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Infrastructure: the climate change dimension

Investment needs globally are colossal, offering opportunities both to boost growth and to decarbonise

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Authors' note

Llewellyn Consulting was engaged by the *Global Commission on the Economy and Climate* chaired by former President of Mexico Felipe Calderón and Lord Stern to act as a *strategic partner* to *The New Climate Economy Project*. Working as part of the project team directed by Jeremy Oppenheim, Llewellyn Consulting was tasked with providing "*… intellectual macroeconomic leadership…"* and with *"…framing the key questions and propositions and integrating this narrative into the wider project."*

Our contribution, in large part, took the form of three top-down, concise, forward-looking 'main issues'-type papers addressing the climate change dimensions of: structural change, infrastructure, and international cooperation.

This second paper in the series, *Infrastructure: the climate change dimension*, shows how raising the rate of economic growth and reducing climate risk will likely involve significant investment, including importantly in infrastructure.

This paper was commissioned by *The New Climate Economy Project* as part of the research conducted for the *Global Commission on the Economy and Climate*. However, neither the Project nor the Commission should be taken as endorsing the paper or the conclusions it reaches. The views expressed are those of the authors.

The content of this paper was submitted to the project on 9 May 2014.

The *Better Growth, Better Climate* report, premiered in New York on 16 September 2014 and thereafter presented in Addis Ababa, Oslo, Beijing, and Johannesburg.

Our principal messages: first, economic growth and low carbon emissions are not trade-offs, but rather can, with appropriate policies, be complementary; second, tackling climate change should be framed within requirements for structural change and reform, both featured prominently.

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Infrastructure: the climate change dimension

Raising the rate of economic growth and reducing climate risk will likely involve a significant investment, including importantly in infrastructure. To sustain growth potential, infrastructure will need to be net low-carbon over the lifetime of the asset.

- Infrastructure is central for economic success; the macroeconomic effects can be large
- Infrastructure projects by their nature are political, but not always a political priority
- Yet positive outcomes generally require government involvement
- There are financial, institutional, and historical constraints to infrastructure investment
- These will need to be overcome given that global infrastructure requirements to 2030 are massive – perhaps exceeding the value of the current stock
- Such large-scale investment requirements offer scope to decarbonise economies and to strengthen climate resilience

The role and characteristics of infrastructure

Infrastructure is important for economic success

A country's infrastructure is central to the functioning of its economy, its development, and to the welfare of its people. Infrastructure, as per its broad definition, includes both physical (tangible) and non-physical (non-tangible) assets, and can be thought of as the economic arteries and veins that enable people, capital, goods, commodities, water, energy, information, and more to move efficiently both within, and into and out of, an economy:

- It includes the economy's networks for: transport; energy generation, and storage; communications; waste management; and water distribution and treatment;
- It extends to: roads, railways, airports, seaports, power lines, pipes and wires; electronic communications, including broadband; flood defences; intellectual capital; and
- Most economists would also include 'social infrastructure': housing; hospitals; schools; universities; the legal system; government research institutions; and more.

It boosts aggregate demand and aggregate supply

Infrastructure facilitates the delivery of goods and services that promote prosperity and contribute to quality of life; and adds to the productive capacity of the economy. Over the coming several decades, infrastructure stands to be of particular importance, for two fundamental reasons:

- Near term, infrastructure investment adds to demand; while
- Longer term it adds to supply.

Infrastructure investment can affect economic growth over and above merely adding to the capital stock by facilitating:

- Trade and the division of labour;
- Competition in markets;
- More efficient allocation of activity across regions;
- The diffusion of technology;
- Better organisational practices; and
- Access to new resources, both physical and human.

A unique asset class

Investments have particular financial characteristics

Infrastructure investments are a unique kind of asset class with particular financial characteristics, which include:

- Long asset duration:
  - 25 or 30 years; perhaps much longer.
- Inflation protection:
  - Revenues are often combined with an inflation adjustment mechanism, either via regulated income clauses, guaranteed yields, or other contractual guarantees.

- Monopoly or quasi-monopoly market position:
  - Assets benefit from a strong competitive position, economies of scale, and often resolve, in full or in part, network externality issues.
- High barriers to entry:
  - Assets tend to be difficult to duplicate due to scale and the costs and resources involved.
  - For example, highways and bridges which are both expensive to build and maintain.
- Demand that is both inelastic and predictable.
- Long term cash flows that are steady and predictable:
  - Which supports significant levels of leverage.

A number of available classes of investment

A number of investment classes are available

A number of investment classes are available. These include:

Bonds

- Most infrastructure projects are highly geared (say 85-90% debt; 10-15% equity). Bonds are normally: investment grade; inflation-linked (and to project revenue); secured on physical assets or contracts; issued by states, municipalities, utilities, other corporates, SPVs.
- Bonds are often issued once a project is complete, by which stage risks have usually reduced.

Equity

- Investors can buy shares in listed companies: utilities, energy, and transport. Large investor funds with in-house expertise are able to finance individual projects.

Geared pooled direct investor funds

- Many are based on the private equity model. Before the 2008 crisis, many were highly geared and promised exits after seven years, despite there being no real economic rationale for the time-frame.

Non-geared direct investor funds

- The Borealis direct investment model is one example:
  - Investment arm of large Canadian pension plan (OMERS) with significant capital.
  - Long term, 'buy and hold' strategy; direct control over assets; avoids agency issues with fund managers.

Macroeconomic and political considerations

Macroeconomic effects can be large

The effect that infrastructure spending has on output depends on myriad factors, including:

- The precise nature of the spending;
- The project's longevity;
- The stance of monetary policy and the state of the business cycle;
- The health of the financial sector and the extent of credit constraints on the household and business sectors; and
- Externalities and spillover effects.

Empirical evidence suggests that effects differ both across countries and sectors, and vary over time, with episodes of under- and over-provision and efficient and inefficient use. As might be expected, infrastructure apparently exerts a greater long-term impact on growth at lower levels of capital stock.[1]

The value of the infrastructure multiplier

Multipliers depend on specific circumstances

The value of the infrastructure multiplier – the increase in GDP following a (1%) increase in infrastructure spending – will depend on the quality, nature, and timing of the investment, and in particular on the potential for long-term impacts on productive potential and productivity.

It is likely that multipliers are larger: for public investment than for other fiscal policy measures; when the stance of monetary policy is easy; the private sector is unable or unwilling to borrow; unemployment is high; and the economy is working below full capacity.

A survey of a broad range of pre-crisis literature on infrastructure suggests a multiplier range of between 0.5 and 1.5. More recent, post-crisis estimates have put the value as high as 2.0 or more.[2]

Political priorities

Infrastructure is not always a political priority

Infrastructure investment is not always a political priority. Politicians faced with a choice of either spending on often-disruptive infrastructure – e.g. upgrading water mains, repairing power grids, replacing transport links – or implementing tax cuts or increasing spending in health or education, will often opt for the shorter-term 'more-populist' type measures.

The fact that the benefits brought about by infrastructure tend to accrue over longer rather than shorter time periods, and that projects can be several years in the (often politically painful) planning process, often runs contrary to political timeframes and objectives. Public opinion can be fickle, and political support can quickly change. Creating new constituencies can be helpful in overcoming such challenges: this may involve sectors, regions, and people most likely to benefit from the change.[3]

The role of government

Positive outcomes often involve government …

Experience in many advanced economies suggests that the largest, most complex projects, such as airports and railways, need a (government) sponsor – even though the bulk of the financing may come ultimately from existing public markets:

- Governments cannot avoid planning, delivering and, to some extent, partially financing projects, at least in their early stages.

… both for large and small projects

For smaller projects too, such as individual hospitals, schools, or renewable energy plants, the government can also play an important role, e.g. through Private Finance Initiatives (PFI). As regards governance, a stable and accessible long-term programme of infrastructure investment will need to be:

- Coordinated across different departments, and levels, of government;
- Devoid of frequent policy reversal and prevarication over key decisions;
- Supported by regulatory stability (particularly in often heavily-regulated energy and utilities); and
- Dovetailed with the ability of construction firms to supply the necessary resources to do the job.

Public debt concerns are manageable

Public debt concerns are manageable. Countries' national accounts could be re-presented to make clear the fundamental distinction between public debt that is backed by saleable assets, and 'general' public debt that is not. By making this distinction, investor concern would be directed more at the composition of the public debt, and less towards the overall grand total. This would make explicit the notion that not all debt is created equal; that not all debt is quite the dead weight on the economy that it is sometimes presented as being. Investors would then be able to make their own, independent, assessment of the market value of the investment undertaken.

A number of advanced countries (including Australia and New Zealand) do now in fact publish the net worth of their government sector.

Constraints on investment

Various broad constraints hinder investment

Infrastructure investment is hindered by a number of factors which can be divided into the broad categories as below. Constraints include:

Investment opportunities

- The limited number and sporadic nature of projects.
- Lack of political commitment to particular projects over the long-term.
- Regulatory instability.
- Fragmentation of the market across different levels of government.
- High bidding costs.
- Other risks: construction, operational, business, gearing, legal, environmental.

Investor capability

- Sizes of pension fund – smaller pension funds face particular issues.
- Lack of sector expertise and dependency on third-party due diligence. Regulatory barriers; investor short-termism.

Conditions for investment

- Negative perception of the value of infrastructure.
- Lack of transparency in the sector or shortage of data.

Institutional factors also constrain investors

Institutional factors can also be particularly constraining. 'The devil is in the detail', and experience differs considerably across countries. Some investors or funds are:

- Mandated not to take on construction risk;
- Reluctant to take on the costs of environmental clean-up after the project is completed;
- Averse to getting involved in illiquid investments, particularly the smaller pension and insurance companies;
- Focused on five- to seven-year return horizons (e.g. private equity ventures), which can rule out being a conduit for financing infrastructure investment;
- Not geared up to handle the governance requirements of such long-term investments;
- Put off by the absence of common project definitions and common performance metrics of risk and return; and
- Deterred by the absence of active mechanisms to pool smaller insurance and pension fund capital.

Boosting investment

Considerations in boosting investment are numerous

Considerations in achieving increased investment are numerous. Those of particular importance will likely include some, perhaps all, of the following:

- **Government debt.** In many advanced economies, with debt levels high, it is likely that any solution must avoid permanently expanding government debt.
- **Long-term financing.** Private long-term financing is potentially available, in significant quantity, particularly from many pension and insurance companies.
- **Mobilisation.** Long-term financing needs to be mobilised: institutional arrangements are often such that the private sector cannot do the job alone.
- **Government's role.** It is important for government to be doing that which only it can do, notably: setting appropriate institutional framework and helping to alleviate construction risk.
- **Low-carbon dimension.** Fostering a low-carbon economy necessitates infrastructure investment beyond traditional green sectors such as renewables:
  - Electric car charging networks and smart grids, for example, require economy-wide planning and infrastructure investment on a national scale.

Three broad-level proposals

Three broad-level but specific proposals for boosting infrastructure investment are listed below. Each differs in terms of its breadth and degree of concentration, but each would help in delivering greater policy coherence, boosting investment, and addressing both the problems of weak aggregate demand and poor infrastructure:

- **'Invest and sell' asset transfers.** The government could borrow directly to finance investment expenditure in projects that stand to produce marketable output. The stated intention would be to sell these assets to the private sector, either partially or wholly, when times are better and the private sector has regained its willingness to invest.
- **Private Finance Initiatives (PFI).** Beyond fixing the banks, more could be done to reanimate PFIs, not least by recalibrating them away from service infrastructure towards investment in energy, broadband, and transportation; and by government taking on more equity risk.
- **National Infrastructure Banks (NIB).** A NIB – with a the requisite broad long-term remit to invest in large-scale infrastructure projects, bolster competitiveness, help foster low-carbon investment, and be an important mechanism to tap pension and insurance funding – would

offer an all-embracing approach to investment in productive assets. It would provide guarantees, issue bonds, and provide a long-term vision for policy, thereby contributing to a continually-full pipeline of investment projects.

A National Infrastructure Bank could help

The NIB could also be part of a broader National Investment Bank with a remit to perform something of a countercyclical macro stabilisation policy role, extending to such areas as SME financing, and perhaps including a rebalancing objective.

From an economy-wide perspective, infrastructure development of long-lived assets ought to be compatible with a low-carbon economy – another long-term challenge. Realising fully a low-carbon economy stands to mean going beyond the 'traditional' green 'renewables' sectors and the corresponding relatively narrow support available from small-scale renewables-focused banks. Infrastructure and large-scale investment would benefit therefore from broad cross-sector rather than narrow aims. To ensure primacy of the low-carbon considerations, the objectives of the 'green economy' would need to be core to the NIB and on a par with other core objectives such as growth and competitiveness.

Financing additional investment need not hit consumption

Moreover, financing additional investment need not impact consumption; the key issue is the responsiveness of supply:

- Countries with large margins of spare capacity (currently mainly the OECD economies) can finance some additional investment without reducing consumption.
- Countries without apparent spare capacity (most of the developing world, until recently at least) may be able to finance additional investment without reducing consumption, to the extent that the additional investment adds to GDP and capacity.

Existing vulnerabilities

Climate-related extremes have shown vulnerabilities

Impacts from recent more frequent climate-related extremes – including heat waves, droughts, floods, and cyclones – have revealed the many pre-existing vulnerabilities that climate variability brings, including exposure of the many 'human systems' e.g.:[4]

- Disruption of food production and water supply;
- Damage to infrastructure and settlements; and
- Morbidity and mortality.

Populations in poorer regions are hit asymmetrically by climate impacts. Hurricane Tomas in 2010, for example, wiped out the equivalent of 43% of St Lucia's GDP;[5] Western Sahel's drought of 2012, and the Philippines' typhoon of 2013 also had devastating impacts. Such disproportionately large impacts, in significant part the due to a lack of preparedness to climate variability, also undermine efforts of these nations to alleviate poverty and foster inclusive growth.

Quality of growth

Infrastructure can facilitate sustainable growth

Infrastructure can both boost long-term growth, and improve the quality of growth, which for these purposes is taken to be:

> *"the extent to which economic growth has a high, or at least improved, likelihood of proving sustainable – in respect of both its environmental effects and its social and political consequences."*

Use of the term is often a reaction to the over-use of measures of output: GDP is the classic case in point, when for example it is used as a measure, or at least an indicator, of welfare. The term is often employed in the context of a diagnosed problem. Thus, for example:

- In an economy in which the share of investment in GDP is worryingly, dangerously, or otherwise inappropriately large, higher quality growth could be taken to mean growth in which consumption plays a proportionately larger role.
- Or, in an economy where a disturbing proportion of output produces cost externalities, growth that produced fewer such external costs could be regarded as higher quality. It is often in this sense that it is used in green growth discussions.

One objection to the term's use is the element of value judgement in the use of the word 'quality'. A value judgement, however, is also made every time that GDP (or any other output

measure) is used for almost any purpose – including in the measuring of GDP itself, which is far from objective.

All regions will likely aim to boost the 'quality of growth'

Notwithstanding, all regions will likely wish to improve their 'quality of growth', and infrastructure most certainly has a role to play:

In slow-growing developed economies (e.g. US, UK, Japan and Euro Area):

- Most currently have quantity growth problems, in large part due to the global financial crisis.
- However, most have a quality problem too, and this will increase unless addressed, given that investment levels have typically fallen post-crisis, not least in infrastructure.

In rapidly-growing developing economies (e.g. China).

- Most do not currently have a quantity problem.
- But they do want to improve the quality of their growth by achieving a sustainable growth configuration.

In moderate or fast-growing frontier economies (e.g. Africa).

- Most need their quantity of growth to develop over the medium-term.
- But even here quality matters, both to maintain (or raise) growth potential, and to provide the necessary infrastructure, networks, and institutions capable of supporting growth.

Investment requirements

Global infrastructure needs are massive

Global infrastructure requirements are massive: McKinsey[6] suggest that, without taking account of any climate-change considerations, around $57 trillion-worth will be needed between 2013 and 2030, purely to keep pace with global GDP growth:

- This estimate includes the needs for transport (roads, rail, ports, and airports), power, water, and telecommunications;
- The estimate is almost 60% higher than the $36 trillion spent globally over the past 18 years; and exceeds the estimated value of today's total global infrastructure.

The $57 trillion, however, would not be sufficient to address the major backlogs and deficiencies in infrastructure maintenance and renewal, or to meet broader development goals. Funding these needs could prove to be a challenge for three reasons:

- First, the post-crisis constraints on public budgets in many economies;
- Second, potentially higher and more volatile resource costs in the future; and
- Third, the additional costs required in making infrastructure resilient to climate change and less harmful to the environment.

Some estimates are even higher. The New Climate Economy puts the base-case figure (again, pre climate change considerations) at around $89 trillion.

Decarbonising economies while strengthening climate resilience

Infrastructure investment offers low-carbon scope

In the context of the coming decades, this large expected infrastructure spending offers great scope to decarbonise significant parts of the economy. Such expenditure has a large potential pay-off:

- The IEA estimates[7] that, for every $1.5 trillion of investment in clean-power technology not undertaken by 2020, $5 trillion of investment would be needed thereafter to get back on track and compensate for the increased emissions.

A significant share of current infrastructure investment is in high-carbon assets. This raises the risk, therefore, that such assets might be stranded as economies decarbonise:

- Coal lock-in is a particular issue: coal plants built between 2000 and 2020 could use up one quarter of the world's 'carbon budget' to 2100 over their 40 to 50 year lifetime;[8]
- Similarly, oil investments between 2015 and 2025 could become stranded were the view to develop that fossil fuels do not have a long-term future:
  - This might lead low-cost producers to pump their oil as quickly as possible, causing the world price to crash, and thereby stranding more expensive oil assets.

Investment can reduce climate vulnerability

Low-carbon infrastructure can also reduce exposure to climate variability. Resilient infrastructure would be beneficial in energy, transport, water, building, and ICT sectors, and this can be achieved by incorporating specific components. For example:

- Microgrids for water and energy infrastructure can buffer local service users from impacts elsewhere; and
- Retrofitting bridges and electricity transmission lines can support decentralised distribution networks.[9]

Infrastructure can realise various co-benefits

The economic co-benefits of such infrastructure investments can also be significant, and many are non-climate related. For example:

- **Fewer outages and increased reliability for utilities and the customer.** The overall economic costs of power shortages typically range between one and four percent of GDP in Africa.[10]
- **Reduced damage costs.** Loss and damage from disasters have been rising over the last three decades, from an annual average of around $50bn in the 1980s to just under $200bn each year in the last decade.[11]
- **Continued provision of basic services to the population.**

The importance of cities

Cities' infrastructure needs offer risks and opportunities

The infrastructure needs of cities also offer both opportunities and risks. An ever-increasing proportion of the world's growing population is going to be living in cities – in around 20 years' time an additional 1.5bn people are expected to be living in urban areas.[12]

Some cities will have a high population density: others a low population density. In many high-population-density cities, public infrastructure costs are generally lower than in equivalent but lower-population density cities. Reasons for this include shorter transport networks and less diffuse utilities infrastructure. However sprawling suburban living has remained popular in many countries and regions. On pure cost grounds, therefore, it is not evident that higher density cities will be preferred.

Not all forms of urban development are equal from an environmental perspective either. There is considerable variation in emissions among cities with similar per capita incomes – a result of their urban form, energy mixes, and industry shares:

- Paris, London, Hong Kong, and Tokyo have around one-quarter of the energy intensity of the most polluting cities.

How cities develop over the coming decades will have a major bearing on global emissions:

- Fast-growing cities are planning and committing to long-lived urban structures, which offer both an opportunity (to decarbonise) and risk (of locking-in high-carbon infrastructure).

Urban infrastructure requirements also offer scope to strengthen climate resilience.

The sectoral level

Energy systems present a particular challenge …

At the sectoral level, energy infrastructure systems in particular are capital- and carbon-intensive. Various high- and low-carbon growth configurations are potentially available, each with its own costs, benefits, and distributional impacts. Policy choices can be made to achieve low-carbon outcomes, and avoid lock-in.

Changes in the energy mix have implications not only for the energy sector, but for the wider operation of the economy. A major challenge, both for the near-term and for the longer-term, is to mobilise private sector savings to finance infrastructure investment:

- Political-economy decisions involving deep institutional change at the nexus of energy and finance will be a key driver of the costs of transition.

By making a major contribution to demand and supply potential, low-carbon infrastructure investment will break the apparent, but false, dichotomy between growth and action on climate change.

… but needs go beyond the power sector

The power sector, given its large size, is likely to be the most important to decarbonise:[13]

- Electricity and heat generation accounts for over two-fifths of global CO_2 emissions.

- Transport and industry sectors are important too, however, each accounting for just over one-fifth of CO_2 emissions.

Any long-term solution will need to encompass all sectors, particularly as the electricity and heat sectors supply, and are therefore integral to, transport, industry, and residential end-use.

Low-carbon investment needs

Low-carbon investment needs are manageable

The IEA estimates[14] the investment requirements in energy supply and demand technologies from 2010 to 2030,[15] across power, buildings, industry, and transport, to be around $42 trillion. This total assumes a world with no carbon abatement – their six-degree scenario (6DS). The number rises to around $55 trillion in the IEA's two-degree abatement scenario (2DS). Hence the estimates imply that to decarbonise energy infrastructure across sectors would cost an additional $13 trillion-odd.

To illustrate, in terms of an annual requirement, investment in low-carbon (or 'clean') technologies would need broadly to double from current levels, to around $500bn per year by 2020, and thereafter to double again to $1 trillion per year by 2030 (to achieve the IEA's 2DS).

This additional low-carbon investment requirement could however be outweighed by the long-term benefits of decarbonisation. To give one example, total fuel savings alone would likely run into tens of trillions of dollars.[16]

More recently, The New Climate Economy has estimated that – largely as a result of reduced fossil fuel supply chains and benefits from compact cities – the low-carbon increment to 2030 could be as low as $4 trillion. This is just 5%-odd above their base-case figure.■

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[1] See Egert, B., Kozluk, T. and Sutherland, D., 2009. *Infrastructure and growth empirical evidence.* OECD Economic Department Working Paper No. 685.
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[10] Duarte et al., 2010.
[11] World Bank, 2013.
[12] UN World Urbanization Prospects: 2011 Revision & UN World Population Prospects: 2012 Revision.
[13] IEA, 2013. CO_2 emissions from fuel combustion.
[14] IEA, 2012. *Energy Technology Perspectives 2012*.
[15] The IEA's *Energy Technology Perspectives 2014* does not include a figure for 2030 and includes only a 2050 estimate.
[16] IEA, 2014. *Energy Technology Perspectives 2014*.

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