Connecting the dots in infrastructure development and management: The Africa agenda for new innovation

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1.0 Introduction

It is widely accepted that the growth and prosperity of nations is dependent on economic infrastructure. Infrastructure is constituted by cyber-physical systems that enable communications (e.g. postal, telephone and internet) as well as transportation (e.g. road, water, air), energy (e.g. electricity and gas) and other utilities (e.g. drinking water and waste) (Chandler, 1977; NAO, 2013). It provides the basis for economic growth and prosperity through the provision of essential services that enable economic and social activity. As a result, it delivers significant benefits, both directly through the services it delivers, and indirectly through the impact of those services on the rest of the economy (Nightingale et al 2016). However, these benefits come at a cost. Infrastructure is expensive to build, operate and maintain. The provision of infrastructure involves degradation and the consumption of natural ecosystems, displacement of local communities, CO2 emissions, noise and pollution. Infrastructure is typically long-lived and the costs of poor choices and mistakes can affect future generations. This is especially prominent with politically motivated infrastructure investment decisions, which have a lifespan that coincides with electoral cycles. To complicate matters further, the costs and benefits of infrastructure provision fall unequally across society in a way that benefits a minority (usually local to the area of infrastructure development) although the distribution of costs are more widely spread (for example in investments funded by taxes) (ibid). In this context, infrastructure investment decisions are not only complex they are inherently political.

The 'infrastructure gap' is a major issue stalling economic growth potential, especially in the developing world. The African Development Bank (AfDB) stated that $170 billion is needed every year in infrastructure investment if the continent is to meet this potential. According to the Office of the Special Advisor on Africa at the United Nations, roughly 60 percent of the continent's population have no access to modern infrastructure. In sub-Saharan Africa electricity-generating capacity per capita has barely changed in the last 20 years with only 35% of the population having access. A 2015 report from the World Health Organisation claims that over 300 million people lack access to reliable drinking sources, while around 700

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million have no access to sanitation. Similar issues are seen in the provision of electricity (over 600 million have no access to electricity) and transport (only about a third of people have access to roads). This highlights an important question about how far the shortfall can be financed locally by the African governments. This leaves two main options; 1. Either obtain loans from large successful foreign countries (such as China) or 2. Attract investment from the private sector. At the heart of either option, however, is always the consideration of the funding capacity of a project (or a country) that will support any initial form of financing[6]. In the case of African countries, the origin, reliability and predictability of this funding capacity is not always clear which adds an additional degree of difficulty for infrastructure provision in the continent.

China plays a major role in African infrastructure projects with an estimated investment of approximately $100 bn this century. However, loans frequently come with requirements to use Chinese labour and equipment, which can frustrate the transfer of skills or capabilities for the host nations. There is also a significant concern about the ability of some African countries to repay Chinese loans. The lack of indigenous capabilities in design, implementation and operation of infrastructure systems is another major issue that manifests in a long history of failed, abandoned and underachieving projects. This raises some important questions about the development and retention of local capabilities in a way that would enable African economies to reuse these capabilities Perhaps there are examples around the world which can reveal ways for Africa to improve its infrastructure delivery performance. Developed countries also have problems in delivering and operating infrastructure successfully and there are numerous examples of projects that overrun on cost and schedule and don't deliver the benefits that were promised. This paper will address this point by examining how innovative practices from other economies might contribute to closing the African 'infrastructure gap'. The paper will draw mainly on experiences in the UK where there have been some major improvements in the delivery of infrastructure projects over recent years. We suggest that there are three fundamental building blocks that will help close the African infrastructure gap: (1) innovation in the provision of infrastructure services, (2) more effective project and programme delivery forms and (3) Public Private Partnerships (PPPs) that allow the sharing of risks and rewards between public and private parties. We begin with a short discussion about the nature of innovation in general and then explore what this means in the context of complex infrastructure systems.

[6] Increasingly the infrastructure financing community differentiates between the concepts of "financing" and "funding". "Financing" refers to the short-term initial capital that is used for the delivery of infrastructure assets (i.e. different combinations of equity and/or debt from various capital sources). "Funding" refers to who actually pays for infrastructure and its related services in the long-term (i.e. tax payers and/or users and/or natural resources) (Roumboutsos et al, 2018).

2.0 What is Innovation?

The concepts of invention and innovation are often confused. The word innovation comes from the Latin word 'innovare' which means to make something new. It involves the creation of something. However, it is not the idea itself that is the innovation, but the process of turning that idea into new products, processes and services. What is more, literature also often discusses the commercial gains that need to occur for the subject firm in order for an innovation to be considered successful. Innovation literature highlights that when we think of innovation what we are actually conceptualising is change. This is an important point. Innovation involves doing something better rather than doing it differently. There are two main forms of innovation. Firstly, *incremental innovation* that involves small changes usually based on existing knowledge and capabilities e.g. improved versions of existing products, services or processes. Secondly there is *radical innovation,* where large changes occur that require new knowledge and capabilities. Radical innovation may also render existing capabilities redundant and this is why it is referred to as disruptive innovation. Besides the different forms of innovation, there are also different types of innovation: 1. *Product innovations*: the development of new or improved products – e.g. iPhone(s); 2. *Service innovations:* the development of new or improved services – e.g. Hot-mail; 3. *Process innovations:* the development of new or improved processes or ways of doing things in production or operations; and, more recently; 4. *Business model innovations:* the development of a new way of creating and capturing value in an economic system. It is important to distinguish between these forms and types of innovation because infrastructure systems are complex and will be subject to all of them. In the next section we unpack this complexity in the provision of infrastructure assets and services in more depth.

3.0 What is infrastructure?

Although the term is used casually, the roots of the term *infrastructure* can be traced back to the 1840s in France. In this context it referred to physical tracks, beds and cuttings to support a new railway. Infrastructure remained a specialised technical term until the post-World War 2 period when it was used in NATO to refer to fixed facilities such as air bases and technical systems that supported the economy and military. By the 1960s it was adopted by development economists to explain underlying differences in the growth rates of developing countries. Later it was extended to explain the technological basis for differences in regional growth and economic performance. The term economic infrastructure has evolved and is generally used to refer to transport (roads, railways, air and sea transport); energy networks (gas and electricity); water and wastewater; solid waste management; and telecommunications systems. Since 2000 there has been a growth in terms such as 'social infrastructure', followed by 'critical infrastructure' and 'green infrastructure'. Social Infrastructure captures housing, education, health, justice (including contract enforcement),

security, culture and leisure, research, science and public broadcasting (which tend not to be based on networked utilities).

3.1 Projects, risks and performance

Virtually all infrastructure as a policy intervention will be delivered through programmes or projects as organisational vehicles that have defined timescales, budget and scope. A key issue for policy (government) and industry (the actors in the value network) is how to control infrastructure cost to ensure acceptable levels of value for money and effective outcomes (the right things are built). Moreover, investment decisions need to avoid technological-lock where long- lived choices, that may seem appropriate now, become inappropriate for society in the future as normative expectations and technologies change.

All projects are time bounded and involve coordinated activities that move from an initial plan or idea to implementation. Gradually a completed artefact or system or set of activities are constructed through the delivery lifecycle (Nightingale and Brady, 2011). Projects are inherently forward looking but also uncertain. At the start of a project the end result may be known, however, the plan and pathway to implementation may change. Concurrent engineering and more agile design approaches may be necessary. However, these emergent approaches to project delivery have implications for the design of lower-level components and systems. Process changes can lead to cost and schedule overruns. In general, the more complex a project is, the more likely it is to go wrong and this creates a complex and unstable control environment which can manifest in ongoing modifications and potential redesign chain reactions (Nightingale, 2004).

The successful provision of infrastructure can be threatened by several different types of risk; political risks, investment risks, industry-level capacity risks and project-level risks to name a few. Infrastructure decisions involve political choices based on a set of assumptions and priorities. **Political risks** can be mitigated by engaging stakeholders to collect a variety of views and interpretations that explore alternative policy mixes rather than adopting a single definitive plan (Stirling, 2010). Once projects are completed investors may bear an **investment risk** because the planned return based on the appraisal costs of capital will not be recovered. In the UK a variety of public finance initiatives have attempted to mitigate investment risks. The scale of major infrastructure projects means that they intensively consume workforce capacity. This creates an industry-level **capacity risk** linked to shortfalls in capability and the right kind of talent. The provision of the right type of capabilities can be planned once a pipeline of work becomes visible. As a major infrastructure client, Governments can play an important role in mitigating this risk by publishing a coherent plan to enable firms to invest in a steady stream of capabilities.

The project management literature on **project-level risk** describes the importance of early-stage planning processes to mitigate downstream delivery risks. Extensive stakeholder engagement is recommended to avoid choosing projects that are unlikely to deliver the required social and economic benefits. Rigorous project appraisal processes, such as

reference class forecasts, can be used to benchmark the risk profile characteristics of similar projects. Once a project is commissioned, early engagement with suppliers can aid the development of more realistic plans. Audit-based "checks and balances" are also recommended to mitigate intentional forms of "strategic misrepresentation" (Flyvbjerg, 1996; 2012) or attempts to create wasteful buffers and misleading plans (Clegg et al, 2012). Mitigating the relational risks associated with poor cooperation between the client (sometimes the government) and supplier network may require incentives and control practices to assign and align accountability for risks to delivery objectives.

3.2 Essential characteristics of infrastructure systems

Infrastructure systems provide and deliver a continuous flow of **essential services.** Demand can be inelastic (it is hard to identify proxies for it) and a lack of provision can become a political problem because infrastructure services are increasingly seen as a responsibility of the State and a precondition for living and working in any economy. To be excluded from essential services is in many ways to be excluded from political, economic and social life. The provision of essential services has a social and technological basis as they are provided through **large technical systems** (Mayntz and Hughes, 1988; Hughes, 1987) – where social priorities and technical provision of infrastructure are closely bundled into an intertwined socio-technical network. These large technical systems are there to deliver essential services to their users; however, they are far from perfect and are subject to multiple **market and governance failures.** For example, the political risks associated with market failure of infrastructure provision can result in interventionist and **heavily regulated** markets. This is partly due to the inherent complexity and uncertainty of the markets these systems operate in and the difficulty in regulating and predicting change that infrastructure services will both cause and be subject to during their delivery. The scale and scope of these large technical systems creates major benefits and disbenefits. The requirement for large-scale investment, the high barriers to entry, as well as the inelastic nature of demand for most of these services means that infrastructure systems were historically developed and operated as natural or induced monopolies.

In policy and economic terms, the necessity of infrastructure systems is often attributed to the value that the delivery of infrastructure will generate for its stakeholders. This value can have various forms, such as economic and social value, configured into a network of activities. These activities can be conceptualised as a value network where the architecture of the network has a major influence on how the various components work together to deliver infrastructure services. The coordination and integration of the components often involves an orchestration of efforts between private and public organisations to create value that is delivered to users either free of charge (for example the public road network) or in exchange for a user fee (such as toll roads).

The key generic tasks in infrastructure provision form a network of value-creating activities as shown in Figure 1.

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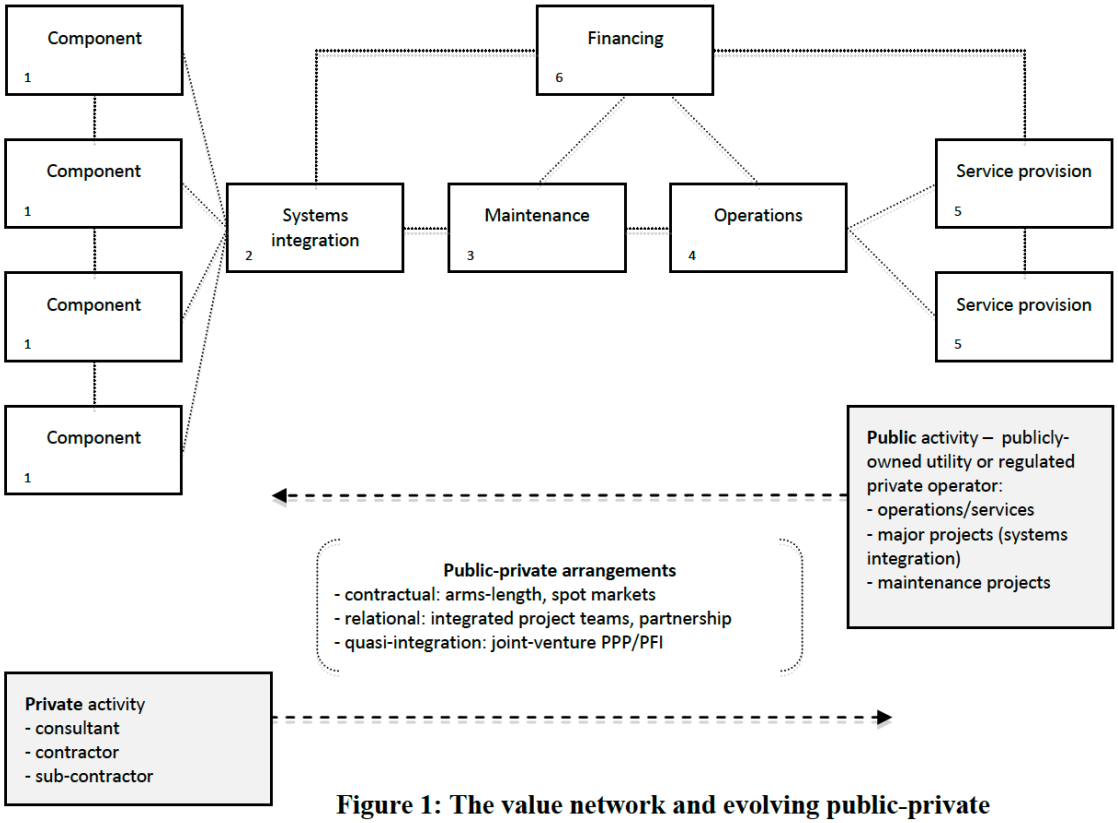

Figure 1: The value network and evolving public-private interface in infrastructure provision

Source: Reduction in the Cost of Execution of Current Business Models; Nightingale, P., Brady, T., Davies, A., (2016) in ICIF Working papers UCL

Figure 1 presents the accumulation of value through the progressive performance of a number of activities (numbered in boxes) that create valuable services for infrastructure end users. These users include individual citizens, business and government customers, among others. More specifically, moving from the left to right Figure 1 shows the following:

(1) The supply of components includes physical products (parts, materials, and sub-systems) and services provided by a variety of organisations (e.g. build-asset consultancies) involved in the engineering, design and construction of new build systems, such as facilities, buildings, IT and physical infrastructure.

(2) Systems integration refers to the high-level task of integrating the goals, plans and priorities of multiple organizations into a coherent network. This involves complex control and coordination of knowledge experts to sustain progress and avoid value destroying disagreements.

(3) Maintenance refers to the services involved in maintaining, preserving and extending the potential life of fixed assets.

(4) Operation refers to the range of services required to operate a system throughout its life cycle, such as monitoring, controlling and optimising the performance of buildings and infrastructure.

(5) Service provision refers to the delivery of a range of services to meet end user requirements, such as improvements in reliability, safety and performance and added value services (e.g. online "pay as you go" underground train services) and other enhancements that improve the user experience.

(6) The financing element relates to all different activities in the value network, from systems integration to service provision (activities 2-5), whether public, private or mixed. These refer to designing, constructing, maintaining and operating infrastructure in order to deliver the intended services to its users/stakeholders.

Summarising, we conclude that infrastructure creates value for various stakeholders in the provision, operations and use domains. This value is realised through interactions between the different parties. Innovation can take place in all parts of the value network. It can also take a variety of forms. We may observe product and service innovation at a component level – this can be either incremental (e.g. improved or updated products, technologies or services) or radical (brand new products – e.g. photovoltaics - or services). We may see process improvements in operational activities such as maintenance and management of the asset base within the system. Innovation can also be linked to new models of financing and/or funding. Fundamentally it can involve changes in the underpinning business model which determines how value is created, captured and distributed across the network. In the next section we consider in more depth business model innovation and the role of risk and a variety of different Public Private Partnership delivery models.

4.0 Business and delivery model innovation

A business model refers to how a firm, endowed with technology, capabilities and assets successfully configures its organisational structure (Teece, 2010) and orchestrates its relationships with external stakeholders (Amit & Zott, 2012). It describes the elements of a business – such as a firm's capabilities, resources and position. It describes a value network as well as a strategy to create value for the firm *and* its customers (Magretta, 2002). It reflects *a hypothesis* about what a customer wants and how to best meet these needs whilst capturing value (Teece, 2010). It is widely accepted that the distribution of risk can influence the successful provision and delivery of infrastructure. A variety of business models have been observed that attempt to place and distribute the responsibility for risk.

These are demonstrated in Figure 2, which describes the configuration of risk within different business models.

	Mode 1: Risk Transfer	Mode 2: Risk Negotiation	Mode 3: Risk sharing	Mode 4: Risk bearing
Responsibilities in the value network	Prime contractor performs systems integration and manage subcontractors	Contractor set up to perform service-led integrated solutions	Client-consultant partnership to perform systems integration	Client is systems integrator and works with partners
Risk allocation	Risk transferred to the prime contractor	Risk dialogue model for high risk projects	Client shares the risk	Client bears the risk
Relationships	Commercial and legal 'contracting' relationships	Gradual selection of preferred supplier	Client works in co-located team with consultant	Agreements with contractors, integrated project teams

Figure 2: Infrastructure Business Models and different risk modes

Mode 1 is a traditional contractual relationship where the responsibility for risk is transferred from the client to a prime contractor. The prime contractor is accountable for the management of subcontractors and performs the role of a systems integrator. Mode 2 is a contractor-led model where the contractor is responsible for the provision of integrated service solutions. In Mode 2 the strategic selection of a contractor-partner is critical and an ongoing risk dialogue is necessary to co-develop service solutions. Mode 3 is a client-contractor partnership where risk-sharing responsibilities may require co-located teams. Mode 4 has been observed in high-risk large-scale megaprojects, such as Heathrow Terminal 5 (Brady and Davies, 2011; 2014). The client bears the overall risk of the programme and acts as the systems integrator with overall responsibility for delivery and management. A variety of contractors are organised into integrated delivery teams. Mode 4 is a client-led risk model designed to enable teams to focus on co-developing superior innovative solutions rather than rigidly delivering to fixed plans. In summary, business models assign accountability for risk. Each mode involves a configuration of responsibilities and this reflects an appetite for risk and a judgement about who is best placed to manage risks. In turn, mitigating and managing risks requires an architecture of control to steer infrastructure programmes towards successful delivery. These points highlight the importance of business model design to match the right organisations to the right kind of risks.

Public Private Partnership (PPP) arrangements are a way of assigning the distribution of risk between the public and private sector. In the 19th century radically new infrastructure technologies such as electricity systems, telephony and the railways were developed by competing private firms. Gradually, 'natural monopolies' were placed under various forms of public ownership in Europe and Federal regulation in the US. Private sector business models could no longer attract investment or offer viable alternatives to the monopoly model. To overcome market failure Government funding and regulation enabled the value created to be distributed evenly. Over the past 30 years, the responsibilities and boundaries of public infrastructure monopolies has been reshaped. It has become harder for governments to finance large-scale infrastructure projects. Many of the core activities previously performed by public-sector infrastructure operators have been transferred to the private sector. A mechanism to facilitate this has been the delivery of infrastructure through PPPs[7]. PPPs are a delivery model that sits roughly in the middle of a wide spectrum of possible relationships between the public and private sectors for the provision of infrastructure services ranging from fully public to fully private.

4.1 A short history of PPPs[8]

It is difficult to pinpoint the exact origin of PPPs but we do know that this delivery model was used in the USA by the Federal Government during the 1950s and 1960s to stimulate private investment in inner-city infrastructure and regional development. The Carter administration in the 1970s, the Reagan administration in the 1980s and the Clinton administration in the 1990s continued and expanded their use, based on the (not always justified) assumption that the private sector could more efficiently and effectively provide goods and services than the public sector. Since then, PPPs have been used extensively in the USA for prisons, water supply and wastewater treatment (Kwak et al, 2009).

PPPs became more popular worldwide in the 1980s when a number of governments were pursuing policies of privatization reducing the role of the state in providing a range of services. In the late 1980s in the UK the Conservative government was strongly influenced by the US experience. The adoption of PPP schemes was part seen as a way of stimulating economic regeneration at a local level. What followed was a rapid growth of public private partnerships for the development of public sector infrastructure. The rise of 'new public management' (NPM) was intended to improve the efficiency of public service provision. By the 1990s new public management and market-based philosophies further influenced the development of PPPs. Gradually PPPs became popular in Australia and a comprehensive programme involved the development of ports, sporting facilities, roads, hospitals, water and electricity systems. By the late 1990s this diffused to the construction of airports, schools and courts. While most

[7] Yescombe and Farquharson (2018) provide definitions as well as a thorough treatment of PPP-related concepts and issues.

[8] Nightingale et al, (2016) describe this genesis in more depth

European countries were also attracted to PPPs, it was in the UK that their use really became widespread.

In 1991 the UK Conservative Government adopted the concept of the Private Finance Initiative (PFI) from Australia. In times of fiscal constraint, it was considered the best way to draw private finance and professional expertise into public services. It was believed that PFI would enable public sector organisations to spread the cost of infrastructure investment over the lifetime of the asset. More importantly PFI enabled the transfer of risk and allowed the Government to remove assets from its balance sheet[9]. Subsequent Labour governments fully embraced the concept and expanded the PFI programme. PFI projects were used across a range of sectors including defence, prisons, hospitals, roads, schools, housing and waste facilities which echoed the Australian approach.

In the UK Initial reports published by the National Audit Office (NAO, 2003, 2005) compared the construction performance of PPP and traditional procurement. These reports revealed that only 30% of conventionally procured projects were delivered on time and 27% within budget compared to figures of 70% and 78% for PPPs. However, despite these favourable evaluations, a contentious political debate emerged associated with a few high-profile project failures and this led to a torrent of criticisms of the scheme. The global financial crisis in 2008 made it increasingly difficult to attract private financing for certain large infrastructure projects. This resulted in the Government establishing a suite of support schemes, such as the UK Guarantees scheme. Despite these failures, the Conservative/Liberal coalition government (formed in 2010) continued to commission new PFI projects across a wide range of sectors including transport, education and health. However, in November 2011 a substantial review of PFI was undertaken. In December 2012 this led to the termination of the PFI programme and the launch of a new scheme called PF2 (HM Treasury, 2012). The new scheme aimed to provide solutions to various unsatisfactory aspects of the original PFI model. It attempted to address the slow and expensive procurement process which led to increasing costs and reduced value for the taxpayer; the inflexibility of PFI contracts that stifled the adaptation of requirements over the life cycle of a PFI project and insufficient transparency of taxpayer liabilities. Moreover, the inappropriate transfer of risks to the private sector led to higher risk premiums charged to the public sector. This led to questions about the ability of PFI to achieve Value for Money, a cornerstone of the rationale underpinning the scheme. In effect, PF2 maintained the view that the private sector should be involved in the delivery and investment of public infrastructure and services. It was designed to speed up the time from inception to contract and create greater transparency and contractual flexibility. This reframed the role of the Government to become a shareholder in future programmes,

[9] Off-balance sheet accounting of infrastructure PPP assets has since been revisited and relevant guidance has been issued by the statistical office of the European Union (Eurostat) and the European PPP Expertise Centre (EPEC) of the European Investment Bank (EIB) (EPEC, 2016).

enjoying gainshare arrangements that would enable the Government and private sector shareholders to share financial rewards.

Despite these efforts to revitalise the UK PPP market, PF2 was only used for a handful of projects. In October 2018 PF2 was terminated as a scheme (IPA, 2018). This has created a natural gap in terms of the shape and form that private participation in infrastructure provision will take in the UK. However, PPPs as a delivery model have continued to propagate in continental Europe (EPEC, 2017). In other parts of the world PPPs have enjoyed the ongoing support of multilateral banks and development agencies. PPPs have received worldwide attention (ITF, 2018) as a possible delivery model innovation.

The next section shares insights from the UK about the latest programmes for reform in the delivery and provision of infrastructure. The UK has a long history of poor delivery performance and cost overruns (Egan 1998; Latham 1994). Several recent initiatives have focused on improving the management and delivery of large-scale high-risk projects.

5.0 UK government initiatives to improve infrastructure delivery

A review of the cost of infrastructure in 2010 confirmed that the UK was more expensive than its European peer group[10]. Higher costs were mainly incurred in pre-construction and project initiation. The main contributing factors identified included[11]:

- stop-start investment programmes and the lack of a visible and continuous pipeline of forward work;
- blurred governance structures and a lack of clarity and direction over key decisions at inception and during design;
- the management of large infrastructure projects and programmes within a quoted budget, rather than aiming at lowest cost for the required performance;
- over-specification and the tendency to apply unnecessary standards, and use bespoke solutions when off-the-shelf designs would suffice;
- inefficient and bureaucratic use of competition processes, with some clients risk averse to the cost and time implications of potential legal challenges; and
- lack of targeted investment by industry in key skills and capability limiting the drive to improve productivity performance.

A programme of improvement was identified to improve the efficiency and effectiveness of infrastructure delivery in the UK. The review concluded that infrastructure costs could be reduced by at least 15%.

[10] Infrastructure Cost Review: Main Report, 2010
[11] Nightingale et al, 2016

The review highlighted the following objectives:

- Improve visibility and continuity of the infrastructure investment pipeline
- Improve the effectiveness of project and programme governance
- Greater discipline in the commissioning of projects and programmes and smarter ways of using competition
- Developing an environment to encourage investment and reduce direct construction costs

The National Infrastructure Plan, also published in 2010 described the UK's poor performance in delivering infrastructure:

> *"for several decades the UK's approach to infrastructure investment has in general been timid, uncoordinated, incremental, wasteful in its procurement and insufficiently targeted to supporting balanced and sustainable growth in the economy, both economically and environmentally. The result is that our infrastructure is ageing, plans are unclear and costs are too high.*"

Four years later a further report by the Treasury claimed that a reduction of 15% in capital expenditure had been achieved across infrastructure sectors. In railways, highways, water and flood defence savings were achieved by improving the collaborative engagement of supply chains. The report also described the benefits of grouping projects into programmes and the use of smart procurement processes. Other efficiencies were achieved through technological innovation - for example, in electricity generation by adopting renewable technologies.

In 2017 the Infrastructure and Projects Authority (IPA), located in the UK Cabinet Office, published a report called *Transforming Infrastructure Performance (TIP).* The TIP report highlighted a strategy to transform productivity in the construction of infrastructure where the government would act as a champion for change. TIP provided details of a long-term and short-term programme to improve the delivery and performance of infrastructure.

Three long-term issues were addressed aimed at

- Prioritising investment in the right projects
- Improving productivity in delivery
- Maximising the overall benefits of infrastructure investment

The report made several suggestions to improve infrastructure performance:

- *Optimization of project portfolios* **-** avoid investment in weak projects. Evaluate potential effects on the entire network rather than individual projects in isolation.
- *Streamlining delivery* **-** investing in early-stage project planning and design to support economic, social and environmental priorities. Procuring for growth by encouraging smarter commercial relationships, improved contracts with risk assignment and incentives that align with delivery objectives.
- *Making the most of existing infrastructure* - getting more out of existing capacity. Boosting asset utilization, optimizing maintenance planning, expanding the use of demand-management measures and digital technologies to drive efficiencies
- *Government needs to build capabilities* - to strategically plan, coordinate and implement infrastructure across organisational boundaries and also drive improvements across its own organisation. For example, by improving pipeline visibility, project initiation and procurement practices, benchmarking and evaluation, whole life planning and cost control.

It is hoped that the Transforming Infrastructure Performance programme will significantly improve how infrastructure is planned, procured and delivered. Switching the focus to whole life performance of the infrastructure system and moving beyond cost and capital efficiency of individual projects. Gradually projects plans would focus on exploiting opportunities made possible by new technologies to create superior levels of socio-economic value for infrastructure users. Improved efficiency and productivity in delivery would drive superior returns for investors. The first steps towards this transformation are underway through a targeted programme of investment to upskill project delivery capability within government and recruit and retain talent within construction.

In addition to these government initiatives there are several recent examples of improved performance in the delivery of infrastructure projects. Starting with Heathrow T5, and followed by the 2012 London Olympics, Heathrow Terminal 2, Crossrail and Thames Tideway; a steady flow of projects in the UK have been or are being successfully delivered on time and budget. Although rigorous procurement and appraisal processes played an important role in the success of these megaprojects, they also share a common flexible approach to planning and control. Rather than fixing the front-end of the project and removing deviations from plan these projects navigated change by developing a controls approach that encouraged innovation and learning as the programmes progressed. Calibrating risk and carefully apportioning accountability for risks enabled the projects to focus on harnessing innovation through formalised organisational structures.

Research on these infrastructure megaprojects (Davies et al, 2017) has distilled the lessons into five rules for large high-risk projects as shown in Figure 3 below.

Rule	Purposes	Practices
1. Assess what's worked before	• Learning from other project sectors and research organisations • Capturing own prior experience • Evaluating risk and uncertainty	• Case studies and site visits • Recruitment of expertise
2. Organise for the unforeseen	• Flexibility and adaptability • Changing behaviours • Risk-sharing	• Integrated client and contractor teams • Flexible contracts • Partnerships and collaborations
3. Rehearse first	• Exploring options • Prototyping, proving and improving • Identifying and reducing uncertainty	• Off-site try-outs • On-site tests and trials • Simulations and models • Solution development
4. Calibrate and apportion risks appropriately	• Pairing stability and change • Managing innovative components of the project differently from standardized and predictable aspects	• Structured process to change the project plan • Contracts tailored to address uncertainty in the projects and sub-projects • Design is frozen progressively to deal with unexpected events
5. Harness innovation from start to finish	• Formalising structures and processes for guiding, shaping, creating and using innovations	• Explicit innovation strategy statement • Establish innovation governance and leadership • Develop, capture and share innovations

Figure 3: Five rules for managing large high-risk projects (Drawn from 'Five Rules for Managing Large, Complex Projects', Andrew Davies, Mark Dodgson, David M. Gann and Samuel Macaulay, MIT Sloan Management Review, 2017

6.0 Insights from UK experience

The previous sections have highlighted that infrastructure delivery in the UK has evolved based upon a variety of delivery models. This accumulated experience now spans several decades enabling the development of infrastructure and construction in the UK. Effectively, the changing balance of public-private responsibilities, risks and relationships in infrastructure provision has resulted in opportunities for private firms to develop new and sometimes innovative business models. Innovation has been observed in new commercial relationships and organisational forms. Co-located integrated delivery teams, joint ventures, partnerships and framework agreements have enabled firms to share revenues and co-produce valuable solutions and services. However, strategic choices about the accountability and responsibility for risk are the fundamental determinants of how value is configured into different business models. These decisions influence the capabilities that develop across the value chain, the value proposition and the contractual relationships with other partners in the value network. A focus on cost reduction and efficiency may not necessarily lead to improved outcomes for end users so the focus should be on providing better value rather than simply reducing costs.

7.0 The challenges for innovation in African infrastructure provision

The discussion so far on improving the performance of infrastructure projects in the UK has highlighted the characteristics of infrastructure systems that make them difficult to manage – the contextual nature of the environment in which infrastructure projects take place; the number of different stakeholders, many of which may have conflicting requirements; the complexity of infrastructure projects and the risks that are associated with their characteristics. When delivering infrastructure, some of these risks can be managed by reducing their underlying causes whilst developing project management capabilities. Improving cost control is partly an organisational design problem, which requires ensuring that the right organisations, with the right capabilities manage the right kinds of risks. African governments need to consider radically new delivery models for some infrastructure services – moving from the public monopoly-utility model to purely privately owned or joint public/private ownership and operation (as has happened with Mobile telecoms). The ability to do this will vary across infrastructure sectors and countries. For example, the electricity generation sector has great potential to harness new technology to deliver energy using renewable sources (solar and others) and adopt off-grid and mini-grid solutions rather than centralised architectures. To enable this Governments would have to implement policies to dismantle the existing institutional structures that favour the incumbent monopoly suppliers of fossil-fuel-based electricity. For transport, there is a need to shift from national to regional programmes with significant private sector investment in a variety of sub-sectors including ports, railways and roads. Bonded transport and storage facilities would improve logistics because many African countries are landlocked and need more accessible routes to the ports

and neighbouring countries. In the ICT sector, although mobile networks have performed quite well, there could be improvements in the inter-connectivity of competing systems. Investment in fibre-optic technology could improve internet penetration. However, achieving this would imply opening existing monopolies to new forms of market competition.

Clearly, there are opportunities to learn from other countries that have developed their own approaches to infrastructure provision and operation. A reduction in the number of failed and abandoned projects requires a coherent strategy focused on *doing the right projects* as well as *doing projects right.* The former requires high-level capabilities in portfolio management and project prioritisation. The latter depends on the development of programme and project management capabilities. Understanding country and project risk profiles and the impact they have on investor risk appetites is fundamental in order to attract private sector investment into African infrastructure. This is particularly important when it comes to the funding streams for projects as opposed to their financing. This will become even more important if international investment is to be attracted. Currently there is too much reliance on external sources of capability and too little incentive for international investment to be deployed in African countries.

In the future it is paramount that African nations develop their own internal capability, not only in planning and building new infrastructure systems but also in maintaining and operating them. This will strengthen local capacity and enable more diverse market conditions to emerge which can signal to foreign investors a step-change in "doing business". African countries will need to develop and calibrate their infrastructure pipelines according to their internal capabilities. The development of design, build and operating capabilities [12]may require long term major investment and a coherent industrial policy. However, these capabilities may be refined and reused over time. It is important to consider the right balance of international partnerships that not only attract development finance but also the appropriate level of transferable skills and capabilities. These are the key challenges that face the governments of African states. Appropriate policies and approaches that facilitate capability development as well as transparent and mutually beneficial engagement with foreign investors to unlock the widening infrastructure gap.

[12] See Kiamehr (2017) for an in-depth case study of a complex hydro-electricity generation system in Iran. This case highlights how a lack of domestic market can prevent developing economies from building local capabilities. However, it also reveals opportunities to co-develop capabilities and the use of incentives and the packaging of projects to encourage partnerships arrangements, improve reliability and mitigate the risk of escalating costs.

8.0 References

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