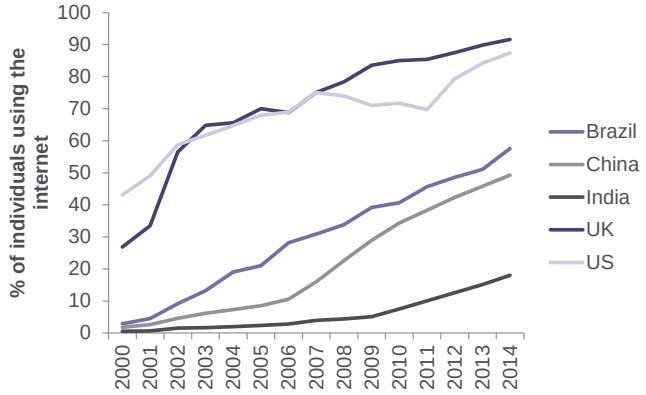
Telecoms Infrastructure

Figure 114. Historic Telecoms Infrastructure Spending in Key Markets



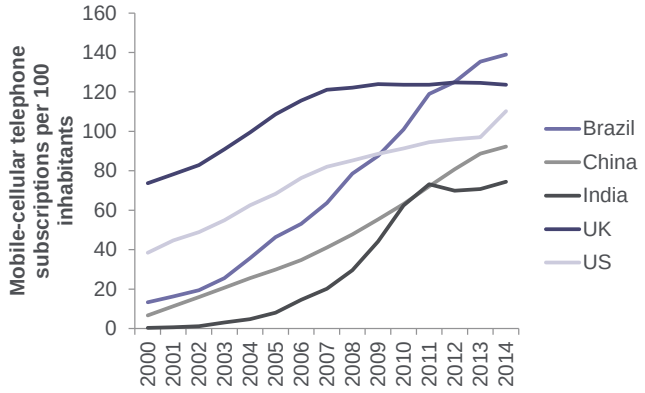
Source: Citi Research

Figure 115. % of Individuals Using the Internet



Source: ITU World Telecommunication,[34] Citi Research

Figure 116. Mobile Subscriptions per 100 Inhabitants



Source: ITU World Telecommunication,[34] Citi Research

[34] ITU World Telecommunication/ ICT indicators Database

Making the World a Smaller Place

Telecoms has been one of the fastest-evolving sectors, so much that the usual long-lived nature of infrastructure has struggled to keep up with the technical need and development

With transport, water, and energy (in its various forms) having been around for centuries, telecoms may in infrastructure terms be seen as something of a new kid on the block. Moreover, its heavily tech-focused nature has led it to be one of the fastest-evolving sectors, so much so in fact that the usual long-lived nature of infrastructure means that the physical aspects of telecommunications have struggled to keep up with technical developments.

While fixed line has been around for well over a century, recent evolution has increased pace significantly, with mobile telecommunications, the Internet, broadband, optic fiber and satellites all being relatively recent developments. This has been reflected in spending activity, with initial copper-based fixed line networks now being replaced by optic fiber. In some markets such as Africa, mobile telephony has leapfrogged fixed line, though this has as much to do with the time taken to have fixed line installed and other 'barriers' as it has to do with the lack of availability of fixed line telephony.

Spend levels have reflected these developments, and vary (as usual) widely around the world, but have in recent years been around 1% of GDP as shown Figure 114. In 2013, $400 billion was spent on telecoms infrastructure. Globally it is estimated that $8.3 trillion is required in telecoms infrastructure investment from 2016-2030.

Global access to telecommunications has ballooned in recent years, however there are still some countries such as India where access to the internet is only 18%

Global access to telecommunications has ballooned in recent years. While approximately 90% of individuals in the US and the UK are using the Internet, In India the figure is still only 18%, though this has risen dramatically from 1% in 2000.

It is not just the availability of infrastructure that drives lower adoption rates, but also income levels, though a mobile phone is often one of the first 'luxury' (or non-subsistence) items bought in markets such as Africa. Mobile subscriptions around the world continue to grow, and the old assumptions of a theoretical maximum penetration of one subscription per person have been overturned by markets such as the UK (see Figure 116). Brazil provides an example of an emerging market where with the right infrastructure, penetration can be equally high.

Crystal ball gazing for the future in tech-related sectors is always fraught with dangers. However, communications look set to continue to grow strongly, driven by the vast amounts of additional data that we are likely to both produce and consume. To give but a few examples, autonomous vehicles will require enormous numbers of sensors, all generating and consuming data, as will the Internet-of-Things more generally, cloud computing and centralized data all contribute to traffic, and the volume, frequency, and method of our consumption of media are all changing. All of these will drive the volume of information in a big data world, and we will have (and demand) the ability to consume that data on the move.

Having said that, we should not confuse telecoms infrastructure and the rise of mobile by thinking it is all 'ether'-based; the only mobile part of our communications is between the handheld device and the tower – the rest is handled by fixed (fiber) networks. With optic fiber theoretically giving the ability to communicate at the speed of light, we may be hard pressed to improve on that – where we can improve, though, is of course the bandwidth, availability, and the technology within the systems, such as repeater stations and to put it simply, how fast they can flash. Lastly, getting fiber closer to the end-user (eliminating the last few hundred meters of copper) is a key driver in developed markets. All of this will require more and better technology, which is likely to keep driving telecoms infrastructure investment long into the future.

Disruptive Telecoms Innovations

The amount of data that will be exchanged over telecoms networks could reach more than a zettabyte in 2020. Fiber optics has revolutionized this sector; however, it is costly, complex and time-consuming

Every day more and more people and devices come online. According to Facebook's Global Head of Engineering and Infrastructure, the amount of data that will be exchanged over telecoms networks could reach more than a zettabyte (1 billion terabytes- enough to fill 20 billion double-sided blu-ray discs) by 2020.[35] The data will not only grow but will also get more intensive through formats such as virtual reality and video. Telecoms companies have invested in infrastructure that allows us to exchange data through our mobile devices, tablets etc. Fiber optics has revolutionized this sector allowing large amounts of data to be transferred at a very fast speed along special cables underground. A fiber-optic cable is made up of thin strands of glass known as optical fibers which carry information between two places using entirely optical technology. The technology is superb, however it is also very costly, time consuming, and complex to install and operate.

Tech companies such as Google and Facebook have become frustrated by the slow pace of rolling out internet connectivity.

Companies such as Google, Facebook, and Space X have become frustrated by the slow pace of rolling out Internet connectivity to different parts of the world. In fact Facebook has started a telecoms infrastructure project which brings together operators, infrastructure providers, and other industry players to work together to develop new technologies and re-think approaches to deploying network infrastructure. The company is also testing drones and satellites to enable the fast deployment of Internet access throughout the world. In our recent GPS report called 'Re-Birth of Telcos as digital service industry', we highlighted Facebook's Aquila Drone project which aims to test the feasibility of broadcasting web connectivity via unmanned, solar powered aerial drones called Aquila. These drones will remain in the air for several months and deliver internet connectivity via lasers. Facebook has also been in the news lately when one of its satellites (AMOS-6) exploded during a Space X prelaunch test. The satellite was part of a project of Facebook's Internet.org program to deliver the Internet to the developing world. Satellite-based communications are not new, however there seems to be a renewed interest in this technology with projects such as OneWeb satellite constellation funded by Virgin Group, Qualcomm, Airbus and Bharti and Space X program which aim to bring satellite internet to remote parts of the world.

Google has launched Project Loon which aims to beam a 4-G like signal down to earth to enable easy connectivity in remote places

Google has also launched 'Project Loon' which is a network of balloons travelling on the edge of space, which beam a 4G-like signal back down to the earth. It seems now less of a science experiment – according to their website they have already flown over 17 million km of test flights to date and been tested in rural area in New Zealand and in the outback of Australia. It has also just launched the project in Sri Lanka in 2016 in a joint venture between the Sri Lankan government and existing telephone operators in the country. Cabling (in particular fiber-optic technology) has enabled fast Internet connections to be deployed to billions of people; however it is rather time-consuming and expensive. It is estimated that currently 4.2 billion people (57% of the global population) do not have regular access to the internet.[36] In the least developed countries, only one out of every ten people is online. It is not yet clear whether balloons, drones, and/or satellites can provide reliable access to Internet connections in future years. However if these systems are successful, they could be deployed at a fast rate enabling more people to have access to the internet (even in rural places), and could potentially change the way telecoms infrastructure is built-in the sky rather than underground or under the sea.

[35] Jay Parikh, Facebook: Partnering to build the Telecom Infra Project, February 22, 2016

[36] ITU and UNESCO, (2015) The State of Broadband 2015: Broadband as a foundation for sustainable development

US Telecoms Infrastructure

The $9 billion program called Connect America will run from 2015-2020 and aims to connect a total of 3.7 million homes and businesses.

Infrastructure investment remains healthy in the US, helped by the low interest rate environment, rising data speeds, and the resulting growth of Internet traffic. A current government-funded project is Connect America Fund Phase II; this is a $9 billion program than runs from 2015 through 2020. It will connect 3.7 million homes and businesses with a minimum 10mbps broadband. This is targeted at underserved and rural consumers. Phase I was smaller and ended in 2014

Private companies are also investing in broadband and communications

Private companies are investing in broadband and communications infrastructure as well: AT&T is upgrading 12 million homes to fiber to the home as a condition of the DirecTV merger over four years. Windstream is upgrading broadband speeds with proceeds from an asset sale, dubbed Project Excel. Charter will be adding 2 million new broadband homes as a condition of the merger with Time Warner Cable. In Canada, the main telecom companies (Telus and Bell) are in the midst of a decade long project to invest in fiber-to-the-home (FTTH).

Many smaller private companies are investing in local or regional fiber infrastructure to serve wholesale and enterprise end-markets. Wireless companies are investing in small cell architectures, putting transmitting equipment on things like lamp posts and bus stop shelters. This is requiring fiber investments by companies like Zayo and other private providers.

Data Center providers such as Equinix, Digital Realty, CoreSite, etc are investing in new infrastructure to house the servers required to run the Internet. This is a combination of single-user facilities as well as multi-user facilities and is a global trend.

New planned projects in the US

New projects include 5G technologies which may be deployed in 2020. Wireline telecom companies are also continuing to invest in their fixed networks

The wireless industry is pursuing 5G technologies which may begin to be deployed in earnest near to 2020, if not after. This is for home broadband and potentially mobile usage over time. Wireline telecom companies are continuing to invest in their fixed networks to push fiber closer to the end user, allowing for faster speeds. On existing copper fixed networks, some are investing to upgrade technologies (ADSL to VDSL2 and others) to improve speeds on legacy networks.

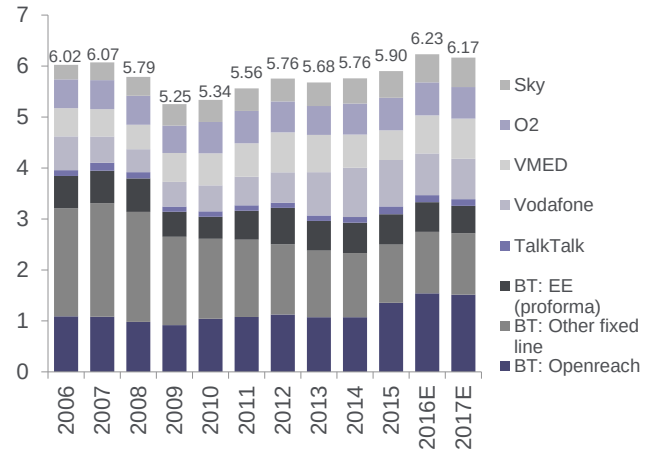
Cable companies are investing in networks to upgrade to newer technology (DOCSIS 2.1 to 3.0/3.1) which will similarly enable faster speeds.

Barriers

The regulatory environment is ever-shifting, and recent changes include codifying net neutrality, reclassifying fixed and mobile broadband as a Title II common carrier service, and the pending ruling on business data services. These have an uncertain impact on investment levels.

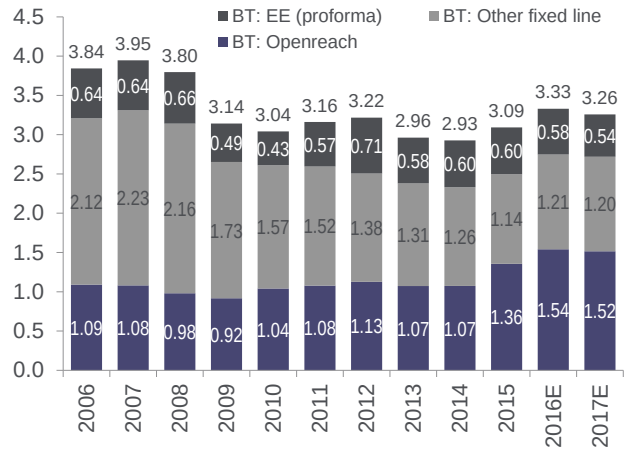
UK Telecoms

Figure 117. Capital Investment by Principle Telecoms Players
£m, year to Dec



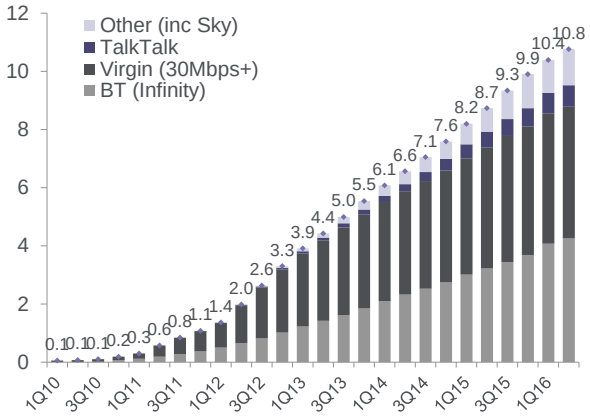
Source: Company Reports and Citi Research Estimates

Figure 118. BT Group Capital Investment Pro-Forma for EE Pre Acquisition (£m, year to Dec)



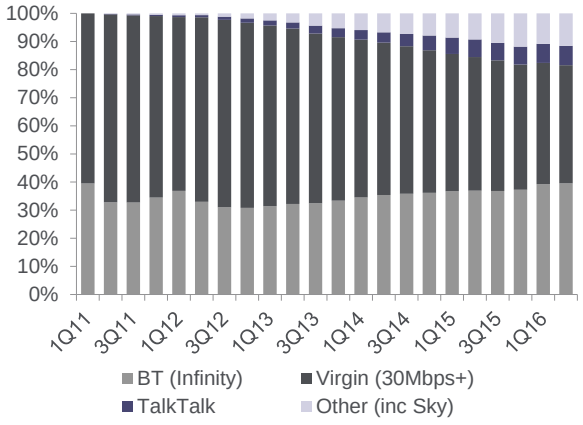
Source: Company Reports and Citi Research Estimates

Figure 119. Superfast Broadband Customers
Million connections, calendar quarters



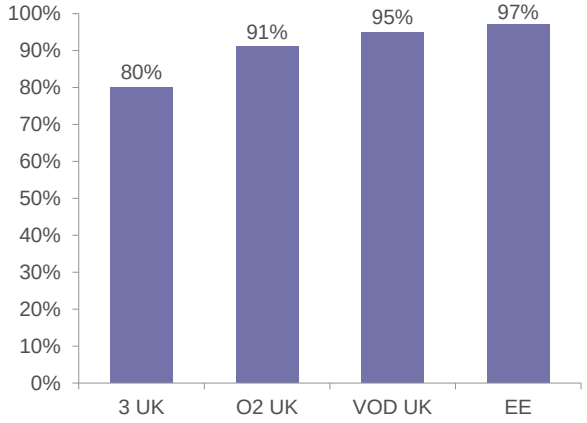
Source: Company Reports and Citi Research Estimates

Figure 120. Share of Superfast Broadband Base
% of connections, calendar quarters



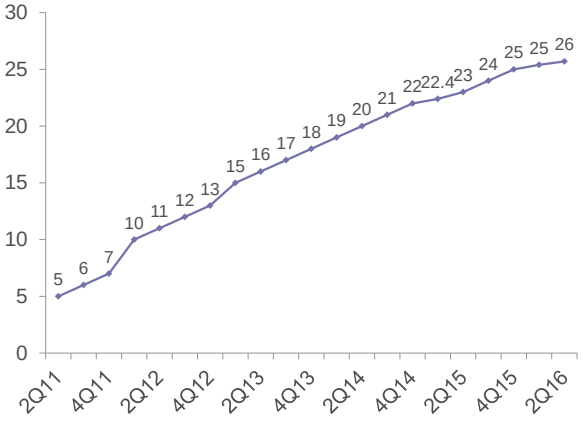
Source: Company Reports and Citi Research Estimates

Figure 121. LTE Population Coverage as of 2Q16



Source: Company Reports

Figure 122. BT's Fiber Coverage (millions households)



Source: Company Reports and Citi Research Estimates

Historical spending

The two main investment telecoms infrastructure programs in the UK over the last few years have been rolling out super-fast broadband and upgrading to 4G

The two main investment programs in the UK's telecoms infrastructure in the last few years have been rolling out super-fast broadband through investment in the local fixed networks and upgrading mobile to 4G. The super-fast broadband build out started with Virgin Media upgrading its cable network to Docsis3 standard enabling broadband speeds of over 100Mbps at a relatively low capital cost per home. The BT program involved deploying fiber to the cabinet and VDSL and now supports speeds up to 80 Mbps where available. BT deployed or upgraded tens of thousands of curb-side cabinets and installed power to many for the first time as well as fiber optic lines for the connection into the core network.

Industry capex grew at CAGR of 2.6% per year from 2010-2016, however overall investment as a % of GDP decreased in the same period

Industry capex from the major players decreased to £5.25 billion in 2010 from £6.02 billion($7.4bn in 2006 as BT completed its core IP 21st Century Network deployment and tightened its investment criteria, possibly in part reflecting the challenges of the credit crunch. From there it recovered to £5.9 billion by 2015. Industry capex grew 2.6% per year CAGR over 2010-16. However, overall investment as percentage of GDP declined from 0.43% in 2006 to 0.32% in 2015. Capex growth in mobile was mostly driven by deployment of 4G, after a lean period as 3G took time to get going commercially and then started to run into a question of shortening asset lives as 4G came closer. Operators with older networks prepared for 4G by upgrading their cell site equipment to single Radio Access Network which integrates multiple technologies and frequencies, reduces power load and footprint and is 4G ready. In fixed line, until lately BT Openreach and Virgin Media saw only a modest increase in capex to fund local broadband upgrades with Openreach capex only really stepping up materially in 2015 as its subsidized rural network build passed key customer adoption thresholds, effectively triggering recycling of subsidy back into the scheme.

Future investment needs and major planned projects

We believe that the peak of 4G investment has now passed given that coverage level is > 90%

We believe the peak of 4G investment may now have passed as the three largest operators have reached a coverage level of >90% of the population. Nonetheless BT plans to go further and extend 4G to 92% geographic coverage of the UK by September 2017 and 95% by the end of 2020. As of June 2016 BT's 4G geographic coverage was over two-thirds of the UK's landmass, corresponding to 97% population coverage. Other operators may follow, but with high population coverage of 4G in place, we expect the emphasis for wireless capex to shift gradually to increasing capacity and filling in hot spots.

On fixed we expect capex to remain at somewhat elevated levels

On fixed, we expect capex to remain at somewhat elevated levels for the next few years as BT continues to extend superfast broadband in rural areas and, in 2017, starts commercial deployment of G.fast, capable of up to 330Mbps in its trial configuration.

Liberty Global subsidiary Virgin Media is extending its cable network aiming to build past 4 million new premises by end-2019 at a total cost of around £3 billion, taking its total network reach from 13 million homes to 17 million. The company says that the targeted new premises are less than 50 million from its existing network with two-thirds less than 20 million away. The company is targets ~40% penetration and an initial average revenue per user of about £45.

BT has announced two large scale pilots of G.fast in Cambridgeshire and Kent, which will reach 25,000 homes and businesses and offer download speeds of up to 330Mbps. BT says it has selected suppliers for its commercial equipment which will go into the pilots, and that deployment will be carried out in the fourth quarter of 2016. All being well, this will lead to full commercial launch shortly thereafter. BT targeting to upgrade around12 million premises to ultra-fast broadband by 2020 of

which around 2 million are set to be fiber to the home and the rest G.fast which is based on fiber to the cabinet but requires shorter copper line lengths than VDSL at up to 300 meters.

UK government initiatives

The UK government had made a policy priority of extending fast broadband coverage

The UK government has made a policy priority of extending fast broadband coverage, both fixed and mobile, across the country and there have been a number of important initiatives. Principal among these are:

- **Subsidized build of fixed fast broadband infrastructure** in rural areas, administered for central government by Broadband Delivery UK (BDUK), with an aggregate public sector budget of £1.7 billion ($2.1bn).

- **Mobile coverage targets built into license terms –** Ofcom included in its 2013 auction of 4G ranges an 800MHz block with a coverage obligation. In addition the government has come to an arrangement with the mobile operators to have new coverage targets added to their license terms. Specifically:

  – **Single 4G license with coverage targets:** Telefónica O2 paid £550 million for the 2x10MHz block of 800MHz spectrum that carried a coverage obligation in 2013. The obligation requires it, by no later than end-December 2017, to cover an area within which at least 98% of the population of the United Kingdom lives, and within which at least 95% of the population of each of England, Wales, Scotland and Northern Ireland lives. The quality stipulation is that the network should be capable of providing, with 90% confidence, a mobile downlink speed of not less than 2Mbps when the network is lightly loaded.

  – **Geographic coverage commitments added to license terms:** The government announced in early 2015 that UK mobile operators had accepted license amendments that commit each of them to take voice and text coverage to 90% of the UK's geographic area by 2017 and full coverage to 85%.

The Digital Economy Bill is the first piece of UK primary legislation which carries the government's aspirations for faster infrastructure deployment

- **Digital Economy Bill 2016 –** The first piece of UK primary legislation in the media and telecoms sectors for some time had its first reading in the House of Commons on July 5, 2016 (no date yet set for the second reading). This bill carries the government's aspirations for faster infrastructure deployment, as well as rules regarding content and regulatory oversight. This should help fast broadband deployment by providing fixed and mobile operators with stronger code powers to oblige landlords to host their facilities on reasonable terms, be that via wayleaves for fixed line ducts and cables or land for cell towers with power and access for engineers. The Communications Code is dated and versus other utilities leans strongly in landlords' favor. The bill proposes radical changes that are being opposed by landowners and their lobby organizations, however, rural demand for better broadband also represents a strong political force which is generally more supportive of the network operators' position.

  A 2015 report by Deloitte, commissioned by the Mobile Operators Association, identified up to £270 million in savings if the Electronic Communications Code were updated to ensure "fair and proportionate" rents, money that could be directed at network investment. It found that in the UK rental for mobile phone sites is 30 times that of electricity or water companies. The government's proposals to align Communications Code powers much more closely with those of water, power and gas utilities, where such powers are largely taken for granted, are overdue, in our view, and likely to be a material help in reducing barriers to investment and improvement in coverage and quality of both fixed and mobile networks, particularly in rural areas. They are, however, likely to prove

contentious and see opposition particularly from farming groups whose livelihoods can depend disproportionately on income from mobile operators under the current regime. With wider deployment set to make up for some of the losses on lower prices (and consolidation from network sharing) there may some room to compromise. We expect the bill to take some time to make it through Parliament.

- **The Communications (Access to Infrastructure) Regulations 2016** came into force on July 31, 2016 and obliges infrastructure owners to allow access by communications providers, subject to certain restrictions. This brings into UK law the EU Directive (2014/61/EU) on measures to reduce the cost of deploying high-speed electronic communications networks.

Broadband delivery UK

£1.7 billion is available to support extending superfast broadband coverage to 95% of households by the end of 2017

Total central government, local authority and European Union funding comes to £1.7billion to support extending superfast (>24 Mbps) broadband coverage to 95% of premises in the UK by the end of 2017. Broadband Delivery UK (BDUK) is the public sector organization which is responsible for allocating the central government funds and implementing the Government's policy.

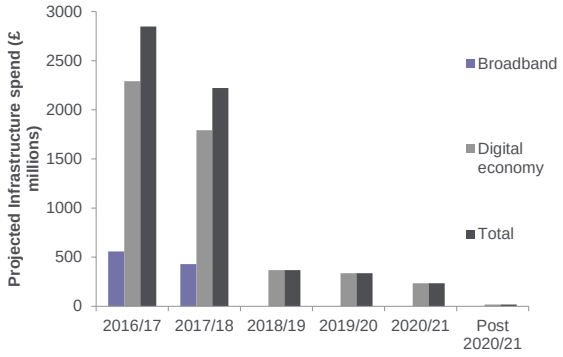
The BDUK program comes down to:

- Phase 1 : Super-fast broadband coverage to 90% of premises by early 2016 and access to basic broadband (2Mbps) for all from December 2015
- Phase 2: Superfast broadband coverage to 95% of premises by the end of 2017
- Phase 3: Explore options to provide superfast coverage to remaining 5% of premises

The UK government allocated £530 million, including £300 million from TV license fee revenue, to Phase 1 of the superfast broadband roll-out and a further £250 million to Phase 2. The rest of the funding came from local authorities and the EU.

We expect UK telecoms revenue to grow but only slightly over 2016-2020 with a decline in initial phase compensated by data-led growth in later years. We believe revenue will suffer modestly near term due to price competition and regulatory changes such as reductions to BT's Ethernet pricing at sub 1Gbps. In the medium term we believe revenue growth will move back in to positive territory led by increased fast broadband and LTE penetration and rising data usage.

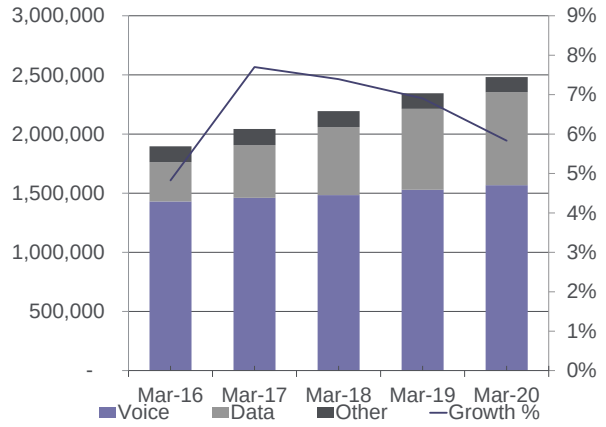
Figure 123. Telecoms Elements of UK National Infrastructure Plan



Source: HM Treasury, Citi Research

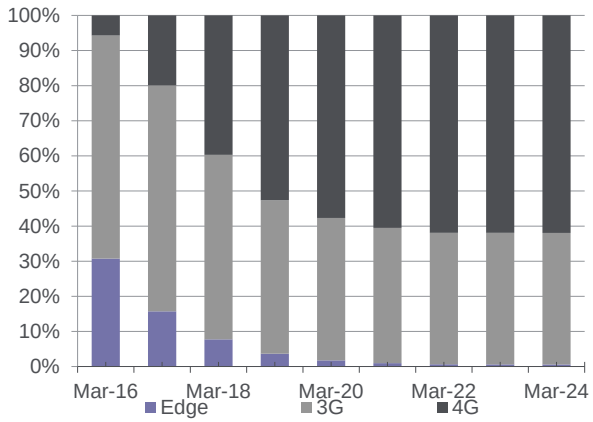
India Telecoms

Figure 124. Telecom Revenue Breakdown (Rs m)



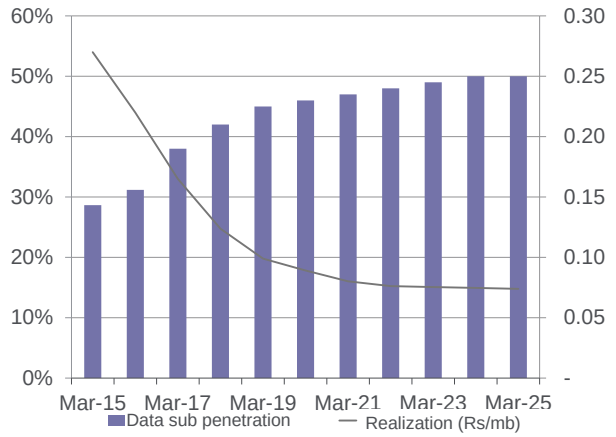
Source: Citi Research

Figure 125. Data Revenue Breakdown



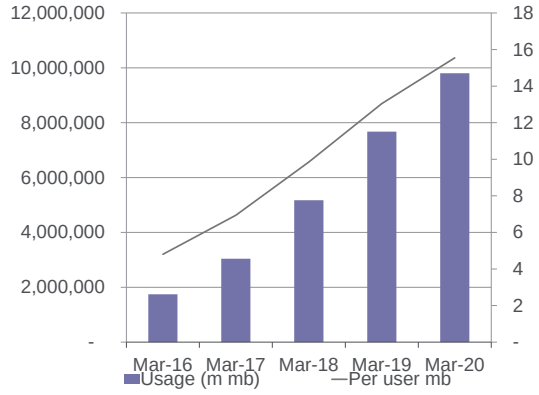
Source: Citi Research

Figure 126. Data Penetration and Realization



Source: Citi Research

Figure 127. Industry Data Volume and Per Subscriber Usage



Source: Citi Research

Figure 128. Snapshot of Digital India

	Digital India
Social Impact	Information access - Government, private - empowerment
Economic Impact	Efficiency, information, Government Services
Financial Impact	$1 broadband spend, $5 gain
Businesses Impacted	Telecoms, Tower companies, IT services, optical fiber manufacturers
Targets	100% smartphone penetration by 2019; broadband connectivity to 250K villages (50%); reduce electronic imports to 0 by 2020 ($20b+ currently)
Government Spend	Rs 1.1 trillion (130b additional)
Challenges/ Risks	Execution risks, ecosystem for electronics manufacturing
Website	http://digitalindiamib.com/

Source: GoI, Media reports and Citi Research

Growth outlook

Indian telecom industry revenues are estimated to grow at a CAGR of 7% over the next 4 years (FY16-20E), with voice growing at a 2% CAGR compared to data at

24% CAGR; this should increase data's contribution to industry revenues from 18% currently to 32%.

EDGE currently constitutes ~30% of industry data revenues despite the rapid growth in 3G. It is still early days for 4G whose revenue contribution to fiscal year 2016E data revenue is estimated at 6%. We expect EDGE's contribution to industry revenue driven both by rapid growth in 3G/4G as well as decline in number of subscribers using EDGE. As a result, EDGE's revenue contribution is estimated to decline to only 4% by fiscal year 2020E.

3G and 4G both will see rapid growth and longer-term, we expect 4G revenue to overtake 3G despite a late start. This will be due to higher per subscriber data usage on 4G vs. 3G. Already, Idea has disclosed that its 4G data usage is 1.5x of its 3G subscribers and ~70% of the smartphones being sold in India are 4G-enabled.

The percentage of subscribers starting to use data is likely to see a significant jump from ~30% currently to 42% over the next 2 years, driven by 3G/4G handset affordability, and a reduction in data rates with entry of new capacity of Jio. We estimate ~40% reduction in tariff cut from FY16-18E.

Digital India – A major government push

The government has launched several initiatives including Digital India (with a capital outlay of US$18 billion) which aims to improve connectivity in India.

The Indian Government has launched several wide-ranging economic-social programs, including Jan Dhan (financial inclusion), Swachh Bharat (Clean India), Make in India (manufacturing) and Digital India (access). Digital India is an aggressive effort to wire-up India through broadband access across villages, building on high mobility access, public Wi-Fi hot-spots, electronics manufacturing, and IT-led improvement in delivery of government services to both public and businesses. India witnessed a massive connectivity and efficiency step-up in the last decade on mobile telephony; this program should significantly build on it, though of the total capital outlay of Rs1.13 trillion ($18bn) for Digital India, only Rs130 billion ($2bn) is for new schemes.

Digitization could bring real change for India, as fixed-line and Internet penetration are still low, and mobile coverage is patchy. Internet connectivity could build on recent mobile growth and become the platform for the spread of literacy, health, and information, and ties in well with the Jan Dhan initiative.

Digital India intends to provide comprehensive broadband coverage through a National Optical Fiber Network (NOFN), covering 250K gram panchayats (village elected bodies) providing 100 mbps link through BBNL (Bharat Broadband Network Ltd.) by December 2016. In addition, there are plans to install 40,000 Wi-Fi hotspots by state-owned BSNL. Of this 2,504 hotspots have already been commissioned at 1,227 locations. In addition, it intends to digitally empower all citizens, via four pillars:

- **Access:** Through smartphones, with 100% smartphone penetration by 2019 (25% penetration currently), via common service centers, with 250K such centers to be opened in villages by March'17 to provide access to eGovernance services, and lastly by coverage for 55,619 uncovered villages by 2018.
- **Digital Literacy**: The target is to have at-least one digitally-literate person in every family, in five years.
- **Digital Facilities**: Cradle-to-grave digital identities for all citizens, plus electronic services across a wide spectrum such as education and healthcare.

- **IT for Jobs:** The government plans to train 10 million people, especially in smaller towns and rural areas, for jobs in the IT, telecom, and electronics sectors.

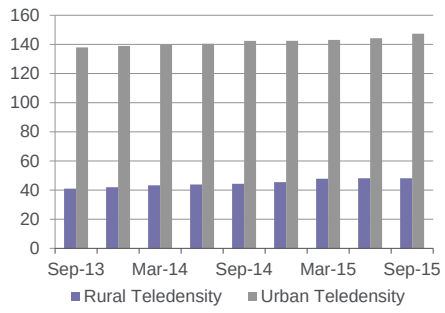
What a more digitized India could mean

Figure 129. Cost-Benefit Analysis for Investments in Broadband Infrastructure

Target	Discounted Benefits ($B) 2015-2030	Discounted Cost ($B) 2015-2030	Benefit For Every Dollar Spent
Increase World fixed broadband penetration by three-fold from 2014 levels (from 10% to 30% in 2030)	$35,930	$1,735	$21
Increase Developing countries' fixed broadband penetration by approx. three-fold from 2014 levels (from 6% to 20% in 2030)	$21,279	$1,031	$21
Increase World mobile broadband penetration by approx. three-fold from 2014 levels (from 32% to 90% in 2030)	$37,659	$2,203	$17
Increase Developing countries' mobile broadband penetration by approx. three-fold (from 21% in 2014 to 60% in 2030)	$21,578	$1,260	$17
Increase World penetration of Fixed+ Mobile Broadband from 42% in 2014 to 100% 2030 (assuming to reach the target with 1/3 of fixed lines and 2/3 of mobile connections)	$38,050	$3,161	$12
Increase Developing countries' penetration of Fixed+ Mobile Broadband from 27% in 2014 to 80% in 2030 (reaching the target with 1/3 of fixed lines and 2/3 of mobile connections)	$21,891	$2,431	$9
Universal fixed broadband penetration by the year 2030	$38,103	$7,343	$5
Universal mobile broadband penetration by the year 2030	$38,072	$2,523	$15

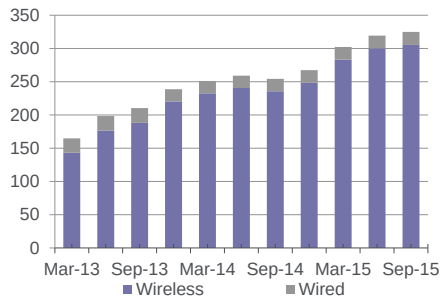
Source: Copenhagen Consensus Centre

Figure 130. Wireless Teledensity in India



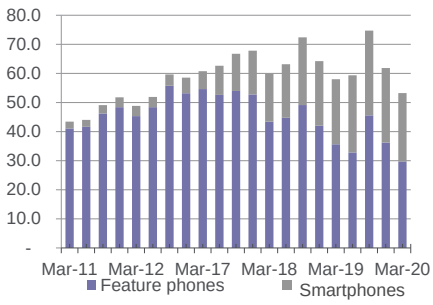
Source: Citi Research

Figure 131. Internet Users (in mn) in India



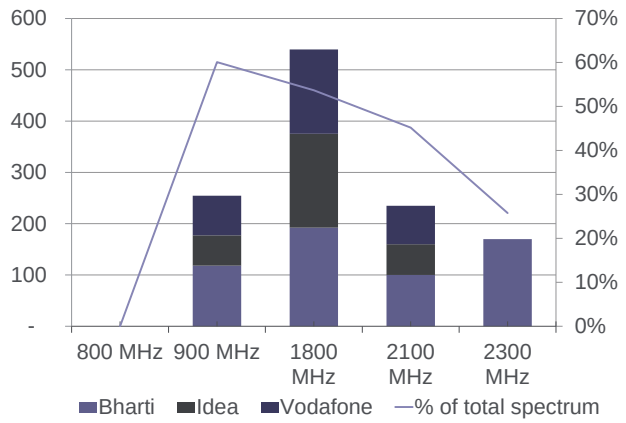
Source: Citi Research

Figure 132. Mobile Phone Shipments in India



Source: Citi Research

Figure 133. Top 3 Operators Have ~70% of the Revenue Share but Only 0-60% of Spectrum



Source: Citi Research

Figure 134. 700MHz Spectrum Reserve Price for Upcoming Auction

Circle	US$ m per 5Mhz
AP	725
Assam	118
Bihar	185
Delhi	1,190
Gujarat	710
Hary ana	139
HP	48
J&K	39
Karnataka	552
Kolkata	445
MP	247
Maharashtra	949
Mumbai	890
NE	33
Orissa	113
Punjab	230
TN	672
UP (E)	343
UP (W)	287
WB	137
Rajasthan	272
Kerala	249
Total	8,571

Source: Citi Research

A 10% increase in broadband penetration can increase GDP growth by 1.4%

While digitization should have significant social benefits, there should also be a significant economic flow-through in productivity and job creation. A recent World Bank study suggests a 10% increase in broadband penetration can increase GDP growth by 1.4% in low- to-medium income countries, while McKinsey estimates that bringing EM mobile broadband up to DM levels could add $400 billion annually to global GDP and create more than 10 million jobs. Citi analysts believe that every dollar invested in (fixed/mobile) broadband infrastructure leads to a benefit of at least $5, the return being greater on penetration than on Internet speed.

With the expected increase in data growth and call quality, the Indian government has started to make adequate spectrum available for auction

Spectrum is the key commodity for a telecom network, but India has one of the lowest spectrum holdings globally. Even the top 3 operators (Airtel, Vodafone and Idea) hold only 5-10MHz in any of the spectrum bands, compared to 10-25MHz in other key markets. With an expectation of rapid data growth and focus on call quality, the Indian Government has started to make adequate spectrum available during auctions, where the Government has made available all the spectrum it holds for the auction. This not only includes spectrum in the existing bands (800, 900, 1800, 2100 and 2300MHz) but also new bands (700 and 2500MHz). Apart from helping improve network capacity, making adequate spectrum available should also ensure lower aggression in bidding during auction.

The government has also announced M&A and spectrum trading/sharing rules to ensure spectrum gets transferred to the stronger players away from players who have under-invested in recent years. We have already seen evidence of it – Airtel has acquired spectrum from Videocon, Augere and Aircel while Reliance Jio has acquired RCOM's spectrum.

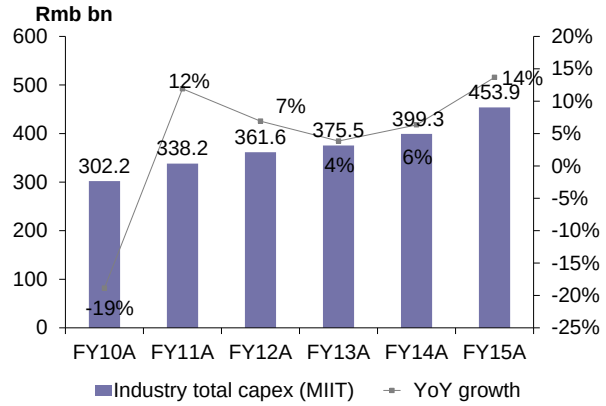
The spectrum price in India is high, due partly to spectrum scarcity in the past, which has forced aggressive bidding. While more spectrum is now available, the reserve price for every subsequent auction has been based on the previous winning bids, leading to its continued high price. Operators have nonetheless been bidding even at these high prices especially for spectrum needed to continue their services (as part of their license renewal). This has hurt the balance sheets of operators many of which have net debt/EBITDA levels of 2.5x or higher for even the top three players. High debt in turn constrains their ability to invest heavily on network rollouts.

We believe it will be challenging for the government to reduce the spectrum price meaningfully due to past controversies where spectrum was viewed as being given away too cheaply. Besides, operators are likely to acquire spectrum in the upcoming auction especially where they need to fill their 3G/4G spectrum gap. However, this could come with some impact related to adequate network rollout.

Lastly, despite the availability of 700MHz band (the most efficient amongst the bands available for coverage) in the upcoming auction, demand is likely to be minimal, with some operators choosing to stay away due to the high reserve price.

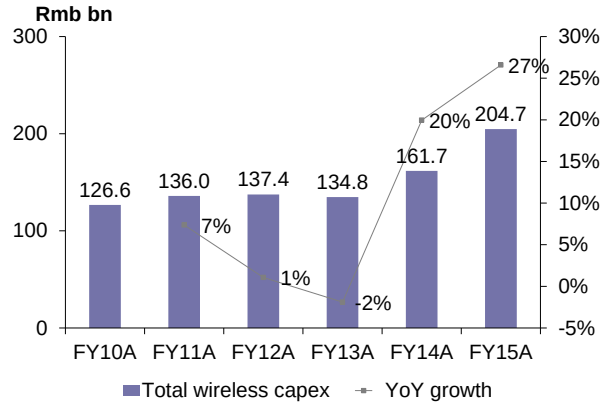
China Telecoms

Figure 135. China: Industry Total Capex



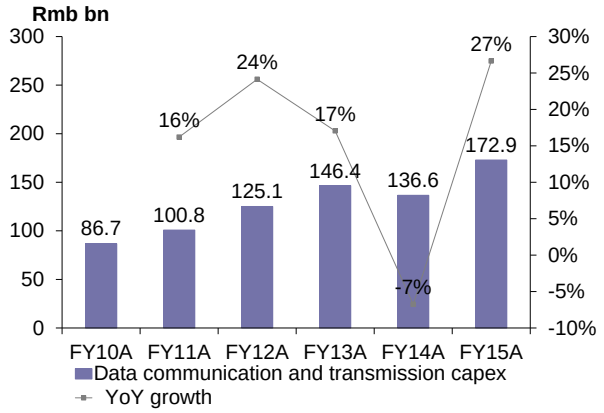
Source: MIIT, Citi Research

Figure 136. China: Total Wireless Capex



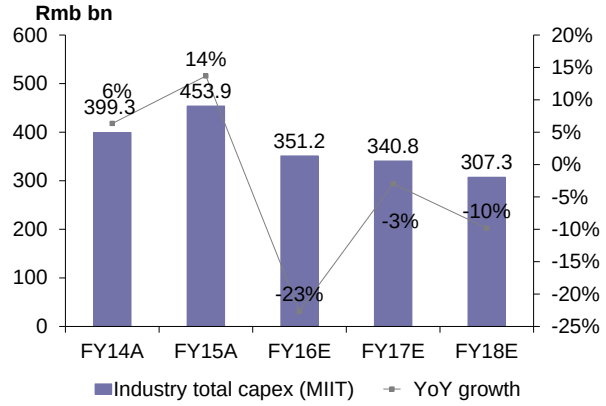
Source: MIIT, Citi Research

Figure 137. China: Data Communication and Transmission Capex



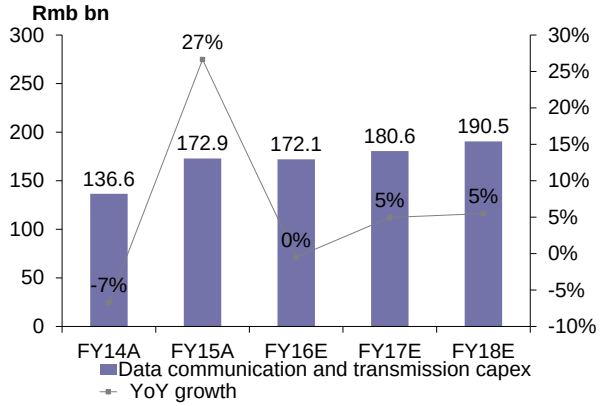
Source: MIIT, Citi Research

Figure 138. China: Industry Total Capex Forecasts



Source: MIIT, Citi Research

Figure 139. China: Data Communication and Transmission Capex Forecasts



Source: MIIT, Citi Research

Historical spending

In China, the industry total capex increase to Rmb 453.9 billion in 2015 from Rmb361.6 billion in 2012

According to the Ministry of Industry and Information Technology (MIIT), industry total capex increased to Rmb453.9 billion ($67.3) in 2015 from Rmb361.6 billion ($53.6bn) in 2012. Total wireless capex increased to Rmb204.7 billion in 2015, from Rmb137.4billion in 2014, driven by peak 4G capex in 2015. Data communication and transmission capex of Chinese telecoms, which mainly includes optical access network, transmission network and datacenter capex, increased to Rmb172.9bn in 2015, from Rmb125.1bn in 2012, according to the MIIT.

Future investment needs and major planned projects

We expect Chinese telecom's to see an overall capex decline in the next 2 years due to a decrease in 4G capex.

We expect each Chinese telecom will see continued overall capex decline in the next two years due to a significant decline in 4G capex. We forecast the industry total capex will decrease by 21% in 2016, compared with a 14% increase in 2015. We expect data communication and transmission capex to increase slightly in 2016 despite a decline in overall telecom industry capex and that growth will be 3-5% in 2017-18 driven by data traffic increases and 5G preparation of telecoms.

Broadband China Strategy

The Broadband China Strategy initiated by the State Council in 2013 aims to speed up networks, lower service fees, and cover wider areas of the country, elevating broadband development as a national strategy. China will boost investments in building fiber optic and faster wireless networks in order to stimulate consumption and drive economic growth.

The plan will be carried out in three stages:

- The first stage (by 2013) focused on building fiber optic networks and 3G mobile networks to improve Internet access speed.
- In the second stage (2014-2015), the focus was on expanding broadband coverage. Half of households (270m) were to have access to broadband and 70 million households were to have access to FTTH by 2015.
- In the third stage (2016-2020), China will be dedicated to network optimization and technology updates. By 2020, broadband household penetration should exceed 70% with speeds of 50+Mbps in urban areas and 12+Mbps in rural areas. Internet users are expected to grow to 1.1 billion in 2020.

Figure 140. Target Number of Broadband Subscribers

Target No. of Broadband Subs	2013	2015	2020 Target
Broadband subs (m)	210	270	400
Among which: Urban	*160*	*200*	-
Rural	*50*	*70*	-
3G/LTE subs (m)	330	450	1,200

Source: The State Council, Citi Research

Figure 141. Target Broadband Penetration Rate

Target Broadband Penetration Rate	2013	2015	2020 Target
Broadband penetration	40.0%	50.0%	70.0%
Among which: Urban	55.0%	65.0%	-
Rural	20.0%	30.0%	-
3G/LTE penetration	25.0%	32.5%	85.0%

Source: The State Council, Citi Research

Figure 142. Target Download Speed

Target Download Speed	2013	2015	2020 Target
Urban broadband bandwidth (Mbps)	20 (for 80% of subs)	20	50
Rural broadband bandwidth (Mbps)	4 (for 80% of subs)	4	12

Source: The State Council, Citi Research

Figure 143. Target Number of Internet Application

Target No. of Internet Application	2013	2015	2020 Target
Internet users (m)	700	850	1,100
Rural internet users (m)	180	200	-
Internet data traffic (TB)	7,800	15,000	-
E-commerce GMV (tn)	10	18	-

Source: The State Council, Citi Research

13th Five Year Plan

According to the 13th Five Year Plan, China is expected to increase its fiber network to all urban areas

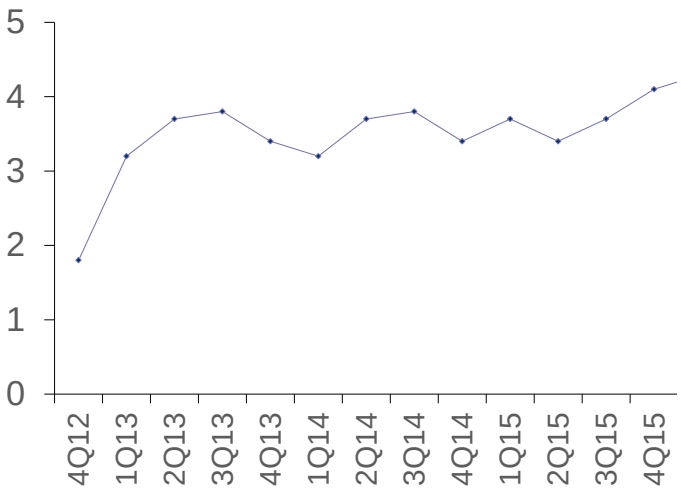
According to the 13th Five Year Plan released in the first half of 2016, China expects to expand the fiber network coverage to all urban areas and 98% of administrative villages by 2020, with households in big and medium-sized cities being able to choose 100Mbps broadband or above, and 50% of village households able to choose 50Mbps broadband or above.

Barriers to infrastructure investment

Fiber network upgrades in China lag behind other developed Asia markets such as Japan and Korea

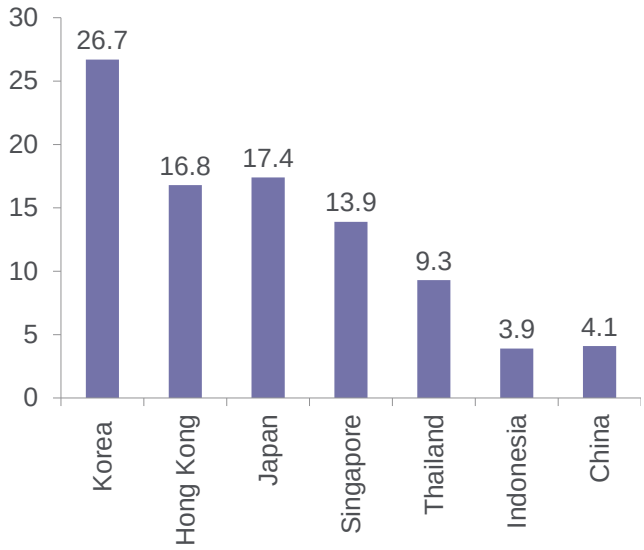
Although China is among the leading countries globally in mobile data networks infrastructure with fast 4G development, the average speed of fixed broadband in China still lags far behind leading countries. Fiber network upgrades in China lag behind developed markets like Korea and Japan by 3-5 years, according to management of Accelink and industry consensus. Chinese regulators recently issued a number of policies to narrow the broadband infrastructure gap, which will help speed up China's fiber network upgrade and fixed broadband penetration increase in the next two years.

Figure 144. China Average Fixed Broadband Connection Speeds (Mbps)



Source: Akamai, Citi Research

Figure 145. Average Fixed Broadband Connection Speeds in 4Q15 in Selected Asian Countries (Mbps)



Source: Akamai, Citi Research

Brazil Telecoms

Brazil mobile-sub base shrinking fast

Brazil telecoms regulator Anatel reported a total of 253 million active mobile accounts in Brazil in July 2016. This is 10% smaller YoY and results from the 28.9 million disconnections just in the last year. The dynamics that supported this shrinkage are still in place, and we see them intensifying, suggesting continued reductions ahead.

The lower number of subscribers seems to have resulted from the recent sharp cuts in Mobile Termination Rates (MTRs), which fell 33% YoY in February 2016, coupled with a weak macro environment.

Off-net pricing drops by half in nominal terms …

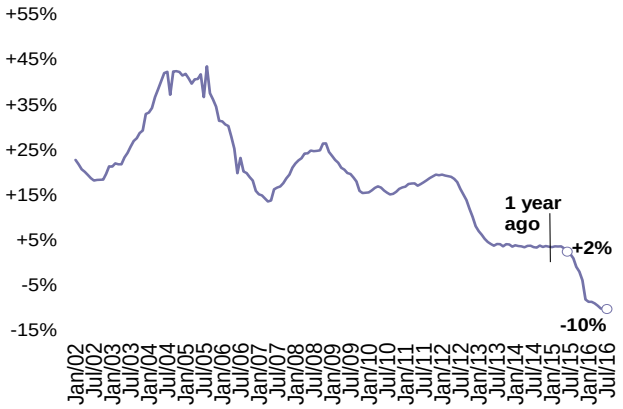
MTRs are scheduled to drop to R$0.05/minute in Brazil in February 2017 – this is a ~50% YoY reduction in nominal terms. Lower MTRs reduces the price of outgoing calls, thus reducing the incentive for users to have multiple SIM cards (as they attempt to only make on-net and cheaper calls). We think this will sustain the ongoing trend of reducing in the active number of mobile accounts there.

Today, 6% of TIM's service revenues came from interconnection (vs. 8% in 2Q15). Likewise, 5% of Vivo's mobile services revenues are from MTRs, down from 6% a year before. With that, just 3% of Vivo's consolidated sales – including fixed-line Telesp and GVT operations – come from mobile termination. Vivo and TIM are the only companies with proper disclosure that allows precise calculations on MTR contributions. They serve ~55% of Brazil's mobile users.

…plus incentives to save on Fistel fees

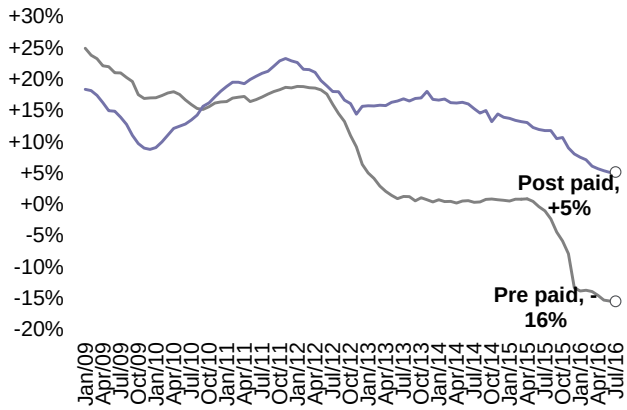
Additionally, companies' stricter disconnection practice – they are disconnecting non-performing pre-paid subs more frequently (to save on Fistel fees), helps accelerate the pace of disconnections. Figure 147 below shows the growth rate of the pre-paid and post-paid subscribers and suggests that the sharp slowdown of the overall growth in Brazil is attributable almost entirely to this phenomenon.

Figure 146. Brazil Mobile-Base Now Shrinking…
Progression of Brazil mobile subscriber-base growth (yoy)



Source: Anatel, Citi Research

Figure 147. …as Companies Start to Disconnect Pre-Paid Subscribers
Progression of pre-paid and post-paid mobile subscriber-base growth (yoy)



Source: Anatel, Citi Research

Brazilian mobile operators pay regulator Anatel R$26.83 for every mobile line that they activate as well as an annual R$13.42 fee for every active sub at the end of every year. We calculate these two components adds to R$6 billion ($1.9bn) for the entire sector in Brazil, or about 6% of industry EBITDA. Because Fistel fees are expensed by operators, reported telecom EBITDA margins in Brazil understate companies' true operating efficiency by about 6 percentage points.

Reduction in Double-Counting Supports Higher ARPUs

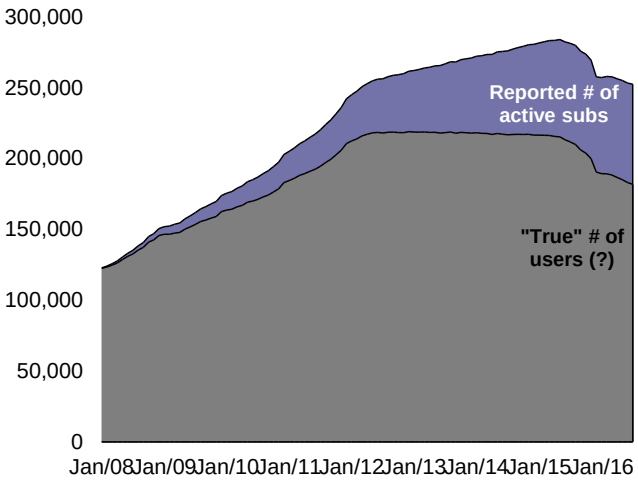
The raw data on Brazil's mobile subscriber base could be misleading. Many subscribers (mostly low-end) typically have more than one SIM-card to take advantage of different promotions and make as many cheap on-net calls as possible. When their credits expire and/or the promotions end, subscribers simply stop making calls, but never cancel their lines with carriers. Still, they stop producing revenues, and this behavior helps dilute reported average revenue per users (ARPUs) until they are finally disconnected by the operator. This may take up to three months – depending on each company's disconnection policy.

Multiple SIM-card usage pollutes reported data

Informal estimates suggest that there may be as many as 70 million (out of Brazil's 253 million reported active mobile accounts) SIM cards that may fall into this category at any given time (Figure 148). This suggests that the number of mobile accounts may drop by as many as a third with ongoing Fistel pressures and reduced incentives for multiple-SIM card usage.

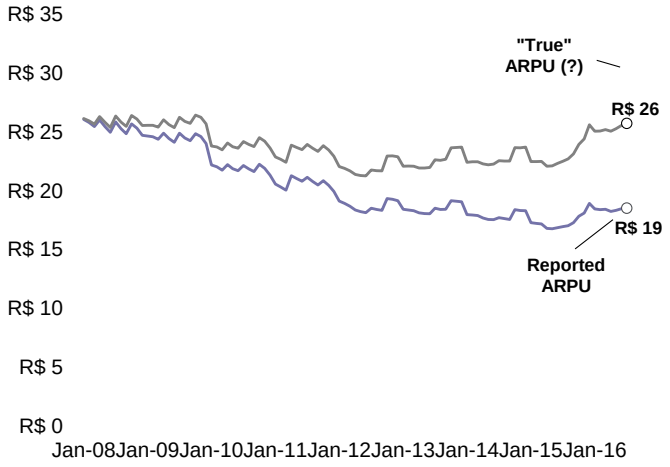
We note, however, that a potential adjustment in Brazil's mobile subscriber base should be gradual. The number of users that effectively generate revenues to operators in Brazil would be around 182 million.

Figure 148. Double-Counting Inflates Mobile Subscriber Base...
Progression of active mobile accounts, vs. hypothetical sub base (´000s)



Source: Anatel, Citi Research

Figure 149. ...and Dilutes Reported ARPUs
Reported vs. adjusted ARPUs



Source: Company data, Citi Research

With an inflated subscriber base, ARPUs are then mathematically underestimated. Today, every active account pays an average of R$19/month to Brazil's mobile operators, but we estimate that ARPUs would be R$26 (Figure 149), without any double-counting in Brazil.

Higher ARPUs ≠ higher industry revenues

Although encouraging, higher ARPUs would not necessarily mean incremental revenues for the industry. In fact, it would simply be a true measure of usage by each individual subscriber, as opposed to active accounts.

Figure 150 and Figure 151 below show our estimates for Brazil's subscriber base – which we think will continue to shrink rapidly. As a result of the disconnection of non-performing subs, reduced regulatory pressure on revenues (as upcoming MTR cuts should be more gradual than in the last few cuts) and continued growth in mobile data, ARPUs should start to expand, at least in nominal terms.

Figure 150. Total Sub Base to Continue Shrinking…
Total mobile subscriber base (´000s)

	2013	2014	2015	2016E	2017E
Vivo	77,245	79,937	73,268	71,803	70,367
TIM	73,431	75,720	66,235	64,248	63,321
Claro	68,704	71,107	65,979	64,989	64,014
Oi	50,238	50,940	48,083	49,206	48,714
Total mobile subs	**269,618**	**277,704**	**253,565**	**250,246**	**246,416**
growth, yoy		*+3.0%*	*-8.7%*	*-1.3%*	*-1.5%*

Source: Company data, Citi Research estimates

Figure 151. …ARPUs to Start Growing
ARPU (R$/month)

	2013	2014	2015	2016E	2017E
Vivo	23.57	23.88	25.74	27.96	29.70
TIM	19.48	18.25	18.07	18.65	20.63
Claro	15.21	14.86	13.37	13.13	13.45
Oi	20.43	18.20	17.14	16.62	17.04
Industry	**19.74**	**18.99**	**18.88**	**19.52**	**20.71**
difference, yoy		*-3.8%*	*-0.6%*	*+3.4%*	*+6.1%*

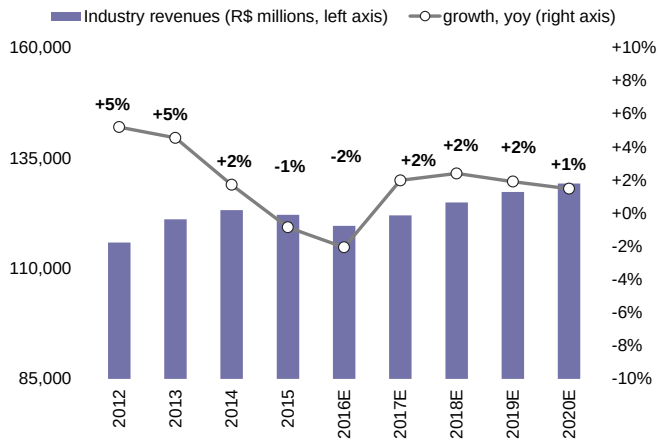
Source: Company data, Citi Research estimates

Despite encouraging ARPU expectations, we do not expect the industry to grow any faster going forward. While we expect revenues to stabilize (after a 5% shrinkage in 2015), we model telecom revenues growing 2% on average in the next five years. However, with inflation expectations averaging ~6% during this time, this actually suggests real pace of erosion of about 4% per year.

While sales of mobile-data services/products continue to grow at a robust pace (~20% for the industry), the business has not yet reached enough scale to support overall revenues as mobile-voice and fixed-line services shrink. Mobile data is roughly a third of mobile service revenues in Brazil today, with voice representing the other two-thirds, but contracting ~15% nationwide.

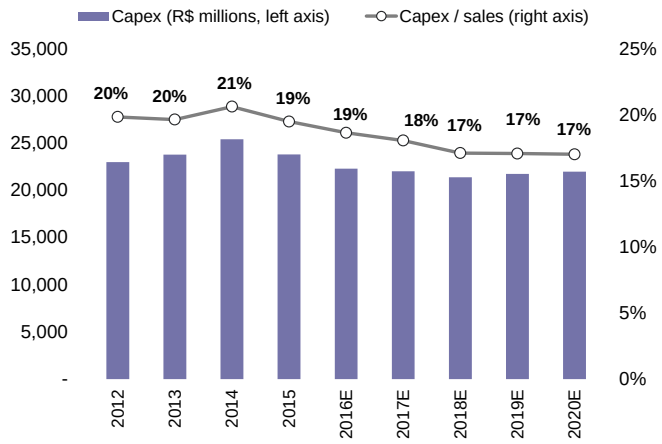
With current dynamics suggesting lower growth going forward (and companies having recently gone through a network-upgrade phase to adopt 4G (or LTE) protocol, we think the level of capex intensity will alleviate to c.17-18% of revenues in the next few years (vs. ~20% in the last five years).

Figure 152. Brazil Telecom Revenues Shrinking in Real Terms
Progression of telecom revenues (R$ millions), vs. YoY growth rate



Source: Company data, Citi Research estimates

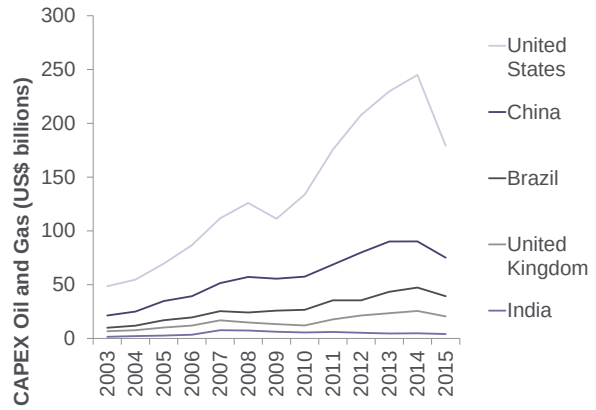
Figure 153. Companies Now More Conservative on Capex Deployment
Progression of telecom capex (R$ millions), vs. capex / sales



Source: Company data, Citi Research estimates

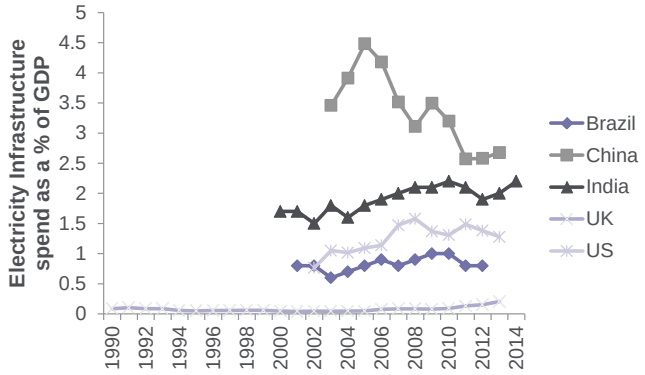
Energy Infrastructure

Figure 154. Upstream Oil and Gas Investment (US$ billions)



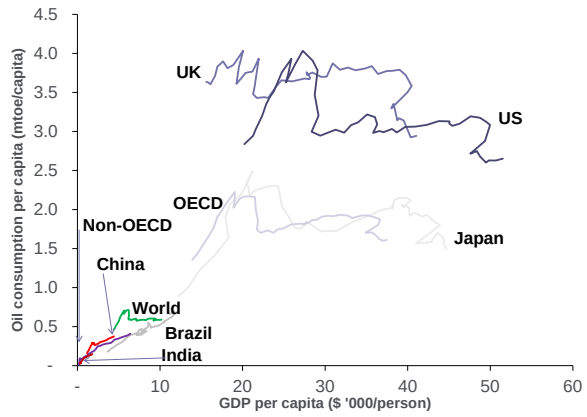
Source: Wood Mackenzie, Citi Research

Figure 155. Infrastructure Investment in Electricity Production as a % of GDP



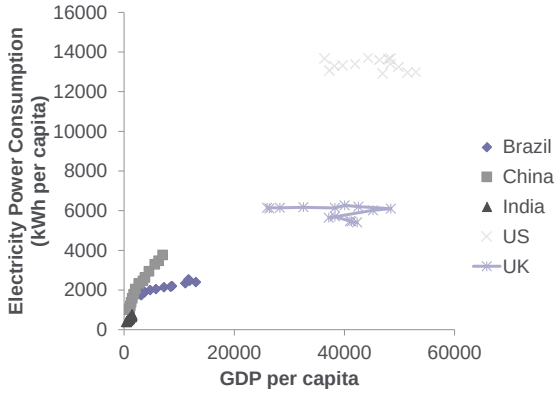
Source: China Statistics, BNDES, Planning Commission India, Citi Research

Figure 156. Oil Consumption Per Capita vs GDP Per Capita



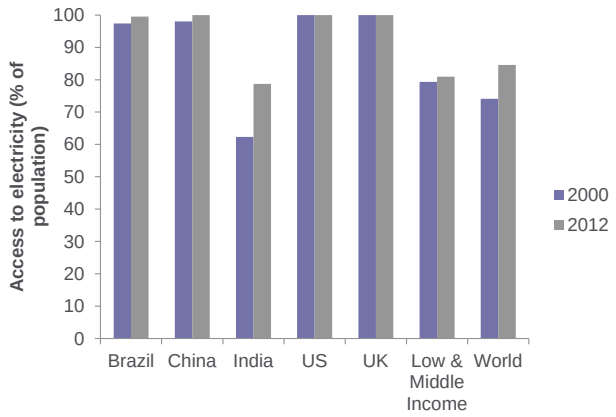
Source: Citi Research

Figure 157. Electricity Power Consumption (kWh per capita) Against GDP Per Capita



Source: Citi Research

Figure 158. Access to Electricity (% of Population)



Source: World Economic Forum[37], Citi Research

Figure 159. Quality of Electricity Supply (Ranking and Value)

Country	Global Rank - Quality of Electricity Supply	Score 1-7
Switzerland	1	6.85
Hong Kong	2	6.78
Singapore	3	6.74
Denmark	4	6.69
Iceland	5	6.69
Finland	6	6.69
Norway	7	6.66
Netherlands	8	6.64
UK	9	6.6
UAE	10	6.6
US	16	6.44
China	53	5.34
Brazil	96	3.78
India	98	3.78

Source: World Economic Forum[37], Citi Research

[37] World Economic Forum, The Global Competitiveness Index Historical Dataset 2005-2015

The World's Biggest Industry

Global capex in energy estimated at $750 billion in power and $850 billion in oil and gas in 2013

Energy is currently the world's 'biggest' industry, with global capex in 2013 of $750 billion in power and $850 billion in oil and gas. Going forwards, the IEA expect investment of around $28 trillion between 2015 and 2030, split equally between the two.

While close to 100% of the population in the US, UK, Brazil, and China have access to electricity, in India it stands at around 78%, with much of the developing world even lower; indeed the IEA estimate that 1.5 billion people, or 20% of the world's population, still lack access to power. As Figure 157 shows, power consumption vs. GDP per capita varies wildly around the world, with the average American consuming more than 4x as much as the average Brazilian, and 34x more than the average person in India. Oil consumption varies similarly; the US consumes the most per capita, using almost 18x as much oil per capita as India, the least of our selected countries. As 'wealth' (measured in terms of GDP per capita) increases in countries such as India and China, energy usage will increase accordingly, as wealthier individuals purchase energy-consuming goods such as fridges, TVs, cars etc.

The ranking of the quality of electricity infrastructure paints a similar picture, where even though China and India have increased in ranking over time, they require significant improvements to facilitate and drive GDP growth – India currently ranks 98th out of 144 countries, as highlighted in Figure 159.

Disruptive Energy Innovations

Energy infrastructure spend is likely to change dramatically in both its nature and scale

Going forward, energy infrastructure spend is likely to change dramatically in both its nature and its scale. Population and GDP growth will drive energy demand, with significant granular differences; energy demand is likely to actually reduce in developed markets as energy efficiency in both electricity and transportation takes effect, while emerging markets will grow strongly with increasing population and wealth thereof.

What we build will change too – one only has to look at the extraordinary rise of renewable energy capacity in recent years, with more renewable capacity being added in developed markets now than conventional, driven of course by the dramatic reductions in renewables' levelized cost of energy. Concerns over climate change are likely to be a significant and growing influence on what we build, and how we use energy; the economics of these shifts were examined in detail in our recent Citi GPS Report Energy Darwinism II.

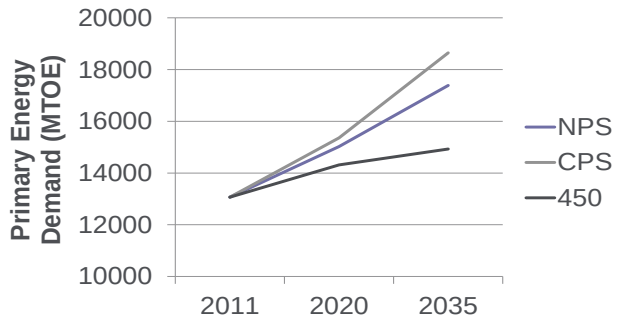
Electric vehicles will have an effect on electricity demand and oil demand whilst autonomous cars will potentially reduce congestion and the need for car parks

In transportation, the way we travel, and in what, are also likely to change. Electric vehicles are likely to have a significant impact in the longer term on electricity demand (up) and oil demand (slower growth, with the potential of 'peak oil' at some point). A new or different network of charging stations will also be needed, whether it is in natural gas in the interim, or electrical charging points in the longer term. Autonomous vehicles, shared vehicles, and other changes to usage will change infrastructure by potentially reducing congestion (consistent flow, more lanes per road), and reducing the need for car parks to name but a few effects.

Energy storage could also open up the door to a 100% renewable energy supply

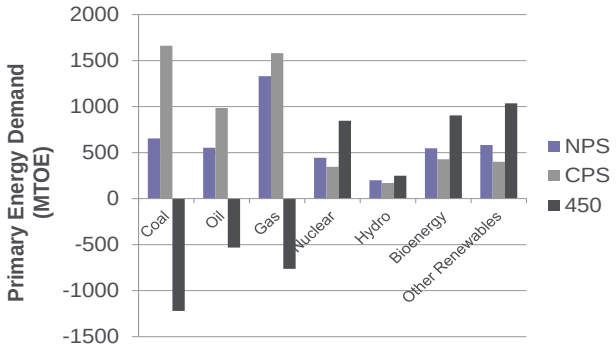
Moreover, the storage potential which electric vehicles (EVs) and other forms of energy storage offer is also likely to transform our energy landscape. Storing energy on a large scale could ultimately open the door to a 100% renewable energy supply, reducing costs and CO_2 emissions in the process. For example the UK's national grid spends approximately £1 billion every year on balancing the grid, and stored energy can play a huge role in reducing these costs.

Figure 160. Primary Energy Demand under IEA Scenarios



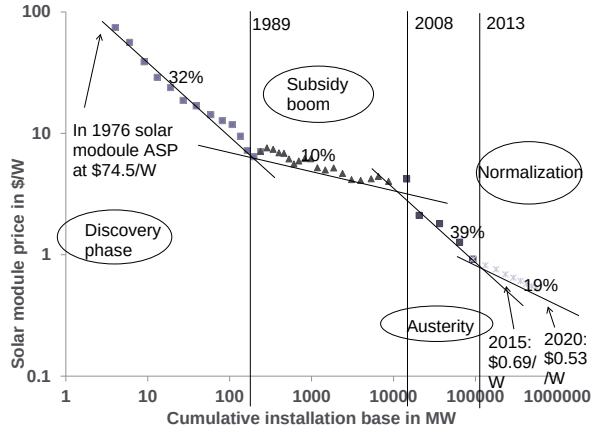
Source: IEA (2013),Citi Research

Figure 161. Change in Primary Energy Demand from 2011 (in 2035)



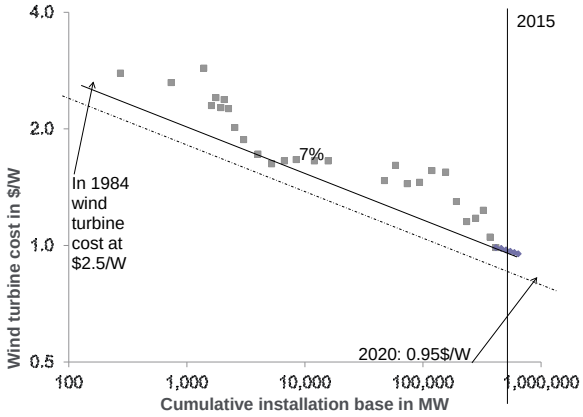
Source: IEA (2013),Citi Research

Figure 162. Solar Learning Rate 19%



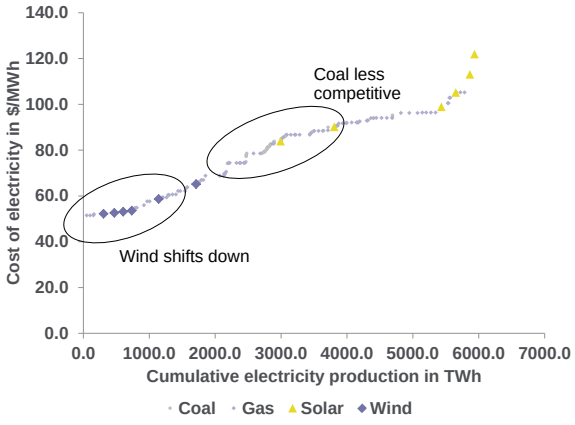
Source: BNEF, Citi Research

Figure 163. Wind Learning Rate 6.7%



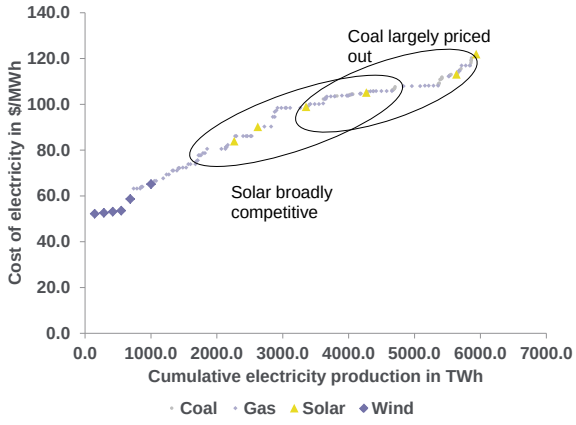
Source: BNEF, Citi Research

Figure 164. Energy Darwinism Cost Curve Out to 2020 at a Carbon Price of $25/t



Source: Citi Research

Figure 165. Energy Darwinism Cost Curve Out to 2020 at a Carbon Price of $50/t



Source: Citi Research

Distributed generation combined with storage can offer the potential for millions of people to generate their own electricity

But it is not just centralized storage that will have an effect; distributed generation, combined with storage, offers the potential for millions of domestic energy traders, generating their own electricity, using it, storing it, selling it back to the grid, buying and storing, with smart appliances and home energy management systems all serving to arbitrage out peaks of demand and hence pricing, as well as potentially reducing utilization rates on conventional generation plant. Given the potential for distributed generation and storage, will we even build electricity systems in the same way, if they are uneconomic, or will we go straight to distributed solar and wind in emerging markets, leapfrogging centralized generation and transmission, much as mobile telephony has leapfrogged fixed line in Africa and parts of Asia?

The energy storage market is expected to increase from $200 million in 2012 to $19 billion in 2017

The energy storage market is expected to grow from an annual installation size of 6GW in 2017 to over 40GW by 2022. An IMS research report forecasts that the global market for storing power generated by solar modules will increase from $200 million in 2012 to $19 billion in 2017,[38] the US being one of the biggest markets. Advances in energy storage technology, growing solar power technologies, falling battery costs and a regulatory shift into self-consumption and away from metering, are encouraging hundreds of companies to build energy storage systems throughout the country. Governments are also setting targets for energy storage systems, such as the California Public Utilities Commission which has issued a target requiring the state's largest utilities to provide 1.3GW of energy storage by 2020. Other states such as New York are also following suit.

There are a number of energy storage technologies such as battery storage (and not just the lithium ion type so loved by industries obsessed with energy density, i.e. weight, such as autos and tech), adiabatic compressed air energy storage, flywheels, power to gas and supercapacitors.[39]. Moixa Technology is working with the Department of Energy and Climate Change (now part of the Department for Business, Energy & Industrial Strategy) and is deploying its energy storage system called mashlow with solar, LED lightning into 300 homes in UK.

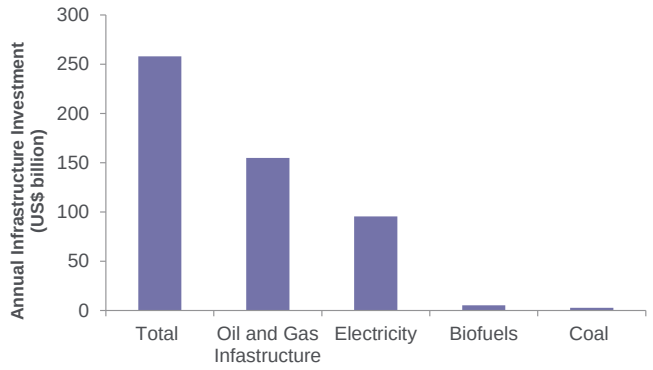
Rapid deployment of energy storage systems is just one of the missing links to better energy efficiency, greater use of renewables and a reduction of CO_2 emissions. Other innovations that are happening in this sector include the introduction of smart metering that can help increase the reliability of a supply system by prioritizing load curtailment in signs of distress[40] and big data as described in our Disruption Innovations IV report.

Energy assets, as with most infrastructure assets, are by their nature long-lived (a coal-fired power station has for example a life of ~40 years) and highly capital-intensive. With relative economics, usage patterns, and returns likely to change so drastically even in the next five years, let alone the next 30, raising capital to build conventional 30-40-year assets has become at best 'challenging', and at worst, unachievable. This uncertainty about the future caused by the rapid evolution of energy market, as highlighted most starkly by the integrated energy curves which we derived in our original Energy Darwinism I GPS report.

[38] Energy Storage Association, www.energystorage.org
[39] Irena, (2015), Battery Storage for renewables: Market Status and Technology Outlook
[40] Strbac G, Konstantelos I, Aunedi M, Pollitt M, Green R (2016), Delivering future-proof energy infrastructure, A report for National Infrastructure Commission (Feb 2016)

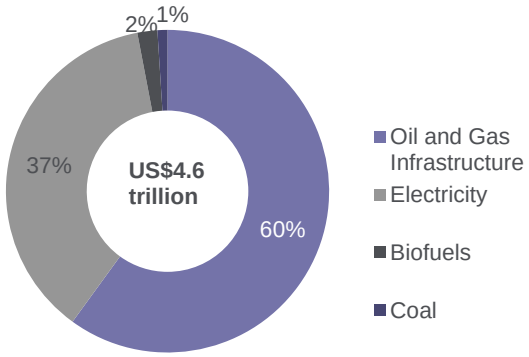
Energy Infrastructure in the US

Figure 166. Annual Average Capital Investment Needs in the US



Source: US Chamber of Commerce, Citi Research

Figure 167. Aggregate Capital Investment Needs (2013-2030)



Source: US Chamber of Commerce, Citi Research

$4.6 trillion is needed to be invested in energy in the US from 2013 to 2030.

The US Chamber of Commerce has stated that the US needs to invest a total of $4.6 trillion between 2013-2030 in energy, with 60% of this required for upstream investment in oil and gas infrastructure and 37% for the electricity production and distribution.

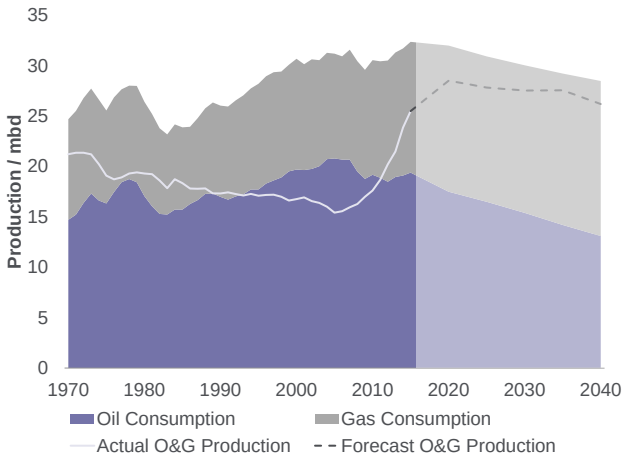
US upstream investment

US shale continues to be a disruptive influence in the upstream incentive curve

The defining feature of the energy landscape in the US has been the rise of shale production since 2010, reversing the previous declines in production. However, the recent downcycle in commodity prices has curtailed activity from ~1600 rigs in 2014 to ~350 in early July 2016 and slashing company upstream budgets by 50-80%. Despite this US shale continues to be a disruptive influence in the upstream incentive curve, making up 62% of Citi's 2022 global cost-curve.

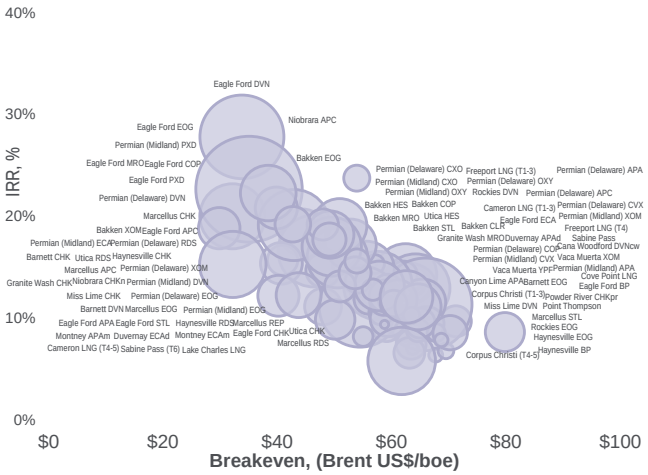
The US also boasts significant resource in offshore Gulf of Mexico currently accounting for 15-20% of US oil production. Economics in the deepwater field largely depend on water depth, size of discovery and proximity to available infrastructure in order to reach attractive $40-60/bbl breakevens.

Figure 168. US Oil & Gas Production vs. Consumption



Source: BP Statistical Review 2016 & IEA World Energy Outlook

Figure 169. US Upstream Projects in Citi's Oil Vision



Source: Citi Oil Vision database *size of bubble = NPV

Domestic, international and foreign national oil companies are all active across the US upstream sector. Onshore leases are majority-operated by independent producers who drill >90% of wells, but produce between 50-60% of the oil production. Offshore acreage, although pioneered by the super majors and large US companies in the 1980s, has increasingly become more dominated by the independents, who now hold >80% of the producing leases.

While Figure 168 shows a flattening of US & O&G production post 2020, there are widely held views that supply could continue growing post 2020; we have some sympathy for this view on the shale side, though less so for oil.

US – power generation

We see power demand growth continuing to decouple from GDP growth

With respect to US power specifically, we see power demand growth continuing to decouple from GDP growth, as companies and regulators continue to focus on energy efficiency initiatives and demand response programs. The resource base is expected to grow with the addition of new renewable and gas-fired generation, but it will be tapered by retirements of coal and nuclear facilities. We also expect to see continued growth in distributed generation (e.g., rooftop solar), but its penetration has not been significant to date.

In the US, most of the large, planned energy infrastructure projects relate to gas transmission, LNG exports, electric transmission, renewable generation, and gas-fired generation. With respect to the power sector specifically, utilities are constantly seeking new investment opportunities (e.g., developing new or improving existing T&D, generation or smart metering infrastructure) since they receive a regulated return on their invested capital. Most of the unregulated companies (i.e., IPPs) are investing in new gas-fired or renewable generation assets given the low price and abundant supply of gas as well as the various state-mandated renewable portfolio standards which stipulate that a certain percentage of generation must come from renewables (varies by state).

Barriers to investment in US power generation

One of the barriers to direct investment in the power industry is that most of the utilities are regulated monopolies

Regarding power specifically, there are some natural barriers to direct investment in that most of the utilities are regulated monopolies, so, as mentioned, the government allows them to earn a fixed return on equity (~8-12% depending on the region) for being the sole provider of electricity in their service territory. Even in Texas, which is deregulated and allows customers to choose their retail electricity provider, a new entrant would still be required to comply with extensive regulations and demonstrate a strong reputation before they could win market share from an incumbent.

We continue to see substantial investment in the utilities sector

The US government is already strongly supporting investment in energy by mandating that utilities procure minimum amounts of generation from renewable resources, requiring investment in emissions control equipment in order to continue operating most coal plants, providing tax subsidies to developers of renewable generation, and allowing companies that produce or transport fossil fuels to trade as partnerships and thus avoid double taxation (i.e., MLPs). We continue to see substantial investment in the utilities sector, with fundraising for US energy and infrastructure funds reaching a record high over the past year. However, there are also programs like the Committee for Foreign Investment in the US (CFIUS) and Foreign Investment in Real Property Tax Act (FIRPTA) that limit foreign investment in energy infrastructure, among other assets.

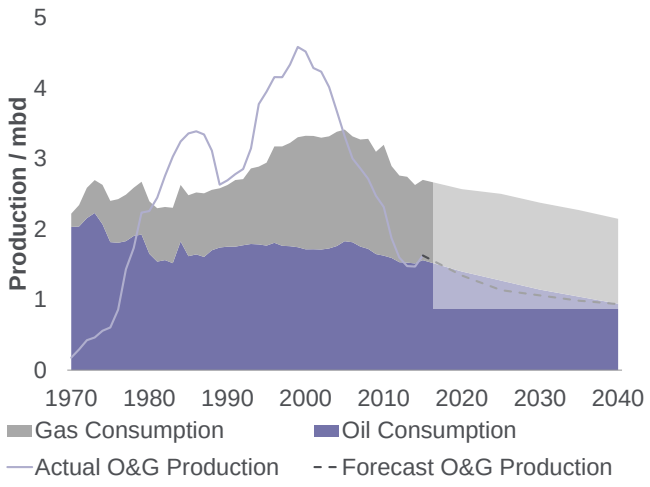
Energy Investment in the UK

Upstream energy investment in the UK

Upstream investment in the North Sea has seen records levels of investment over the last 5 years

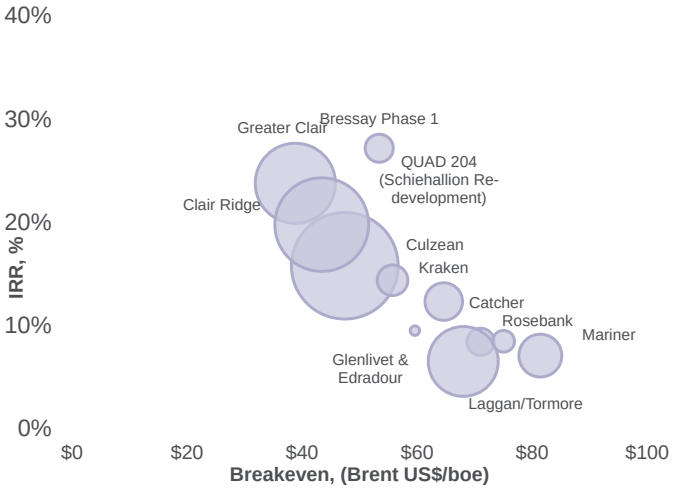
The UK is a mature region that has been producing offshore since the mid-1960s benefiting from established infrastructure and low barriers of entry for investment. Upstream investment between 2010 and 2015 has been at record levels in the North Sea (~$100bn) as a wave of project developments ramped up spend. These developments began start-up through 2015 and into 2016 with further sanctioned projects scheduled to add production from 2017. However, despite record investment levels, these projects will only deliver enough production to temporarily hold back declines, while their sizable capital expenditure requirements have led the UK North Sea to experience negative cashflows not seen since the 1970s. Some of the largest current investment includes Clair Ridge and Quad 204 (both ~$7.5 billion) due to start up in early 2017.

Figure 170. U,K, Oil & Gas Production vs. Consumption



Source: BP Statistical Review 2016 & IEA World Energy Outlook

Figure 171. UK's Upstream Projects in Citi's Oil Vision



Source: Citi Oil Vision database *size of bubble = NPV

The key advantage of more mature basins such as the UK North Sea over frontier regions is that much of the infrastructure required for export is already in place allowing far smaller accumulations to be economic. As throughput falls and the average age of infrastructure is approaching 30 years old, unit costs increase and challenge the commerciality of key hubs.

UK – Power Generation Investment

Figure 172. Growth in Capacity (MW)

	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2016-2025	2010-2016
Biomass	-	-	-	52	315	628		910	420	-	-	-	-	-	-	-	1,330	995
Gas	132	1,767	2,040	510				620	1,619	295	1,398	998	-	-		-	4,930	4,449
Offshore Wind	948	497	909	543	211	529	9	1,086	2,283	2,034	4,499	4,190	5,521	2,700	3,090	1,000	26,403	3,646
Onshore Wind	428	196	394	796	344	592	275	1,517	972	1,137	933	1,237	862	330	183	-	7,170	3,027
Pumped Storage	-	-	-	-	-	-	-	-	-	1,500	-	-	-	612	-	-	2,112	-
Tidal/Hydro	-	8	-	49		20	22	-	10	335	96	158	228	-	40	50	917	99
Solar	-	96	894	765	1,098	2,552	3,667	-	-	-	-	-	-	-	-	-	-	9,071
Total MW of additions	1,508	2,563	4,237	2,715	1,968	4,322	3,973	4,133	5,304	5,301	6,926	6,583	6,611	3,642	3,313	1,050	42,862	21,286

Source: Citi Research

Figure 173. National Infrastructure in the Pipeline in the UK (£ billion)

Sub- sector (£ billion)	No. of projects	Total	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	Post 2020/21
Electricity Distribution	14	18.4	2.4	2.4	2.3	2.3	2.3	2.2	4.3
Electricity Generation	52	140.3	7.1	8.4	9.0	11.2	11.8	13.5	79.3
Electricity transmission	35	18.6	2.4	2.6	2.9	3.8	3.6	2.8	0.4
Gas Distribution	10	6.1	0.9	1.0	1.0	1.0	1.1	1.1	0.0
Gas storage	4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Gas Transmission	5	1.2	0.1	0.2	0.3	0.2	0.2	0.1	0.2
Nuclear Decommissioning	33	19.4	0.7	0.7	0.8	0.7	0.8	0.8	14.9
Oil & Gas	2	34.3	10.4	7.9	6.2	5.5	4.4	0.0	0.0
Smart meters	1	6.3	0.3	0.1	0.3	0.3	0.5	0.5	4.3
Grand Total	158	244.9	24.6	23.5	22.7	25.1	24.5	21.1	103.4

Source: Citi Research

Figure 174. Electricity Generation Investment

	Additional capacity to 2010-2015 (MW)	Total investment (£m)	Additional capacity to 2025 (MW)	Total investment required (£m)
Biomass	995	170	1,330	228
Gas	4,449	2,225	4,930	2,571
Offshore Wind	3,646	14,033	26,403	45,422
Onshore Wind	3,027	5,728	7,170	12,437
Pumped Storage	-	-	2,112	3,000
Tidal/Hydro	99	5	917	49
Solar	9,071	5,193	-	-
	21,286	27,353	42,862	63,707

Source: Citi Research

The UK's power market looks set to be transformed going forward with a move away from coal towards gas and in particular renewables. A milestone was recently passed with the first day in modern times that none of the UK's electricity came from coal-fired generation.

As Figure 172 shows, current plans are for around 10GW of new gas-fired capacity to be built over the next decade, a figure still dwarfed by the massive 26 gigawatt (GW) of offshore wind which is planned. While this table does not show the nuclear plant at Hinckley Point, it now appears that this project has been given the go-ahead.

Total new capacity is expected to cost £64 billion to 2025 with the majority of the investment earmarked for offshore wind

Total new capacity has an expected cost of around £64 billion ($78bn) to 2025, as highlighted in Figure 173, with over 70% of that investment being in offshore wind. As investment costs per megawatt (MW) fall, the competitiveness of this technology look set to improve dramatically, with recent offshore wind bids being made at just €64/MW and €73/MWh in Denmark and the Netherlands, respectively, showing very rapid progress already.

Notable future areas of investment are in nuclear decommissioning, and new areas such as smart meters are appearing, with every home in the UK now having the right to a smart meter for free. Interestingly, battery storage recently won National Grid's tender process to provide dispatchable power (at 1 second's notice), with 210MW of storage being procured, the vast bulk of that being battery and lithium ion based. As with other markets, we expect energy storage to become an increasing area of energy investment going forwards, particularly as renewable and electric vehicle penetration intensifies.

Barriers to UK energy infrastructure investment

There is currently a high barrier to entry as the UK market is mostly regulated (in terms of networks), with even generation moving to being quasi-regulated through capacity payments. However, the regulators (Ofgem) seem to be pushing the agenda towards competition, with attempts to open up part of the networks to competition. Moreover, new areas of investment such as renewables and storage do open up areas of potential for both new players and new investment. Utilities will find it hard to compete on purely financial grounds given the ubiquity of cheap credit, though they can play the card that their expertise gives them an advantage, and the government should consider whether cost is the overriding metric, with security of supply etc. being key considerations. Another risk to investment, is that, with financing costs coming down so much in recent years, utilities may be seen as having earned too high a return spread versus the cost of financing, raising the specter that returns may be reduced to attempt to claw back some of these apparently 'excess' profits, (though they were of course in line with financing costs at the time of agreement).

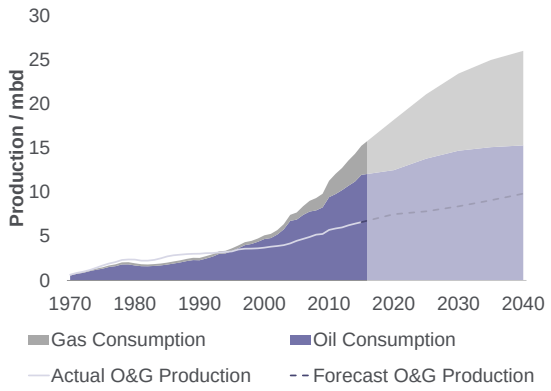
China – Energy Infrastructure Investment

China – upstream investment

China opened up its offshore to foreign investment in the 1990s and its onshore opportunities in the mid-2000s, attracting more than $20 billion of capital

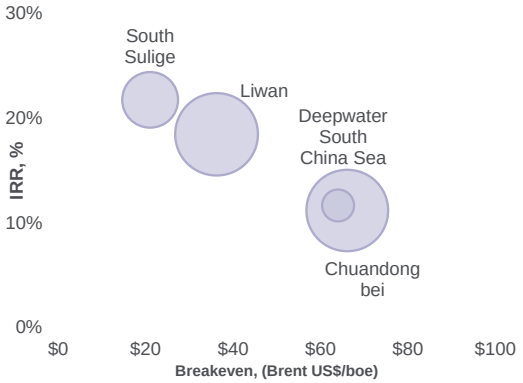
China's upstream industry is the largest in the Asia Pacific region producing 4.3 million barrels per day (mbd) of liquids and 13.3 billion cubic feet per day (bcf/d) of gas in 2015 which currently meets less than 50% of domestic demand. The sector remains dominated by the three national oil companies (CNPC, Sinopec and CNOOC), but with mega oil fields like Daqing/Shengli in decline private investment is beginning to make inroads into the sector. In the 1990s China opened up its offshore, and later in the mid-2000s its onshore, opportunities to foreign investment attracting Chevron, Royal Dutch Shell, BP, Conoco Philips, Total and HSE to invest >$20 billion of capital

Figure 175. China Oil & Gas Production vs. Consumption



Source: BP Statistical Review 2016 & IEA World Energy Outlook

Figure 176. China's Upstream Projects in Citi's Oil Vision



Source: Citi Oil Vision database *size of bubble = NPV

As the central government continues to promote the use of gas to reduce reliance on coal/oil, China is undertaking huge infrastructure investments to supply its ever-growing demand for gas. At this point its gas grid is fragmented, centered on its major onshore producing regions, namely the Ordos Basin in the North East, Sichuan Basin in South West, and Tarim Basin in its remote North West. The first major long distance pipelines were constructed in the late 1990s connecting the Ordos Basin production to Beijing, followed by the construction of the West East I pipeline which began the process of network integration, connecting the remote Tarim Basin with the populated East coast. While Figure 175 shows significant increases in Chinese oil and gas production, much will depend on the success in shale, with early signs not particularly encouraging/cheap.

China – power generation

The Chinese government has set some clean energy related targets such as 210-250GW wind and 110-150GW solar capacity targets by end of 2020 in China, but does not have a target for total capacity. We expect China's power-generating capacity to grow at about 7-9% per year over the 2016-18E period.

China is suffering from excess power-generation capacity and therefore there is little appetite for foreign investment

China is currently suffering from excess power-generating capacity, with utilization rates of coal-fired power plants expected to be below 50% in 2016. Accordingly, there is little appetite for overseas companies to invest in Chinese power plants, (less than 5% market share), due to the oversupply situation, and without fixed and predictable regulated returns. The Chinese power market is dominated by state-owned enterprises, with expansionary decisions not being made solely on financial returns, but also taking into account other factors such as employment, making this a hard market in which to compete or invest.

India – Energy Infrastructure Investment

Upstream energy infrastructure investment

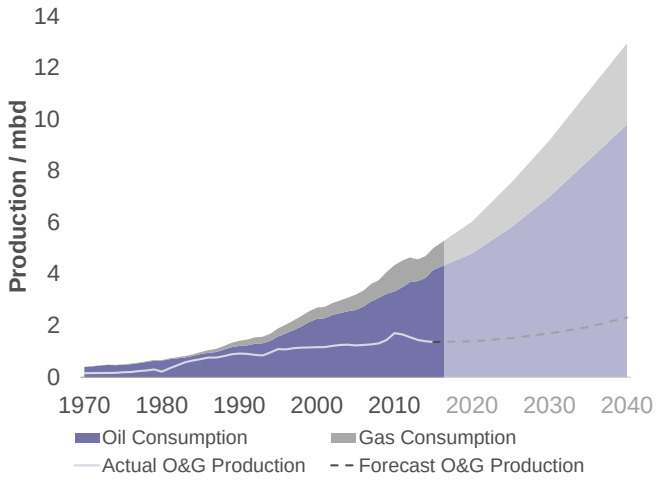
India's upstream sector growth has slowed over the years

India's upstream sector growth has slowed in recent years as bureaucratic barriers continue to place a headwind on upstream investment, translating into a steady decline of domestic production, in direct contrast to a 3% YoY growth in demand in the last 5 years. Most of India's oil, ~70%, is produced by the Oil and Natural Gas Corporation, a multinational company with a majority government-held interest.

India is on average 80% dependent on oil imports and 40% on gas imports; this led the government to relax gas pricing regulation

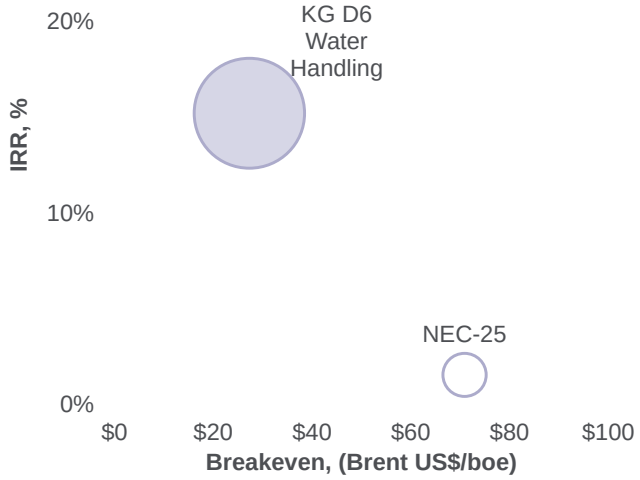
By the end of 2015 India was ~.80% dependent on oil imports and ~40% dependent on gas imports. This led the Indian government in March 2016 to implement a host of policy changes, the most material of which saw a relaxation in gas pricing regulation, a move which BP cites as the core reason its Indian gas projects investment can progress towards sanction.

Figure 177. India Oil & Gas Production vs. Consumption



Source: BP Statistical Review 2016 & IEA World Energy Outlook

Figure 178. India's Upstream Projects in Citi's Oil Vision

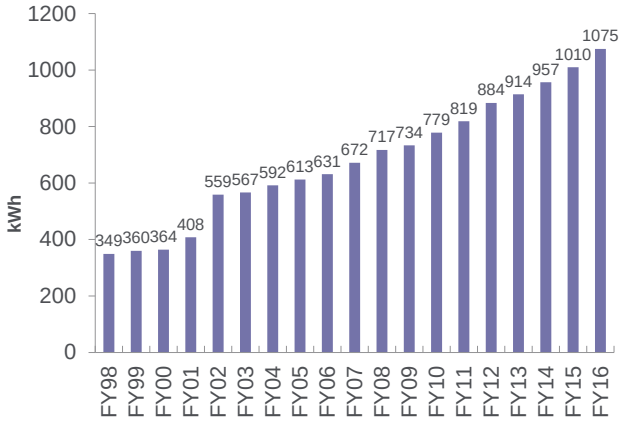


Source: Citi Oil Vision database *size of bubble = NPV

India has around.15,800 km of natural gas pipelines in place, with an additional 11,400 km of gas pipeline under execution or construction. However, the pipeline network is concentrated mainly in the northern and western parts of the country, with a large area still lacking the required distribution network.

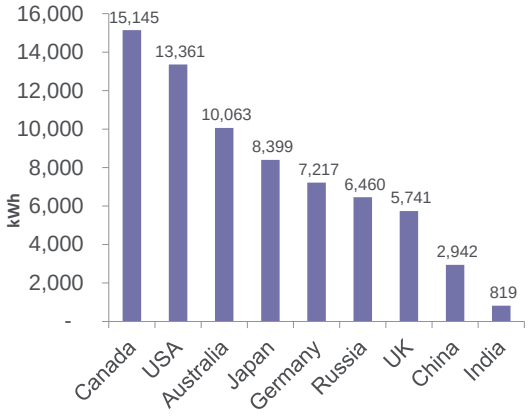
India – power generation

Figure 179. India Per Capita (kWh) Power Consumption



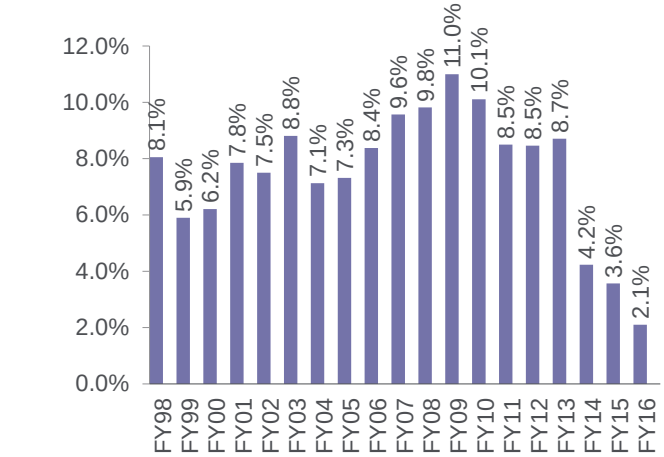
Source: CEA and Citi Research

Figure 180. World Per Capita Power Consumption CY10/ FY11



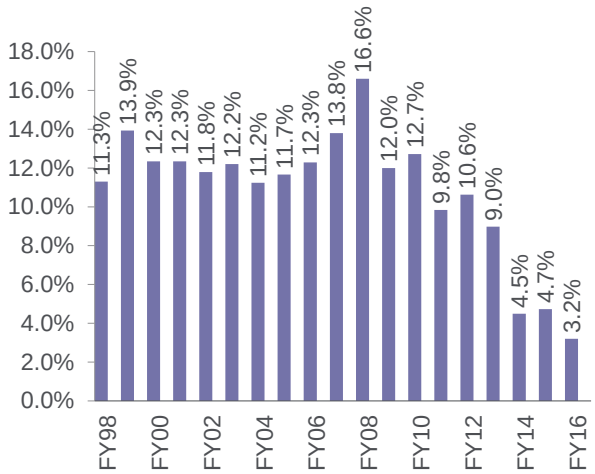
Source: Planning Commission of India and Citi Research

Figure 181. India Annual Energy Deficits



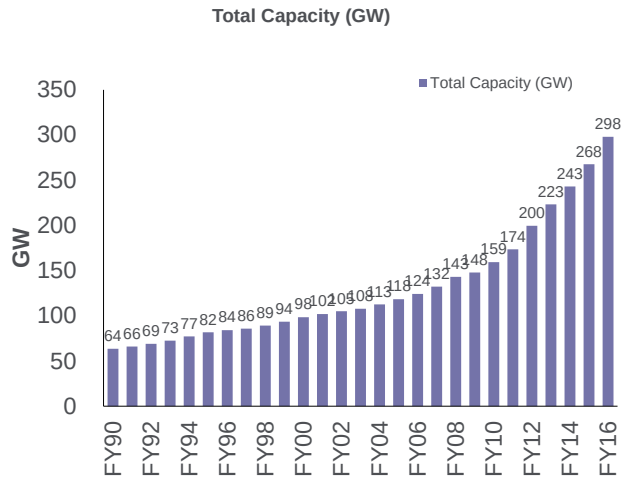
Source: CEA and Citi Research

Figure 182. India Annual Peak Deficits



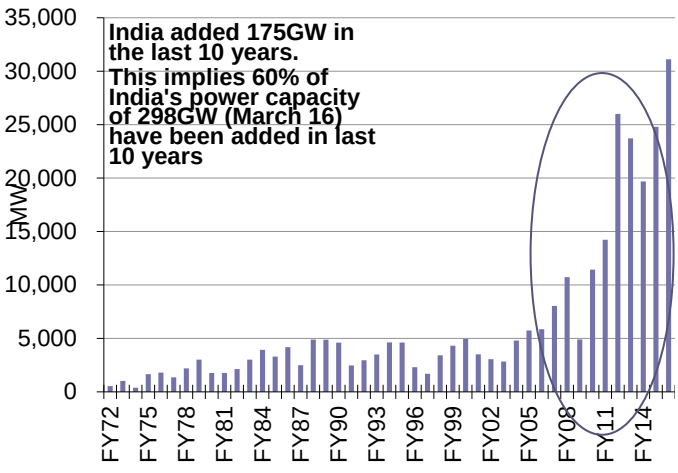
Source: CEA and Citi Research

Figure 183. Installed Generation Capacity Over FY05-FY16



Source: CEA, Citi Research

Figure 184. India Power Capacity Additions



Source: CEA, Citi Research

25% of Indian households do not have access to power

According to the World Bank 25% of Indian households, or around 280 million people, do not have access to power, with India's per capita power consumption amongst the lowest in the world. In comparison, currently China has a per capita consumption of 4,000 kWh, with developed nations averaging around 15,000 kWh per capita.

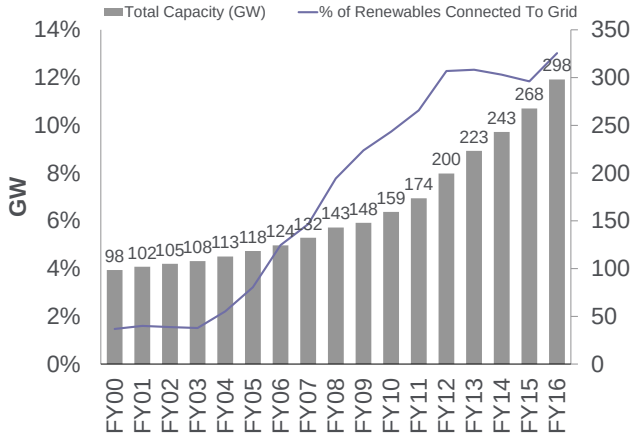
Against this backdrop the recent low power deficit of 2-3% is indeed bewildering to many. India's energy deficit has declined to 2.1% fiscal year 2016 versus highs of 11% in fiscal year 2009. Peak deficit has declined to 3.2% in fiscal year 2016 versus highs of 16.6% in fiscal year 2008.

India has added 175GW of capacity in the last 10 years, representing around 60% of India's power capacity at end fiscal year 2016 of 298GW.

The government is revising its energy targets to include renewables

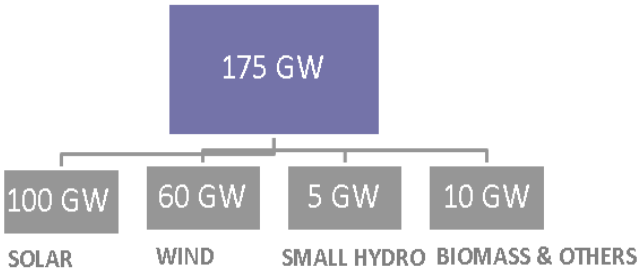
The government's earlier target of installing 20GW of solar capacity by 2022 has been revised up to 100GW (from 3.7GW currently). The government also wants to put in place 60GW (from 23.4GW currently) of wind power capacity, 10GW biomass, and 5GW of small hydro capacities. Attractive state-level feed-in tariffs, generation-based incentives, viability gap funding, and accelerated depreciation are being used as the key drivers to meet these ambitious targets.

Figure 185. India Renewables Connected To Grid



Source: CEA and Citi Research

Figure 186. Road Map For Renewable Power by 2022



Source: Ministry of Power and Citi Research

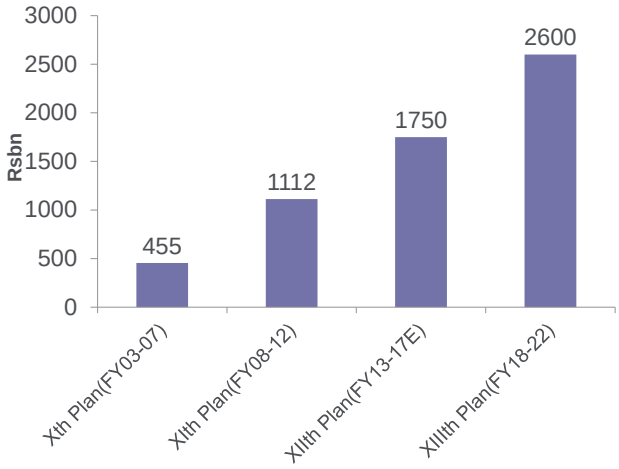
India – power transmission

Figure 187. Progress of Power Transmission Sector in India

TRANSMISSION LINES (IN ckm) At the end of	6th plan	7th plan	8th plan	9th plan	10th plan	11th plan	12th plan addition	12th plan end	As on Aug'16
+500 kV HVDC									
Central	0	0	1,634	3,234	4,368	5,948			9,454
State	0	0	0	1,504	1,504	1,504			1,504
JV/Private	0	0	0	0	0	1,980			1,980
Total	0	0	1,634	4,738	5,872	9,432	7,440	16,872	12,938
765 kV									
Central	0	0	0	751	1,775	4,839			21,525
State	0	0	0	409	409	411			840
JV/Private	0	0	0	0	0	0			3,463
Total	0	0	0	1,160	2,184	5,250	27,000	32,250	25,828
400 kV									
Central	1,831	13,068	23,001	29,345	48,708	71,023			90,476
State	4,198	6,756	13,141	20,033	24,730	30,191			45,738
JV/Private	0	0	0	0	2,284	5,605			15,256
Total	6,029	19,824	36,142	49,378	75,722	106,819	38,000	144,819	151,470
220 kV									
Central	1,641	4,560	6,564	8,687	9,444	10,140			11,009
State	44,364	55,071	73,036	88,306	105,185	125,010			1,48,649
JV/Private	0	0	0	0	0	830			898
Total	46,005	59,631	79,600	96,993	114,629	135,980	35,000	170,980	1,60,556
Grand Total	52,034	79,455	117,376	152,269	198,407	257,481	107,440	364,921	3,50,792
SUB-STATION (in MVA/MW)									
At the end of	6th plan	7th plan	8th plan	9th plan	10th plan	11th plan	12th plan addition	12th plan end	As on Dec'15
+500 kV HVDC Converter/BTB Station									
Central	0	0	0	3,500	6,500	8,250			12,500
State	0	0	0	1,700	1,700	1,500			1,500
JV/Private	0	0	0	0	0	0			2,500
Total	0	0	0	5,200	8,200	9,750	12,750	22,500	16,500
765 kV									
Central	0	0	0	0	0	24,000			1,24,500
State	0	0	0	0	0	1,000			12,000
JV/Private	0	0	0	0	0	0			13,500
Total	0	0	0	0	0	25,000	149,000	174,000	1,50,000
400 kV									
Central	715	6,760	17,340	23,575	40,455	77,225			1,10,050
State	8,615	14,820	23,525	36,805	52,487	73,172			104,657
JV/Private	0	0	0	0	0	630			4,260
Total	9,330	21,580	40,865	60,380	92,942	151,027	45,000	196,027	2,18,967
220 kV									
Central	500	1,881	2,566	2,866	4,276	6,436			9,046
State	36,791	51,861	81,611	113,497	152,221	215,771			2,90,304
JV/Private	0	0	0	0	0	1,567			1,567
Total	37,291	53,742	84,177	116,363	156,497	223,774	76,000	299,774	3,00,917
Grand Total	46,621	75,322	125,042	181,943	257,639	409,551	282,750	692,301	6,86,384

Source: Citi Research

Figure 188. Spending on Power Transmission During 10-13th Plan Period



Source: CEA and Citi Research

Figure 189. India Transmission Sector Capex

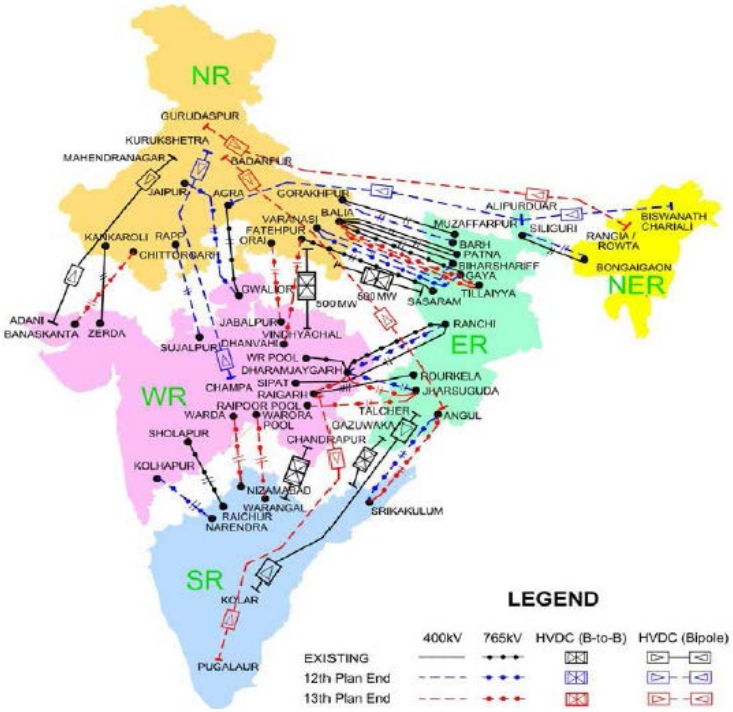
	Xth Plan (FY03-07)	XIth Plan (FY08-12)	XIIth Plan (FY13-17E)	XIIIth Plan (FY18E-22E)
Inter State	200	550	1200	1,300
Intra State	255	562	550	1,300
Total	455	1,112	1,750	2,600

Source: CEA and Citi Research estimates

In India the transmission & distribution system is a three-tier structure comprising distribution networks, state grids, and regional grids. India has been demarcated into five transmission regions viz. Northern, Eastern, Western, Southern and North Eastern. Most inter-state transmission links are owned and operated by Power Grid Corp of India (PGCIL) and intra-state transmission links are developed by respective state electricity boards (SEBs).

CEA estimates spending of Rs2600 billion ($39bn) during XIIIth plan period FY18-22E up 49% from the XIIth plan period to expand and improve India's transmission infrastructure.

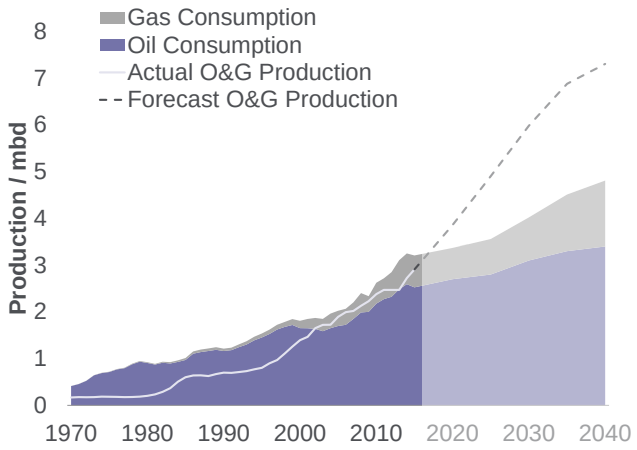
Figure 190. India's Inter Regional Transmission Links Planned Till FY22E



Source: CEA, Ministry of Power

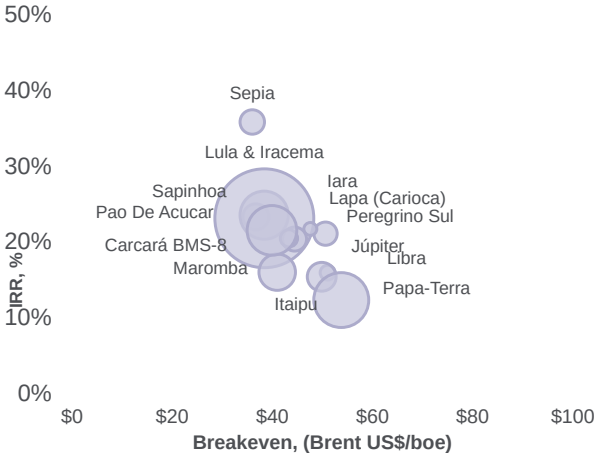
Brazil – Energy Investment

Figure 191. Brazil Oil & Gas Production vs. Consumption



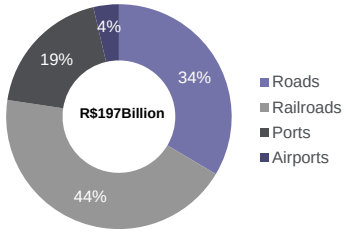
Source: BP Statistical Review 2016 & IEA World Energy Outlook

Figure 192. Brazil's Upstream Projects in Citi's Oil Vision



Source: Citi Oil Vision database *size of bubble = NPV

Figure 193. Proposed Aggregate Energy Investment in Brazil (2015-2018)



Source: Citi Research

The government of Brazil launched a new infrastructure project and plans to invest R$148.1 billion in energy (power generation and distribution) and R$80 billion in oil and gas through three concession rounds.

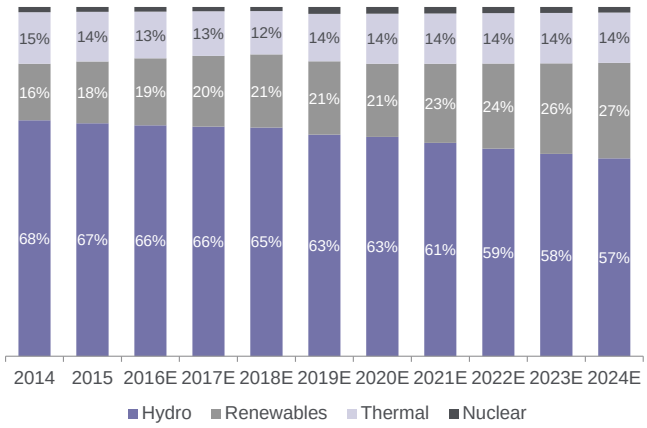
The pre-salt discoveries in the mid-2000s, particularly in the Santos basin, and the country's increasing attractiveness to private investment due to low breakeven developments continue to incentivize investment. Brazil alone has secured >$65 billion of capital in greenfield projects since 2010, leading to expectations that production in the country will increase by >100% before 2035. Petrobras, the Brazilian state oil company, dominates the oil and gas sector although there still exist a wide variety of private Brazilian companies and IOC interest.

Brazil remains in the worst recession in more than three decades and, with Dilma Rousseff suspended from office pending an impeachment trial over accusations of manipulation of government accounts, political uncertainty looks set to continue. In addition, Petrobras faces mounting debt of $126 billion, forcing the company to accelerate its $15 billion of divestment plans, which include stakes in Carcara, Jupiter and Pao De Acucar.

The low break-even of pre-salt Brazil (~$29-55/boe) still makes it a key source of incremental upstream investment for the industry into the next decade despite these broader economic and political challenges. The majority of developments come through Floating Production Storage Offloading (FPSO) vessels and tanker-loaded to coastal terminals as the infrastructure in the region is still relatively limited in scope.

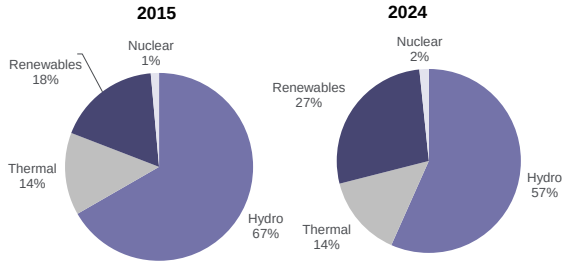
Brazil – Power Generation and Networks

Figure 194. Brazil Generation Matrix



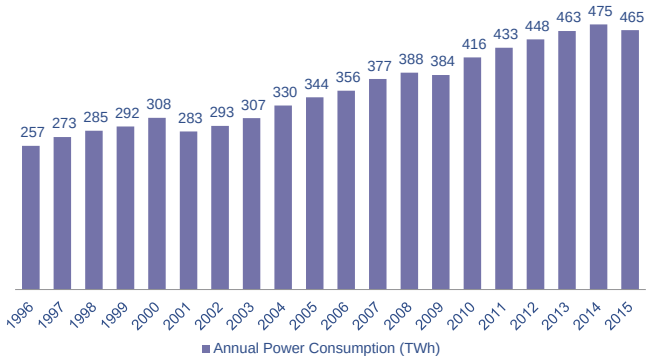
Source: Aneel, EPE, Citi Research estimates

Figure 195. Installed Capacity Matrix Expansion -2015 (L), 2024 (R)



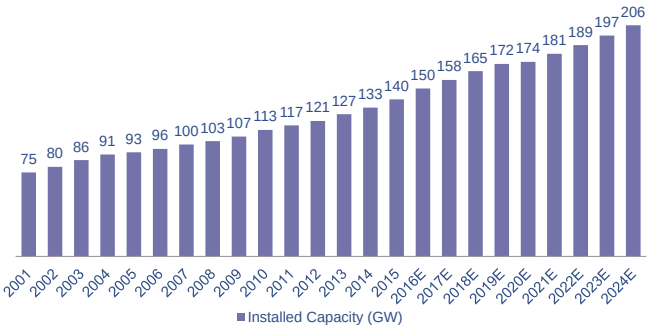
Source: EPE, Citi Research

Figure 196. Brazil Power Consumption (Twh)



Source: Aneel, ONS, Citi Research

Figure 197. Brazil Installed Capacity (GW)



Source: Aneel, ONS, Citi Research estimates

Brazil has a unique generation fleet. Hydropower plants account for 66% of the country's installed capacity. The current 2015-2024 national plan focuses on renewables (hydro/wind/biomass/solar), as seen in Figure 195. The generation sector in Brazil currently comprises 4,597 power plants. The current installed capacity is about 148 GW, mostly coming from hydro power plants (66% of total), followed by thermoelectric (27%), wind (6%), and other sources (1%).

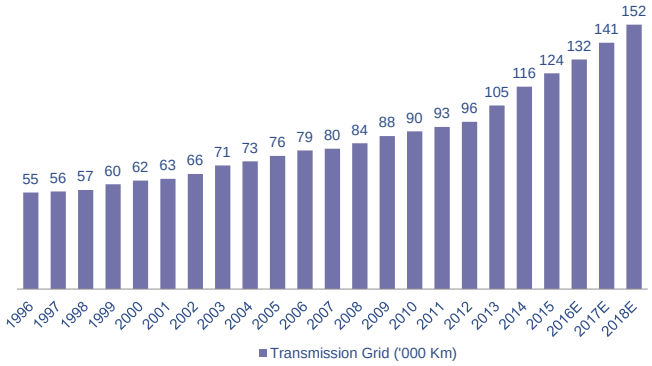
Brazil has a large untapped hydro potential (19.9GW planned through 2018-2022, or 15% of existing capacity; Brazil explores 30% of its total potential). Most of the unexplored hydro potential is based in the North (i.e. the Amazon region), which sparks concerns over environmental feasibility and over the large capex spending on transmission lines to connect plants to main consumption centers, especially the Southeast region. Due to environmental constraints, Brazil has been building only run-of-river plants since the early 2000s and storage capacity has remained almost flattish since then. Following the drought faced in 2013-2014, we expect discussions over the construction of new reservoir plants in the system's expansion to gain further momentum.

The Ministry of Mines and Energy (MME) and the Energy Research Bureau (EPE) are responsible for the sector's long-term planning. The regulator Aneel holds public auctions to contract new generation capacity and grant build-operate-transfer (BOT-like concession rights for winning bidders. Renewables (wind, biomass, solar) are expected to grow to 27% of the country's generation capacity by 2024, up from 18% in 2015. The EPE estimates an increase of ~74 GW of installed capacity (approximately 47% from renewables, 35% hydro, 13% thermo and 5% other sources) in the next decade (implying +4.7% 10-year CAGR), which implies capex spending of R$268 billion ($84bn).

The capex of projects under construction is robust. The recently launched PIEE ("Program for Investment in Electric Energy") estimates total spending should reach R$134 billion (~50% of total estimated till 2024) in power generation through 2018, of which R$92 billion is already committed.

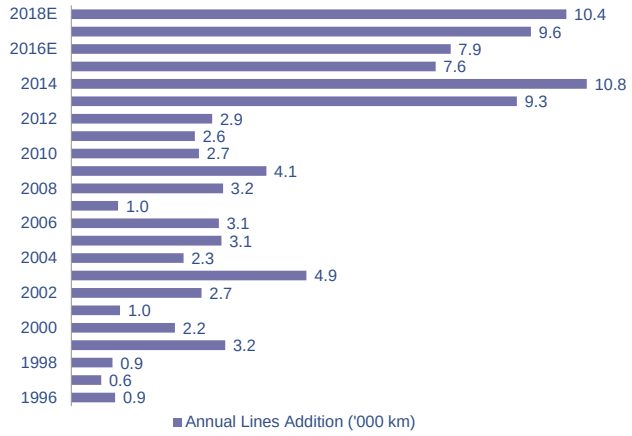
Brazil – Networks

Figure 198. Brazil Transmission Grid ('000 km)



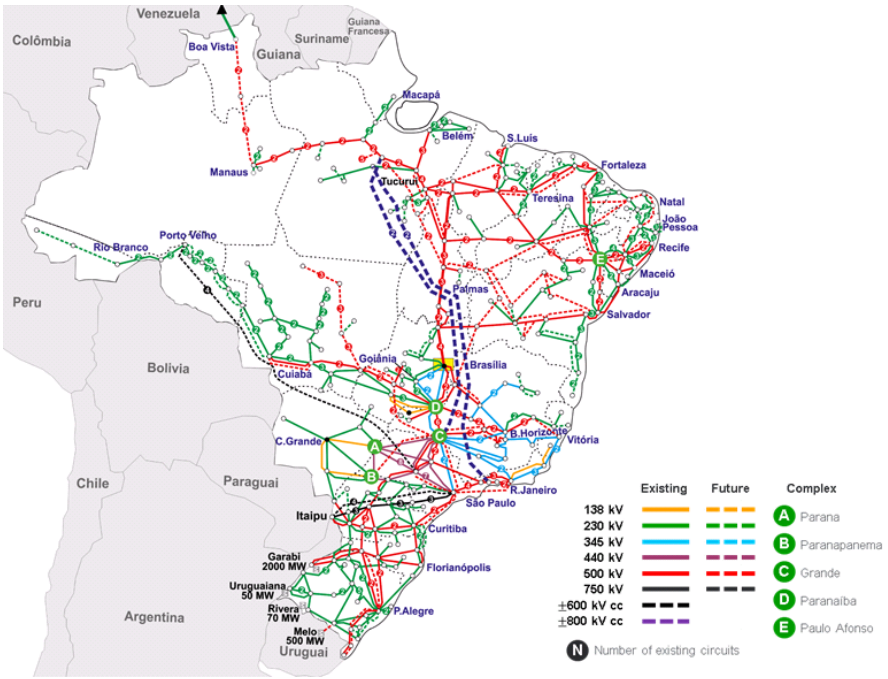
Source: ONS, Citi Research

Figure 199. Brazil Annual Transmission Line Growth ('000 km)



Source: ONS, Citi Research

Figure 200. Brazil Main Transmission Lines



Source: ONS, Citi Research

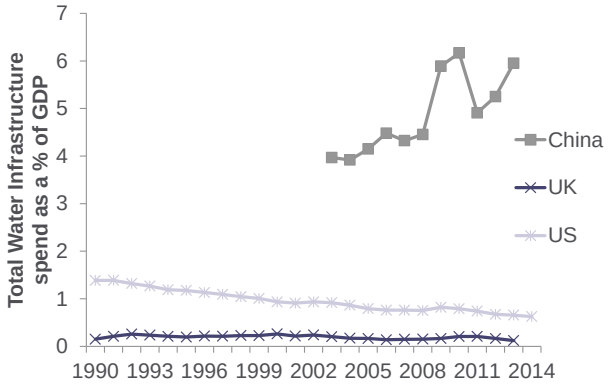
Operation of the Brazilian transmission network is centralized and commanded exclusively by the central dispatcher, the ONS (National System Operator), which has service contracts with transmission companies. Brazil is divided into four electricity submarkets/regions (South, Southeast/Central-West, Northeast, and North). The Brazilian transmission system comprises 104 companies with assets above 230 kV and operating a 123,655 km network. Revenue-wise, the system is predominantly controlled by private-owned companies. The government awarded 66,835 km of lines since the beginning of the privatization process in 1999.

The EPE (Energy Research Bureau) estimates total investments of R$69.4 billion in 2015-2024 of which R$49.7 billion in new transmission lines and R$19.7 billion in new substations. The plan aims to expand the national grid to ~212,000 km by 2024 (implying +5.2% 10-year CAGR).

Retail networks serve 97.8% of the population. Grids have been growing at +5% CAGR since 1999, which translates into annual capex of around R$7 billion per year. The growing role of renewables and distributed energy in the system has ignited the debate on the need for grid upgrades. However, very few initiatives have been developed by local distribution companies. The main issue is the economics of on-site generation, the impacts on regulated tariffs and affordability of the grid upgrades.

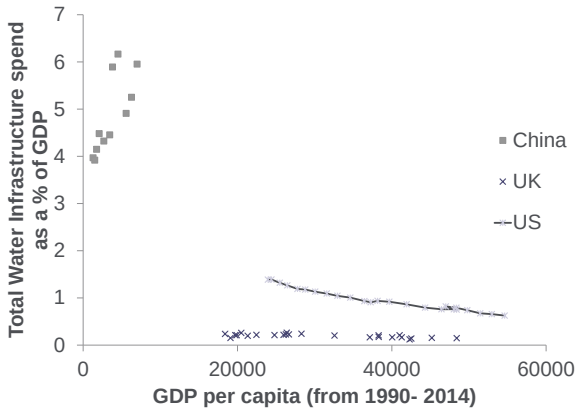
Water Infrastructure

Figure 201. Total Water Infrastructure Investment as a % of GDP



Source: OECD, China Statistics, Congressional Budget Office, Citi Research
* The data for the US only represents public investment

Figure 202. Total Water Infrastructure Investment Against GDP Per Capita



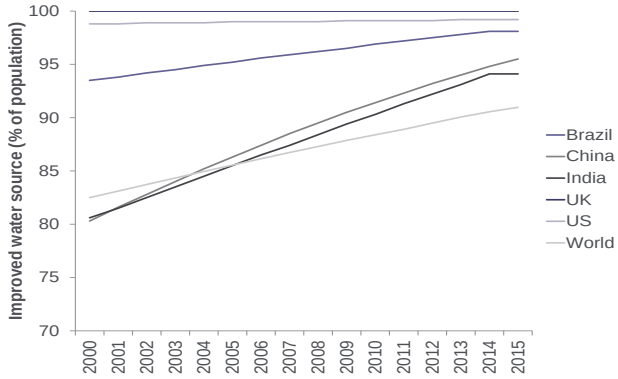
Source: Citi Research

Figure 203. Internal Water Resources Per Capita (m^3 per capita)

	2002	2007	2012	2014
Brazil	31,268	29,364	27,969	27,470
United States	9,797	9,355	8,971	8,838
World	7,001	6,575	6,069	5,925
United Kingdom	2,442	2,365	2,276	2,246
China	2,197	2,134	2,083	2,062
India	1,326	1,226	1,144	1,116

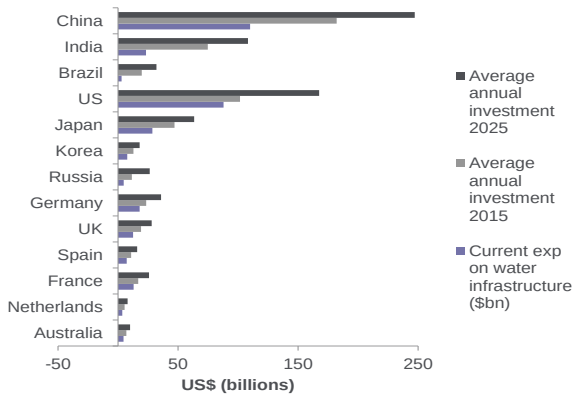
Note: Internal water resources per capita refers to the amount of internal renewable groundwater and surface water available for use.
Source: World Bank, Citi Research

Figure 204. Improved Water Source (% of Population)



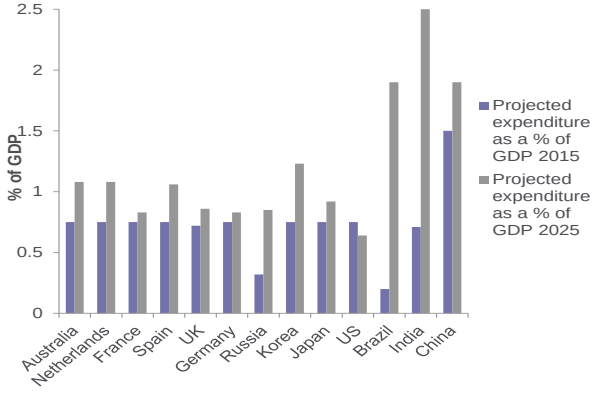
Source: World Bank, Citi Research

Figure 205. Current Annual Expenditure and Future Expenditure Needs for Water Infrastructure



Source: OECD, Citi Research

Figure 206. Projected Expenditure as a % of GDP on Water Infrastructure



Source: OECD, Citi Research

Water infrastructure covers any asset that supplies, treats, or distributes water or wastewater, such as piping networks/sewers, reservoirs, desalination plants, and wastewater treatment plants. Water is a basic requirement for life, and its well-maintained infrastructure is a necessary condition for economic growth. However, many developed markets such as the US need to invest in maintaining and rehabilitating their aging water infrastructure, whilst many developing countries desperately need to build new infrastructure to ensure access to clean water and sanitation. The OECD estimates OECD/BRIC countries need to invest $0.8 trillion annually up to 2020, increasing $1 trillion per year from 2020 to 2030,[41] vs. current expenditure of $0.6 trillion.[42] Going forward the level of expenditure on water services for high income countries should be of the order of 0.75% of GDP (range 0.35% to 1.2%), vs. 2.5% for some BRIC countries and 6% some low-income countries.[43]

The water industry is fragmented, though the last decade has seen a flurry of privatizations and consolidation, mainly in OECD countries, but with EMs such as China now taking up the privatization baton, where about 32% of the municipal water market is served by the private sector compared to only 4.4% in 1998.

Disruptive Innovations in Water

Investing in green infrastructure can reduce costs whilst mitigating floods, improving air and water quality etc.

Water scarcity issues are hardly new; one only has to watch the news to hear about another drought or flood somewhere around the world, with cities in both developing countries (e.g. Delhi and Karachi) and developed countries (London and Los Angeles) facing acute water problems. While historically our solutions have tended to be 'grey' infrastructure (flood defenses, water transfer systems, desalination plants etc.), 'green infrastructure' offers an alternative, being a network of green spaces, street trees, and green roofs that are planned, designed and managed to deliver a number of benefits including mitigating floods, improving air and water quality, cooling the urban environment, enhancing biodiversity, and others[44].

The Philadelphia Water Department saved $4 billion in investing in green infrastructure vs grey infrastructure

The Philadelphia Water Department's 'Green City, Clean Waters' programme will only cost $2 billion over 25 years, vs. a grey infrastructure alternative estimated at >$6 billion. Since 2011, 102.4 acres of new pervious surfaces have been built, and by 2015 a total of 450 acres of new green pervious systems were being planned.[45] Other benefits besides cost savings include an increase in property values by $390 million over 45 years, the creation of over 250 local green jobs and an avoidance of 1.5 billion pounds of annual carbon emissions.[46] New York's PlaNYC aims to use green infrastructure to reduce combined sewage outflow (CSO) from 30 to 17.9 billion gallons per year, and to capture rainfall from 10% of impervious surfaces in CSO areas, costing $1.5 billion less than the 'grey' alternative. They estimate that "every fully vegetated acre of green infrastructure would provide total annual benefits of $8,522 in reduced energy demand, $166 in reduced CO_2 emissions, $1,044 in improved air quality, and $4,725 in increased property value". Elsewhere, precision agriculture offers potential, as do sensors e.g. to allow cities to wirelessly monitor water pipe systems and identify their greatest water loss risks.

[41] OECD, 2006, Infrastructure to 2030, Telecom, Land Transport, Water and Electricity
[42] RobecoSAM Study, Water : the market of the future
[43] OECD (2011), Benefits of investing in water and sanitation: An OECD perspective, OECD publishing
[44] Natural Capital, Investing in a Green Infrastructure for a Future of London, Green Infrastructure Task Force Report.
[45] Christopher Economides (2014), Green Infrastructure: Sustainable solutions in 11 cities across the United States, Columbia University Water Center
[46] Jared Green (2013), The New Philadelphia Story is about Green Infrastructure

Water Infrastructure in the US

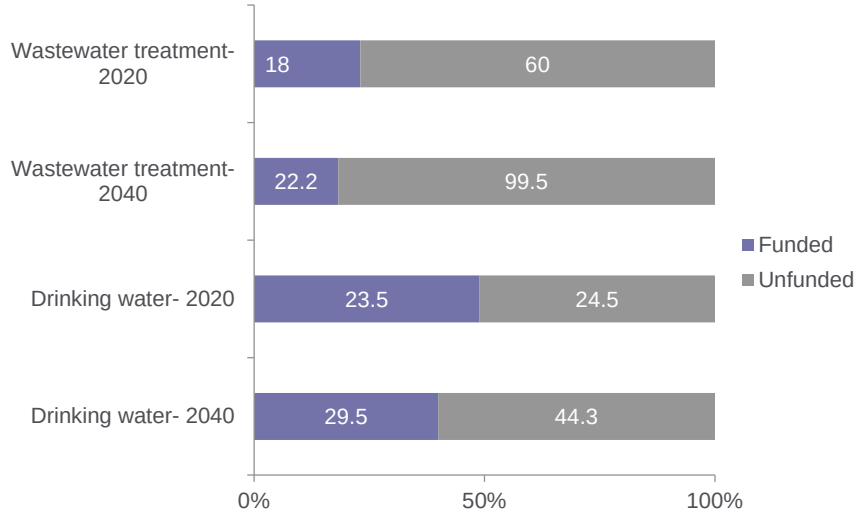
In the US, water infrastructure is aging- a score of D has been given to drinking water and wastewater infrastructure

Water infrastructure in the US is aging and the current investment is not keeping up with the need. The American Society of Civil Engineers (ASCE) has given a score of D to both drinking water and wastewater infrastructure. Much of the drinking water infrastructure is nearing the end of its useful life - an estimated 240,000 water mains break every year. The Environmental Protection Agency estimates that approximately 4,000 to 5,000 miles of drinking water mains are replaced annually, this is expected to peak in 2035 at 16,000 to 20,000 miles of ageing pipes that would need to be replaced annually.

$126 billion of investment is needed by 2020 to upgrade and improve the water infrastructure in the US

Delivery of water and wastewater services in the US is decentralized and strained. The US has about 156,000 public water systems that each serve at least 25 people per day. Of these more than 52,000 are community systems that serve the primary residences of 286 million people – 8% of these community systems provide water to 82% of US population. Maintenance investment for US water mains and sewer system are far too low. Leaking pipes mean that a large amount of water is lost and wasted. The US Geological Survey (USGS) estimate that as much as 23 million m3 of water per day is lost. The ASCE estimate that if current trends continue, the investment required to upgrade and improve the water infrastructure will amount to $126 billion by 2020, and the anticipated capital funding gap will be $84 billion in the same period. By 2040, the needs for capital investment will increase to $195 billion and the funding gap would have escalated to $144 billion, unless strategies and financing solutions that could address the gap are implemented in previous years. In the US only 16% of the water systems are investor-owned — the majority is owned by the local municipality or government. The authors state that if nothing is done to reduce this investment gap then water leakage would increase, the construction of facilities needed to meet environmental standards would be delayed, and waters would become polluted.

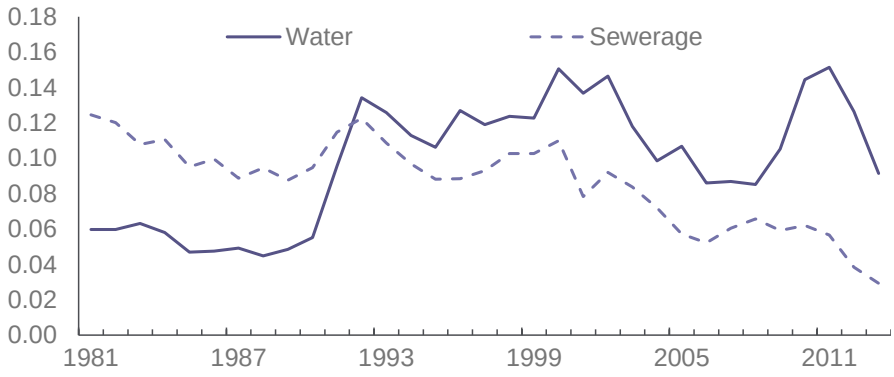
Figure 207. Water Infrastructure Investment in the US up to 2020 & 2040 (US$ billions)



Source: Citi Research

Water Infrastructure in the UK

Figure 208. Investment in Water Sector Increased After Privatization



Source: OECD, Citi Research

Investment in the water sector increased since privatisation of water, however over the last few years it has started to decrease

In the UK the majority of the investment in water is done by private companies; however flooding is the responsibility of the Environmental Agency. In the UK privatization started in 1989 which resulted in ten large investor-owned water utilities representing more than 85% of the countries' total systems.[47] Investment increased since privatization as shown in the Figure 208, however over the years investment has started to decrease especially with regards to sewage treatment facilities. The UK, similar to the US, has aging water infrastructure. For example the London Authority estimates that expenditures to repairs and extend the century old water infrastructure in London will total some £94 billion between 2016-2050 (£33 billion for operating, and £49 billion capex, £11.8 billion green infrastructure for flooding).

Major planned infrastructure projects in the UK

The UK is planning to undertake a number of water and wastewater projects for a total of £23.4 billion

UK infrastructure plans have a number of water and wastewater projects planned for between 2016 and 2021, costing a total of £23.4 billion — the majority of this would be done by the private sector. A major project that is happening in London is the Thames Tideway Tunnel which represents planned enhanced capital expenditure of an estimated £4.2 billion in total. This project is required to ensure that the UK complies with the EU Urban Wastewater Treatment Directive in relation to the discharge of untreated sewage in the Thames. Preliminary construction works start this year and the works are estimated to be completed by 2023.[48]

Figure 209. Planned Water Infrastructure Projects in the UK

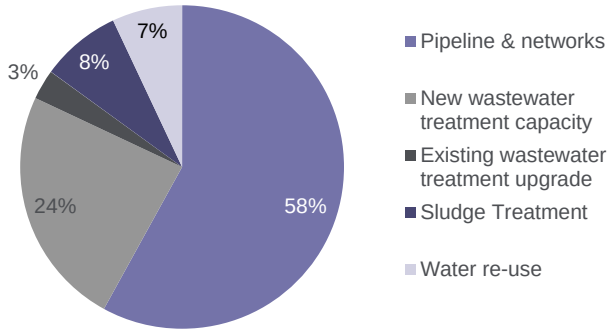
£ billion	Total	2016/17	2017/18	2018/19	2019/20	2020/21
Flood	4.1	0.5	0.6	0.6	0.5	0.5
Water & Sewerage companies	15.4	4.2	4.1	3.8	3.3	0.0
Water only companies	1.2	0.4	0.3	0.3	0.3	0.0
Water & sewage projects	2.7	0.5	0.5	0.6	0.5	0.5
Grand Total	23.4	5.6	5.5	5.2	4.5	1.0

Source: HM Treasury,[49] Citi Research

[47] RobecoSAM Study, Water : the market of the future.
[48] Greater London Authority (GLA), The cost of London's long-term infrastructure, Final Report, 29 July 2014.
[49] HM Treasury, Infrastructure Projects Authority, National Infrastructure Delivery Plan, 23 March 2016.

Water Infrastructure in China

Figure 210. China's Investment Budget for Municipal Wastewater Treatment in the 12th Five Year Plan (Total RMB 427 billion)



Source: RobecoSAM (2015),[50] Citi Research

Although China is home to 20% of the world's population, it only has 7% of the world's freshwater resources. China has low per capita availability compared to the global average estimate – its internal water resources stood at 2,062 m3 per capita. There is disparity between the availability of water in different regions in China — for example south China has plenty of water, whilst the north (including the city of Beijing) has a limited amount of supply for different users.

The government has recognized that there is a need to invest in water infrastructure

China's rapid economic progress and urbanization have put extreme pressure on its natural resources and the environment. It has over the years increased the percentage of population using an improved drinking water source from 80% in 2000 to 95% in 2014 as shown in figure above, though investment is needed to ensure access to safe and clean water in all regions, a need which the government has recognized. In 2011 China set aside RMB 4 trillion for water infrastructure to ensure that water supply can meet the rising demand by 2020. In May 2014, the State Council accelerated the construction of 172 water projects which included water transfer systems (moving water from the south of China to the north), reservoirs and irrigations systems which are all expected to be concluded by 2020 .

Under its 12th Five Year Plan the total investment for municipal wastewater infrastructure was estimated at RMB 427 billion

China also needs to improve its wastewater treatment facilities. Under its 12th 5-Year Plan the total budget for municipal wastewater treatment was expected to reach RMB 427 billion (see Figure 210). However significant investment is needed to ensure that that wastewater is treated, especially in the 300 cities in China which currently does not have such facilities (as of 2015). Supplying clean water and building wastewater treatment facilities is expensive — the government is turning to private capital for some of this investment. Currently about 32% of the municipal water market is served by the private sector compared to only 4.4% in 1998. The government also acknowledged China's poor water resources and the over extraction of groundwater in some regions in its 13th five year plan (2016-2020). Premier Li extended the water consumption targets at 670 billion m3 and requires reducing water consumption per unit of GDP by 23% over the next five years. The plan also aims to develop and continue upgrading urban sewage facilities. Wastewater treatment rates are expected to increase to 95% in urban areas and 85% in non-urban areas.

[50] RobecoSam (2015), Water: the market of the future

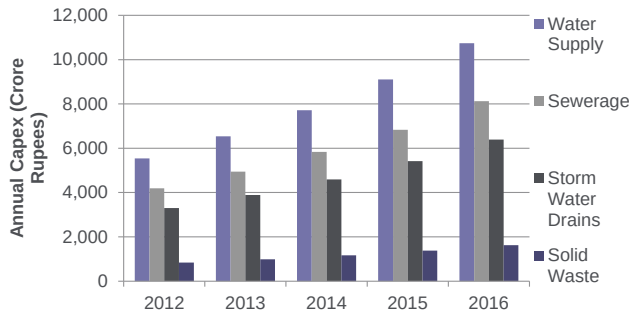
Water Infrastructure in India

Figure 211. Investments in Rural Drinking Water, 1951-2012

Plan Period	Investment Made (Crore Rupees) Center	State
First (1951-56)	-	3
Second (1956-61)	-	30
Third (1961-66	-	48
Fourth (1969-74)	34	208
Fifth (1974-79)	157	348
Sixth (1980-85)	895	1,530
Seventh (1985-90)	1,906	2,471
Eighth (1992-97)	4,140	5,084
Ninth (1997-2002)	8,455	10,773
Tenth (2002-07)	16,254	15,102
Eleventh (2007-12)	39,211	49,000

Source: Planning Commission India, Citi Research

Figure 212. Requirement of Capex on Financing Water in Urban Communities



Source: Planning Commission India, Citi Research

India has one of the lowest per capita internal renewable water resources

India has one of the lowest per capita internal renewable water resources estimated at just under 1,200 m3/per capita. A country is considered to be water stressed if it has less than 1,700 m3 of water available per person. Therefore India is facing a situation of water shortage and with demand expected to increase over the years, this will only get worse. India's growing population is putting a severe strain on the country's water resources. Although access to improved water resources has increased over the years (between 1990 and 2012, 534 million people gained access to an improved drinking water source), there is gross disparity between different areas of the country. 29% of rural people and 23% of urban people still lack access to safe and clean water resources.[51] Ninety percent of total wastewater in India is also discharged without any sort of treatment.

The Indian government has increased investment in water resources over the years, however there is still much more that needs to be done to ensure 100% access to safe and clean water resources throughout the country (Figure 211). In its 12th five year plan it mentions a number of different targets for both rural and urban communities which aim to improve both drinking water and sanitation over time. Figure 212 shows the estimated capex that needs to be spent on water supply, sewage, storm water, and waste management from 2012 to 2016.

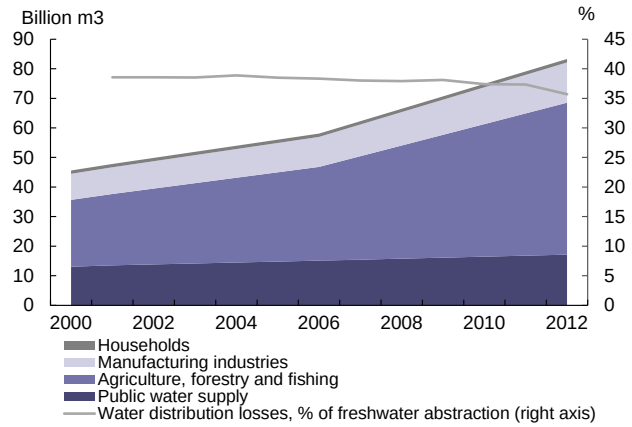
India needs to invest an average of $108 billion per year on water infrastructure

Currently the total Indian water market is estimated to be worth around $12 billion — the government sector contributes to 50% of this, whilst the private sector provides the remaining business. According to the OECD as shown in Figure 205, India needs to invest an average of $108 billion per year up to 2025 on water infrastructure to reach good water quality standards in the country. The government is hoping to encourage private investors to invest in water infrastructure over the years. Bloomberg states that the market for wastewater treatment plans could eventually be worth $17 billion.[52] However there are a number of barriers for private investment which include amongst others bureaucracy and corruption which could be a significant hindrance on the ease of doing business in India, however the new government is trying to clamp down on this issue.

[51] Trade Council India, India Water Industry, sector analysis, August 2015
[52] Bloomberg, Water Woes Signals $17 billion opportunity for India Recycler, May 25th 2015

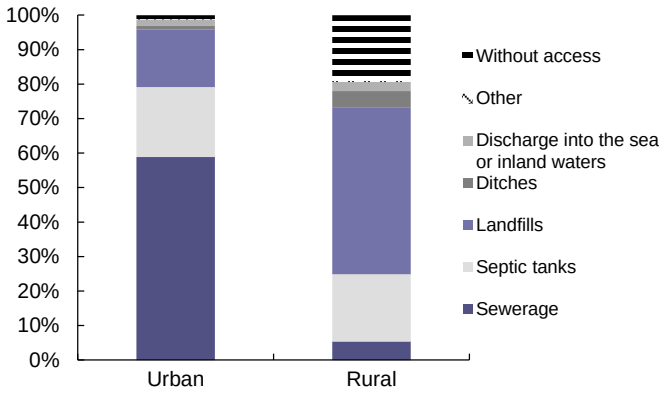
Water in Brazil

Figure 213. Gross Freshwater Abstractions



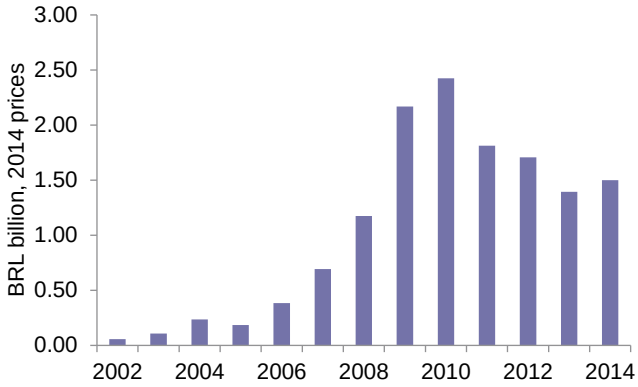
Source: OECD, Citi Research

Figure 214. Access by Sanitation by Type of Services & Area, 2009



Source: OECD, Citi Research

Figure 215. BNDES Investment in Water, Supply & Sanitation Projects



Source: OECD, Citi Research

Freshwater distribution in Brazil is uneven, with the Amazon Basin holding approximately 70% of available water

Brazil has 12% of the world's freshwater resources and some of the largest water basins in the world (e.g., the Amazon Basin). Freshwater distribution is uneven, with the Amazon Basin holding 70% of the available water resources. Annual per capita availability varies from 1,460 m^3 in the semi-arid North-east region to over 630,000 m3 in the Amazon. The city of São Paulo is just recovering from a severe drought from 2013 to 2015 which not only decreased agriculture and factory production but also forced people to ration water resources. Infrastructure investment in water and sanitation facilities is really needed in Brazil, not only to ensure a reliable supply of water in many cities (abstraction of water has increased by more than 70% from 2000-2012) but also for sewage treatment.

The Brazilian National Plan for Investments in Water and Sanitation (PLANSAB) provides guidelines for investments in the sector through 2033. The plan aims to provide full access of water and sewage services to the population. The government estimates total investments of R$304billion for the period of which R$122 billion for sewage infrastructure. Investments are mainly focused ion urban areas (93% of planned spending).

Investment in Brazil is largely public notably from BNDES

Investment in water is largely public — notably from BNDES which has invested in a number of water and sanitation projects over the years. Concessions to private water companies and PPP agreements are used for individual water systems but cover less than a third of urban population. Even though private investment has increased over the years in infrastructure, it has remained rather low in water and sanitation. There are a number of barriers to investing in infrastructure in Brazil — these include amongst others weaknesses in planning, implementation and monitoring and delay in execution of investment that ultimately discourages private investment.

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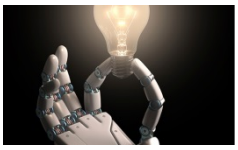

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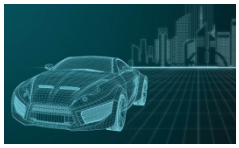

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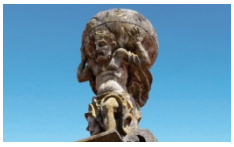

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