ISSUE BRIEF:
Infrastructure

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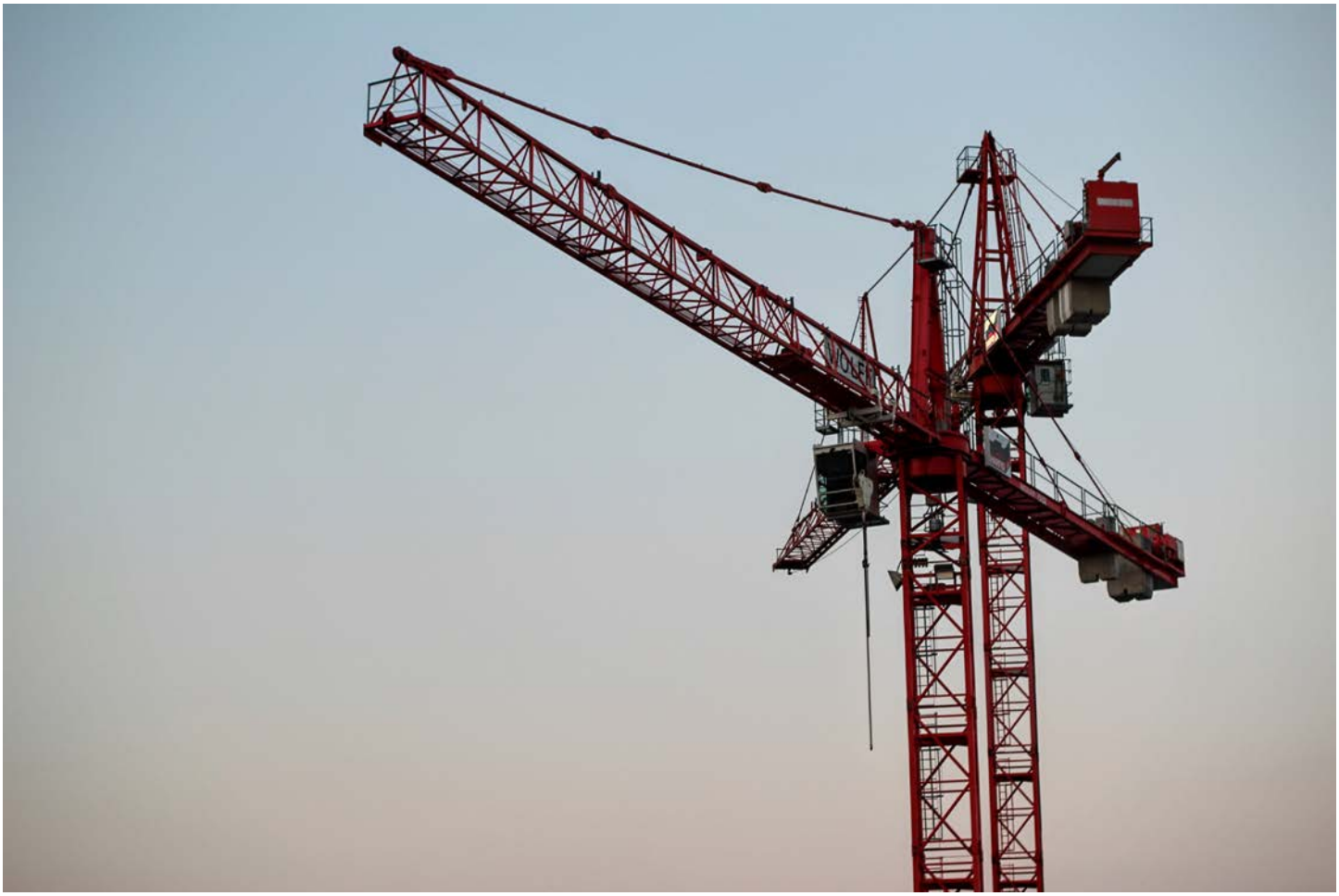

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Introduction

This Issue Brief is intended to provide a broad overview on the status of major infrastructure systems in the US, identify areas that are likely to experience high utilization or tightness of capacity, and propose interventions in the hope of pre-emptively resolving scarcity or crises where the relevant infrastructural systems fail to deliver core services.

At its core, it acknowledges the limitations of centralised, top down approach toward infrastructure development, and proposes some adjustments to conventional decision making that build in additional leeway for bottom up efforts to drive change. Finally, it also attempts to articulate broad approaches to reshape how we think about infrastructure investments and developmental direction.

The brief originated as a response seeking to shape the focus of President Trump's infrastructure spending plan, and carries with it a heavy emphasis on evaluating the suitability of the solutions that have been mooted as a means of translating that vision into action.

This brief would not have come to fruition without the efforts of the following individuals who have provided deliberate, comprehensive feedback that has gone a long way toward shaping a more balanced and robust discussion: Matt Kopko, Bob Poole and Alex Atallah have made instrumental contributions to major content pieces in this document.

Problem Statement

Infrastructure is one of the core aspects of a nation's foundation that has numerous interactions with other domains of governance, and will inevitably assert a significant downstream impact on other desirable outcomes.

We see that infrastructure can serve as a cross cutting, horizontal enabler that can improve connectivity within the economy for market participants and factors of production, thus accelerating the pace of economic growth and broad-based innovation in disparate fields beyond its immediate reach. This is a critical means of injecting vibrancy and dynamism into the economy which cannot be done away with.

As a lever for achieving social outcomes, a more extensive and robust infrastructure system will make headway in ensuring that basic living standards can be provided for all Americans. It also connects previously isolated populations with centralized services, amenities, and a host of opportunities that they had previously been denied access to. These converging trends pave the way toward engendering equity across formerly disenfranchised communities, by providing them with a level playing field that confers better chances of grasping economic opportunities.

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We recognize that addressing infrastructure inadequacies will emerge as a pivotal cornerstone of President Trump's forthcoming economic strategy. Investments in infrastructure intend to stimulate growth through providing increased employment translating into higher incomes and greater purchasing power, expanded long term productive capacity of the economy by laying the foundations for private companies to procure the materials they require for smooth and efficient production, and by facilitating the quality and rate of trade. President Trump's proposed plan will leverage an influx of private funding sources to prompt a renewal of aging infrastructure which are operating below their full potential through a judicious alignment of funding incentives and a reduction in administrative obstacles.

The plan charts a new direction when taken against the backdrop of conventional expenditure in infrastructure, marking a departure from traditional policies which espoused a large government presence which involved setting aside substantial funding streams and taking core decisions on the project's evolution. While we agree with the broad thrust of this policy in funnelling additional resourcing towards augmenting the current infrastructure system, how resources are marshalled and where they are directed deserve additional scrutiny. We want to prioritise domains which are currently constraining other aspects of development, and work towards resolving bottlenecks that stand in the way of improved service standards to users.

Overview of Major Infrastructure Systems

The data identified in the report relies primarily on the ASCE's Infrastructure Report Card[1] as the basis supporting subsequent analyses, produced annually by the American Society of Civil Engineer (ASCE).

Beginning from the raw data and categories that the Report Card has furnished us with, we can then conceive of different buckets for categorizing infrastructure systems. Within each bucket, common themes and governing principles run across the different aspects. These will aid us in elucidating insights and strategies, agnostic to the specific domain or sector, that can be generalised across a number of policy fields.

CONNECTIVITY describes fields which focus on bringing proximity to human interactions and expediting the work of logistics and supply chains. This a field with considerable peripheral interactions with other systems and policy domains. Increasing the connectivity within and between these subsystems to establish a well-integrated, multimodal transport network will yield increasing returns to scale.

RESOURCE DISTRIBUTION refers to infrastructure that span the entire supply chain for a specific resource. These are involved in every stage before the delivery of the resource to the end user, spanning generation or extraction, continuing to distribution and access promotion, eventually to quality control, billing and maintenance.

Connectivity: Aviation

One of the main connectivity levers required to usher in a comprehensive economic transformation a robust and sustainable air transport infrastructure.

A total of 5,1452 airports exist in the US as of 2015, of which 514 generated a total of 8,727,691 flights in that year.

This greatly enhances linkages between domestic cities, and internationally. A total of 5,145[2] airports exist in the US as of 2015, of which 514 generated a total of 8,727,691 flights in that year. On the quality front, the system has performed reasonably well, with 98% of commercial service airport runways rated excellent, good, or fair in 2013.[3] However, complications arise on the capacity front, with only 81.42% of flights being on time. This became particularly egregious in 2007 prior to the Great Recession which severely undercut demand, when only 73.03% of flights at the largest 32 airports arrived on time. This provides a counterfactual estimation of demand should the current trajectory become further entrenched.[4]

Beginning with the Air Commerce Act of 1926, government acknowledged that aviation infrastructure was a priority, and coordinated efforts to bolster air commerce through the operation and maintenance of airports, airways and aids to air navigation.[5] The Federal Airport Act of 1946 enabled the accumulation of considerable financial heft behind the directive to fund a nationwide system of municipal airports, managing to secure over $500M worth of appropriations. Attempts were also made to grant local government autonomy, where states were given capital grants in the form of matching funds to encourage initiative. With the passage of the Airline Deregulation Act of 1978, the barriers to entry and exit from the market were reduced, giving airline carriers greater flexibility in deciding which markets to operate in. Many aircrafts thus dropped unprofitable points in their route, leading to considerable volatility in the quality of earnings which airports received. Thus, recent policy structures have been established with the express purpose of shoring up the revenue base and distributing funding more precisely, so as to future proof the capacity of aviation infrastructure systems from unexpected demand surges. The Airway Improvement Act of 1982 was a step in this direction, reestablishing the operation of the Airport and Airway Trust Fund and the Airport Improvement Program and setting the precedent for tax models which responded to changing usage patterns (e.g. the Passenger Facility Charge, which airports collect for all boarding passengers).

At present, limits on capacity have sharply increased congestion at major airports, given that structural factors such as rising incomes and low oil prices are converging to produce demand conditions that have steadily outpaced capacity growth.[6] Since the pace of income growth is influenced by a multiplicity of other factors, and low oil prices are an encompassing secular trend which can be heavily swayed by geopolitical factors, it thus helps to confine our analysis to the supply side for the market.

One of the chief supply constraints is the federally imposed caps at a maximum of $4.50 on Passenger Facility Charges that permit airports to convert growing utilisation into a force for channelling investment back into their own facilities. As a corollary, despite airlines having implemented a la carte pricing, airline taxes do not extend to discretionary passenger purchases. This in turn affects the magnitude of the Airport Improvement Program grant, which depends on airline ticket taxes as a primary funding source.

This cripples the system, effectively denying it the ability to engage in cost recovery and contain escalating costs of operation. Another major policy problem involves the delayed implementation of the NextGen Air Traffic Control System, which substitutes the current radar-based system with a more efficient satellite based one.[7] These allow planes to fly closer together and take more direct routes, freeing up space by reducing the time for which planes have to wait for a runway to become available. Finally, regulatory burden borne by airports as a result of Federal Aviation Authority (FAA) mandated standards restrict the number of developmental options available to airports to increase facility capacities, further compounding the problem.

These issues are perhaps best encapsulated in ASCE's Failure to Act economic study, which postulated that the average annual investment gap for airports would be $42B between 2016 and 2025, accounting for the protracted deficit in available capacity. The paramount concern is then to earmark resilient funding streams that grow with the level of utilisation, toward improving cost recovery and thus capacity management in this field.

Connectivity: Ports

Within the US, ports handle a sizable volume of over 2 billion metric tons of cargo, encompassing both domestic and international sectors, annually.

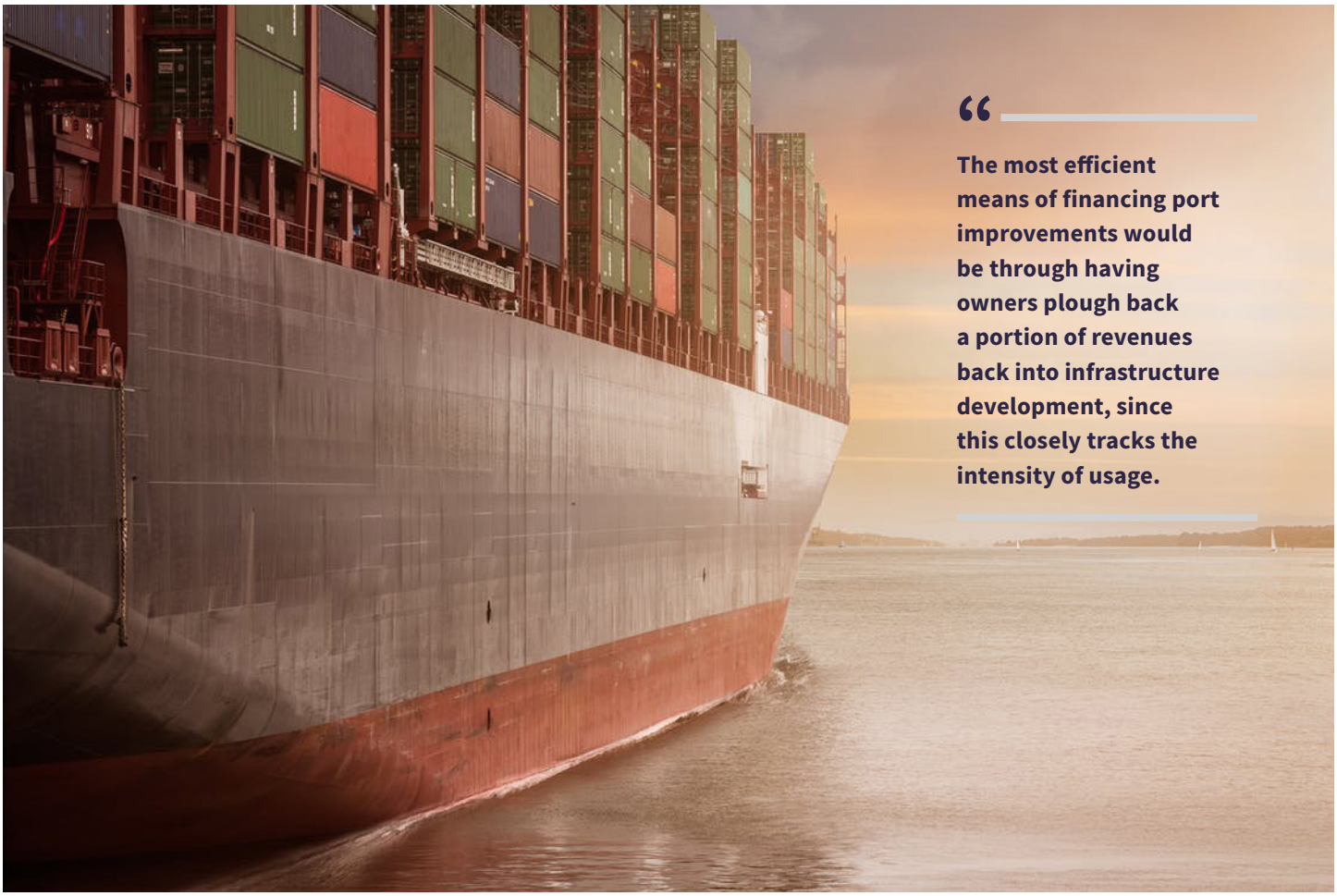
Taken as a system, these account for almost 99% of overseas trade volumes, and thus form an indispensable component of trade networks. As of 2014, this amounted to $4.6 trillion worth of economic activity. The touchpoints between ports and broader economic life in the US are numerous, and have supported both employment (at least 23M jobs in both core and peripheral capacities)[8] and fiscal interventions ($320B taxes generated in taxes in 2017)[9].

Historically, ports were initially viewed as a companion to other inland modes of transport and were discussed extensively in the context of their linkages to railroads. The American Association of Port Authorities began in 1912 to better manage disputes surrounding the discriminatory practices of waterfront railroads. In a similar spirit, concern about the need for improved coordination and better inland transportation facilities led to the emergence of a Port of New York Authority that was preoccupied with access to inland networks. Port development thus took place in a dispersed fashion, with regional concerns connecting ports to other transportation modes serving as the primary impetus for development. The South Carolina Port Authority was created for mobilizing port infrastructure as the United States entered into WWII, while the Maryland Port Authority came into being in 1956 to enable independent stewardship of the Port of Baltimore. To date, investment decisions in port infrastructure have been taken at a local/state level. These decisions have not been folded into an overarching, coordinated federal vision for port systems across the entire US.

With adequate maintenance, ports tend to be characterized by relatively long asset lifespans. These are however punctuated by the need to engage in upgrading scheduled on a regular basis, so as to keep pace with intensifying utilisation and structural shifts affecting how cargo is transported. Take for instance the steady increase in the size of tankers, borne out of a need to realise economies of scale in transportation of goods so as to ensure that costs are kept to a minimum. Such shifts have engendered a necessity for a concerted movement in favour of deeper and wider berths for these larger ships to dock. The case for infrastructure renewal beyond seasonal maintenance thus revolves around the question of how quickly ship sizes are increasing, and how best to plan for infrastructural developments meet current utilisation demands while simultaneously maintaining flexibility to plan for future needs. Currently, we know that as ships become larger, port infrastructure falls increasingly short of the mark. A thorough revamp of supporting systems, which will include longer cargo transferral equipment to pass cargo across longer distances and more extensive storage facilities to house larger cargo loads, will be integral in smoothing out any remaining disjoints between cargo inflow and available capacity.

The severity of need for securing investment sources is somewhat moderated by the pivotal role ports play in regional supply chains and economic networks. Ports generate revenue streams in excess of maintenance cost recovery that accrue to owners, who are often able to purchase and operate them on a profitable basis. The most efficient means of financing port improvements would be through having owners plough back a portion of revenues back into infrastructure development, since this closely tracks the intensity of usage. This runs counter to the logic of federal grant allocation, which redistributing tax proceeds from levies on all incoming cargo to politically selected ports in a manner that diverges from productive usage. Furthermore, federal grant allocation could potentially have a crowding out effect in supporting improvements at ports which serve largely localised interests, and compete directly with each other for incoming trade.

The American Association of Port Authorities (AAPA) contends that the port industry requires almost $66B of additional investment in port related infrastructure over the next 10 years to complement the current slate of private sector investment projects, with an eye on strengthening waterside and landside connection between docks and mainstream transportation networks.[10] Core dimensions of need identified to address inadequate capacity to house larger ships include setting aside funding to maintain and modernize deep draft shipping channels, supporting the coastal navigation portion of the Corps' Navigation program, introducing more discretionary grants for multimodal purposes, as well increasing funding for additional manpower headcounts for Customs and Border Protection.



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Connectivity: Roads

Roads tend to be owned and managed by local and state governments, instead of regional entities.

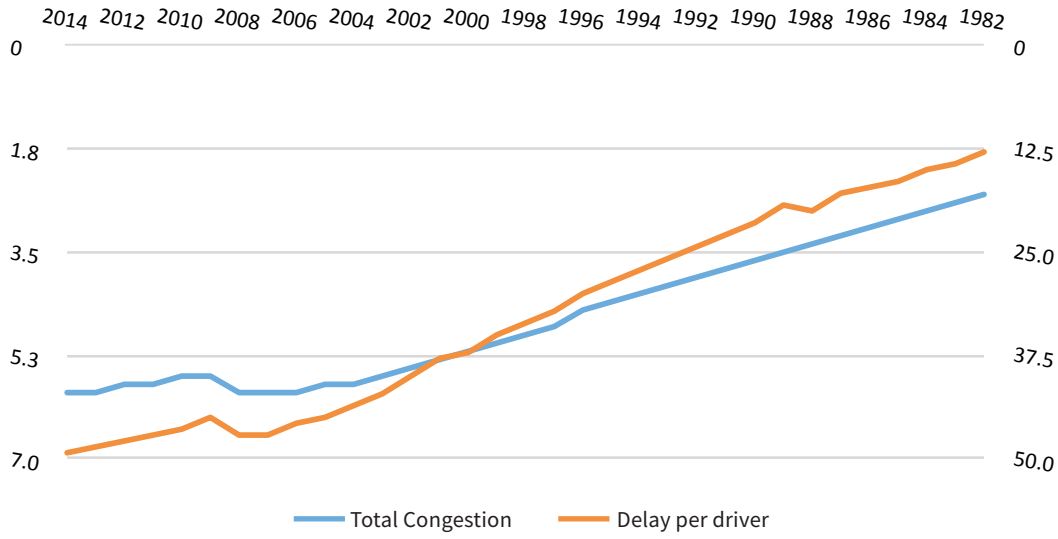
This results in far more discrepancies in qualities across the transportation system. However, major highways were initially funded, and still continue to be funded by federal sources. The 1921 Federal Highway Act generated steady streams of funding of paved two-lane interstate highways to be built, but this program quickly lost momentum and fell into neglect after the advent of WWII. The Federal Highway Act of 1956 provided a welcome impulse to the system as the largest public works project in American history through that time, designating $25B for the construction of 41,000 miles of the Interstate Highway System.[11] Subsequent Federal-Aid Highway Acts, in 1968 and 1973 respectively, helped to effect a shift away from unbridled capacity expansion, toward guaranteeing a minimal level of quality instead, ensuring that highway construction abided with environmental protection requirements and adhered to minimum safety standards.

> **“Within 2014 alone, Americans were delayed in traffic by up to 6.9B hours, resulting in financial losses of $160B in wasted time and fuel costs.”**

We know that following the uptick in car purchases, traffic congestion has increased exponentially. Within 2014 alone, Americans were delayed in traffic by up to 6.9B hours, resulting in financial losses of $160B in wasted time and fuel costs.[12] Observing how delay per driver and total time spent in congestion have changed over the years, we see that total congestion is rising at faster rate than the average delay per driver, suggesting that there are more drivers in the system experiencing longer delays. This underscores the necessity of considering measures to curtail road usage and manage demand, even while additional capacity is added throughout all parts of the system. Another distinct dimension of the problem is that of infrastructure condition.

Taking into consideration how there is a larger number of cars using a finite amount of roadspace, the deterioration in pavement quality has accelerated considerably. 32% of urban roads are deemed to be in poor condition, compared to 14% of rural roads, a sign that congestion has no small part to play in exacerbating substandard infrastructure quality. The poor road quality has also caused drivers to incur additional costs, where a total of $112B in extra vehicle repairs and operating costs was incurred in 2014 alone[13]. Due to the frequency and intensity of road system usage, lapses in service quality and output could have disastrous consequences. The 2007 I-35W bridge collapse in Minnesota led to 13 fatalities and over 140 casualties, a poignant reminder that while sporadic, infrastructure failure can result in costs that are immeasurably high to the wider community.

The ASCE’s assessment of road networks[14] takes on a far less sanguine pall when confronted with difficulties in funding that it is plagued with. Traditional sources of funding that have supported most of the reinvestment efforts, such as the Highway Trust Fund are jeopardized by solvency concerns, where the Congressional Budget Office proposing delaying payouts to states in 2015[15] to ensure that the balance remains above 0.



Part of the reason for the eroding funding sources are the fact that receipts are driven by gasoline taxes, which have remained constant at 1993 levels and are not indexed to inflation. The support provided from fuel taxes is likely to wane even further, against a backdrop of improving fuel efficiency and a taxation system that charges on a per gallon basis.[16]

On balance, the policy direction should begin with curbing the aggregate level of demand for road utilisation, as this could have downstream effects on obviating the need for building more roads, and alleviates congestion directly. This could begin with the designing of choice architecture to motivate switching to other modes of transport which are less infrastructure or space intensive, or facilitating demand aggregation initiatives such as carpooling. On the supply side of the house, more deliberate steps should be taken to ensure that expenditure is sustainable, either through identifying new tax bases, restructuring funding arrangements or determining where investment can be deployed most effectively.

Connectivity: Mass Transit

Transit encompasses all elements of the public transportation system, which typically centres around buses, trolleys, trams, trains, light and commuter rail.

The segment is thus defined by the actual vehicles transporting commuters, distinct from the infrastructure that supports their mode of transport. As a mode of transport, transit plays a particularly important role in facilitating connectivity within concentrated cities with high residential densities that were dominated by central business districts. However, as cities become decidedly dispersed in the future[17], transit's importance is on the wane, given that automobiles become far more useful in navigating across multiple suburban locations than transit systems, which are designed to converge on a centre. From 1960 to 2015, this trend has been illustrated by the declining work trip market share of transit, which began at 12.1 percent and declined to 5.2 percent[18]. Furthermore, transit growth is largely confined to cities with legacy cores such as New York, Chicago, Philadelphia. The policy conundrum here appears to be one of ascertaining how best to phase investment allocation for transit infrastructure renewal, alongside managing outflow of passengers towards other compelling modes of transport, such as automobiles or walking.

The genesis of public transport is inextricably tied to the Urban Mass Transportation Act of 1964,[19] where the issue of connectivity within urban settings was catapulted to the forefront of national attention. To arrest the steady decline in conditions caused by rapid urban sprawl, $425M was set aside for public transportation activities, divided across two discretionary programs for long term development and emergency support. Realising that the large-scale installation of infrastructure required long tail maintenance expenditure which was not provided, the Urban Mass Transportation Assistance Act of 1970 and National Mass Transportation Assistance Act of 1974 sought to close that gap by authorizing long term funding commitments for public transit and subsidizing operational costs.[20] This enabled the confirmation of more infrastructure projects since developers had greater certainty over funding sources. Later legislative action demonstrated a shift towards a multifaceted grasp of transportation needs, such as the Federal Mass Transportation Act of 1987 which set out to fund transit services for rural communities, or the Federal Transit Act of 1998 which established a Job Access Reverse Commute program addressing the unique transportation challenges faced by welfare recipients or low-income job seekers.

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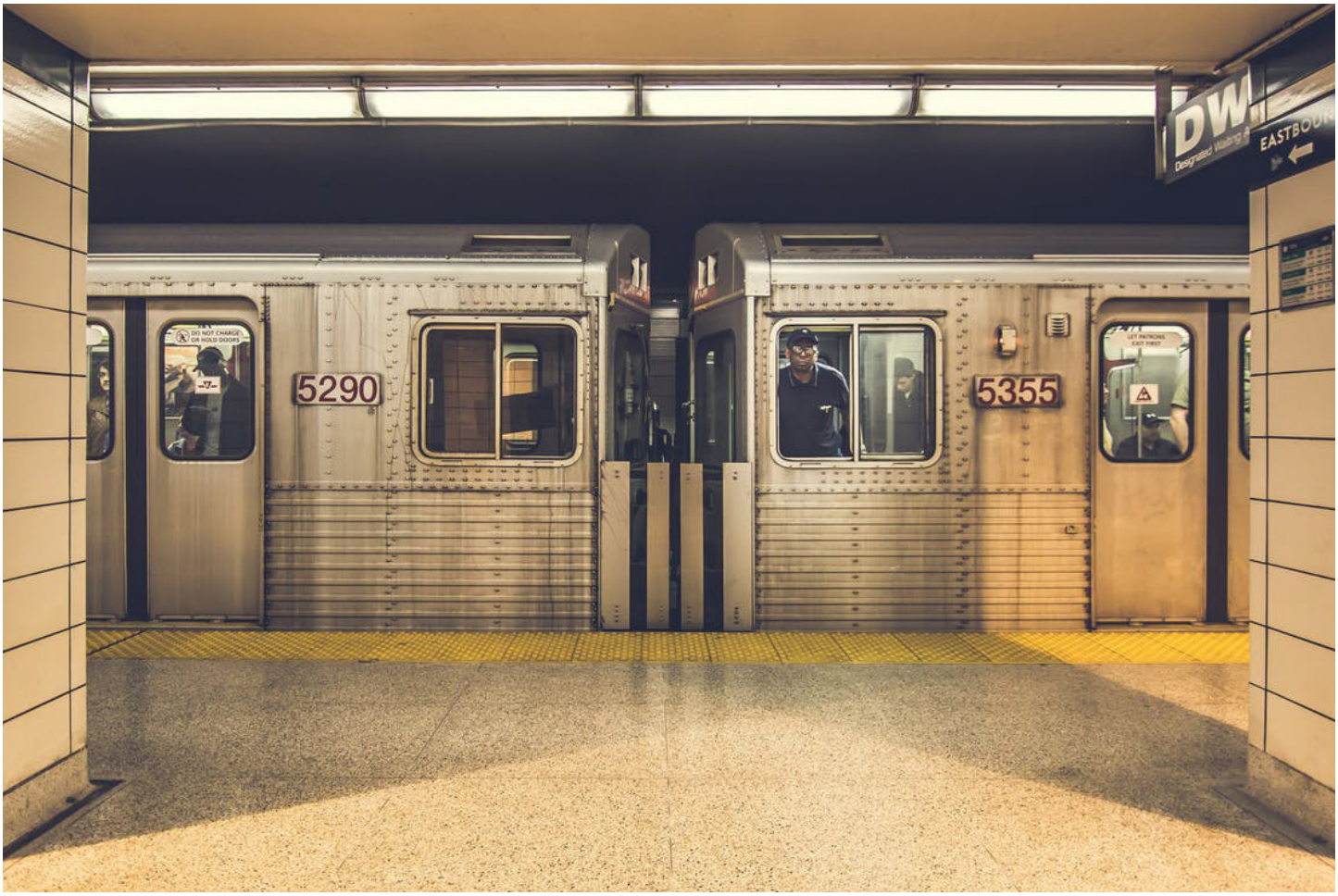


Within the transit sector, capacity growth on the light and commuter rail fronts have outstripped other transit modes, with 26% more urban route miles in rail modes becoming available from 2004 to 2014 relative to 11% in non-rail modes.[21] Despite the recent trend, accessibility to modes of public transport still remains highly concentrated amongst small parts of the population, with public transportation network penetration only reaching only about 61.9% of their intended urban population catchments in 2013. Furthermore, an additional difficulty revolves around how quality of service delivered by the transit system, which is currently limited by the state of disrepair which both vehicles and physical infrastructure are mired in. For instance, 35% of guideway elements and 37% of stations are not deemed to be fit for usage[22].

Funding appears to be the key impediment responsible for lagging service standards in the transit sector.[23] Transit agencies receive direct funding from state, local and federal agencies that is disbursed to supplement the fees they collect for services rendered, with these sources accounting for almost 55% of operating expense recovery in 2015. Agency funding plays an even more indispensable role in capital expenditure provision, and is responsible for almost 78% of total capex outlays in public transportation networks.[24] While the state does play a significant role, these still fall short of bridging funding gap between the current state of play and the threshold for attaining a 'state of good repair' for the transit system. This burgeoning gap stands at $90B today[25] and is felt most acutely in the area of fixed guideway modes, which require more specialised forms of training and equipment to construct.

Connectivity: Internet[26]

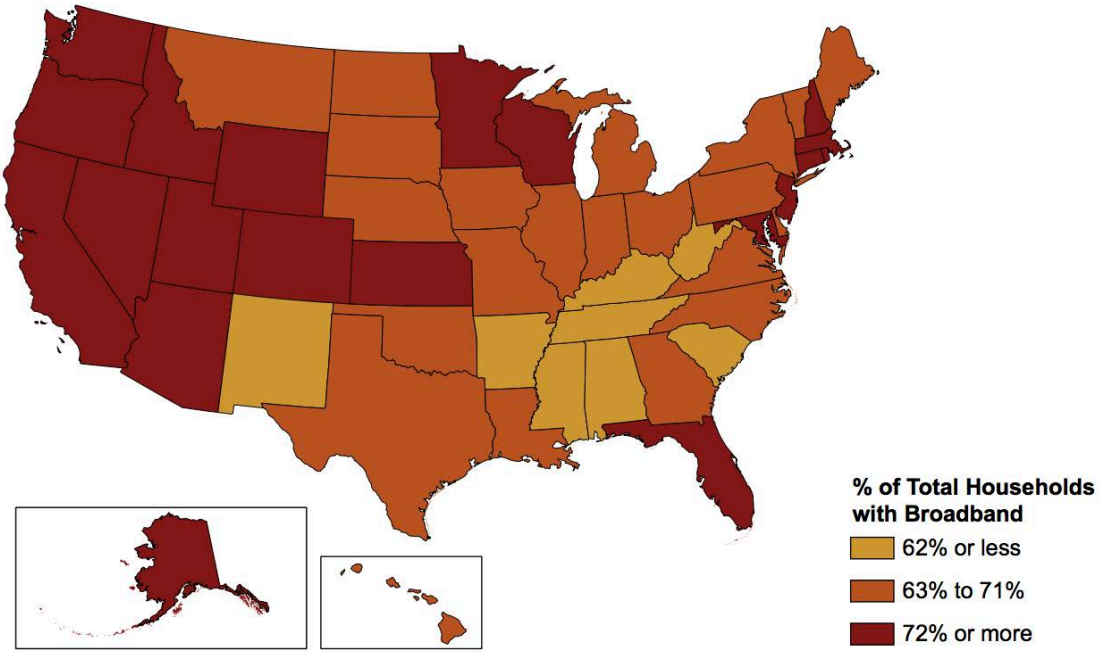
Internet access is a critical economic enabler, because it serves a platform for the delivery of numerous other services in this age such as information, ecommerce, transportation options, media and entertainment, as well as communication.

However, the US seems to be marginally lagging in its Internet penetration rate growth. The latest global ranking of average Internet connection speeds sees the US placed 26th, 4 times slower than the leader, South Korea. Overall Internet users in the U.S. were only 75% of the population in 2015, which ranks 34th in the world.[27] Part of the reason for the situation the lack in growth of broadband penetration rates. While the country's size has obviously made it harder to scale Internet infrastructure, the true bottlenecks to progress lie on the local level.

The privatised structure of the Internet Service Provider space is a contributing factor to the obstructions to more prevalent broadband access. A third of US households have access one option or less for wired broadband services, which indicates the absence of market forces for a third of the entire market.[28] This will have an adverse impact on quality of service delivery, diversity of choice, pricing, and maintenance, as consumers lack the power to switch to alternative options. Localised monopolies are not organically formed, but are encouraged by regulatory practices that facilitate their development. For instance, local governments charge "rights-of-way" fees to lay fiber, which involves installing wires above and below both public and private property. ISPs also have to negotiate with public utilities for renting space on telephone poles and other utility poles, setting up agreements called "pole attachment contracts." Local governments often overcharge ISPs for these contracts, sometimes twice the cost of constructing the whole network.[29]

Top Internet Service Provider State-by-State

Household Broadband Internet Adoption by State, Rounded to Nearest Percentage Point, 2011



Policy initiatives have been undertaken to reverse the decline in internet penetration, and reinject vigour into the push for Internet infrastructure renewal, most conspicuously through the American Recovery and Reinvestment Act, signed by President Barack Obama. The Act requested that the FCC create a national plan for increasing broadband access. It also allocated funding for broadband grant and loan programs for up to $4.7B for improving access in unserved and underserved areas, and an additional $2.5B for rural areas. The FCC also finalised the National Broadband Plan in March 2010, which set out minimum connectivity standards (at least 100 million U.S. homes with 100 Mbps download speeds and 50 Mbps upload speeds by 2020). This would support a certain degree of use cases such as allowing more Americans to have affordable access to robust broadband service, or using broadband to monitor their real time energy consumption.

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Resource Distribution: Energy

Energy consumption levels have remained fairly stable with a slight upward trajectory.

As of 2013, the average American consumed 318 British Thermal Units of energy, a quantity that was projected to grow at 0.4% per year until 2040.[30] Over the short haul, domestic energy systems are understood to be well equipped to manage demand, given the near-term trends of increasing energy efficiency and the prevalence of renewable sources is likely to dampen utilisation levels. From a longer-term perspective, however, the longevity of conventional energy sources that account for the bulk of present consumption requirements has been called into question.[31] Fossil fuels are finite, with predictions suggesting that oil and gas will run out within a 50 year horizon and coal within a 100 year horizon.[32]

The policy sphere has acclimated rapidly to the introduction of new sources and methods of distributing energy. Unlike other aspects of infrastructure covered in this brief, the role of policy has been less to actualize change, but to regulate the rate at which it occurs, given the powerful profit motives that animate energy providers. Some of these impulses can be witnessed most clearly in the Public Utility Holding Company Act of 1935, an archetypal maneuver by government to protect the consumer and level the playing field by controlling the size of utilities and clamping down heavily on questionable business practices among the larger utilities. Other forms of legislation sought to specify parameters around which new energy markets should be defined and priced, such as the 1938 Natural Gas Act and 1946 Atomic Energy Act. Realising the importance of energy resources to economic development and national interest, policies were also crafted to weigh supply against demand and discourage inefficient consumption. These culminated in the Energy Policy and Conservation Act of 1975 which went so far as to establish a Strategic Petroleum Reserve, and the National Energy Act of 1978 which put in place a comprehensive incentive system including taxes, subsidized fuels and market based initiatives to shift demand. The 1992 and 2005 Energy Policy Acts prolong this tradition. A final policy arc reflects America's attempts to reconcile self-sustenance with civic responsibility, where the 2007 Energy Independence and Security Act and the 2009 American Recovery and Reinvestment Act put forth strong inducements that encourage energy conservation through improving efficiency.

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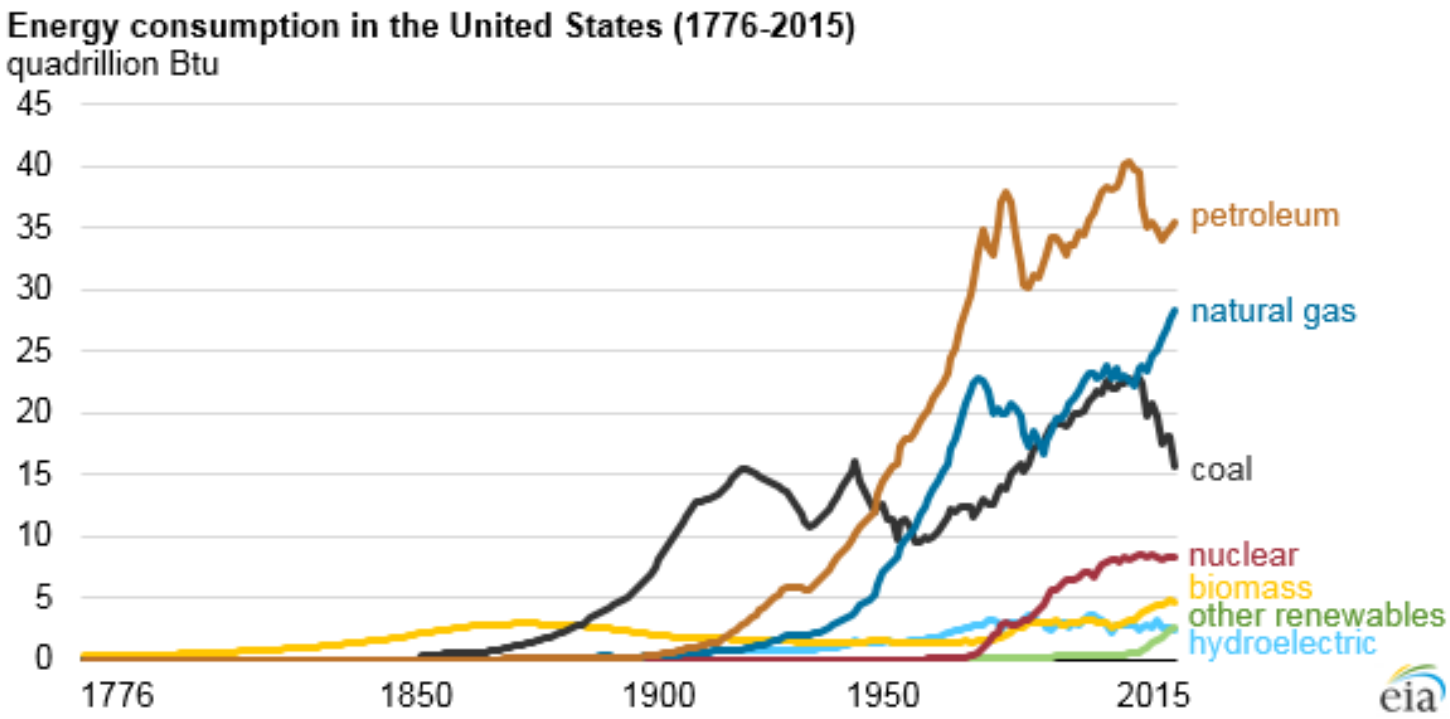

The US is the world's 2nd largest producer and consumer of electricity[33]. However, the delivery of electricity to end users depends on a poorly integrated system comprising generation facilities, substations and transmission grids managed by a fragmented landscape of private and public producers. Most of these facilities are outdated and are likely to become increasingly obsolete due to the pronounced shift in favour of renewable energy and the increasing intensity of usage of electricity. The net result is one of overutilization, which has adverse effects on the cost and reliability of electricity distribution.[34] The cumulative investment gap from 2016 to 2025 is expected to be in the ballpark of $180B, accounting for nationwide costs of replacing the both generation facilities and transmission grids.[35]

Oil and gas is the other vertical which contains a substantial amount of infrastructure. Demand for natural guess is currently driving expenditure outlays in this domain, where consumption has increased by almost 23% from 2006-2016.[36] Expenditure on oil and gas pipelines have thus risen to sustain the higher levels of demand. However, the current organization of infrastructure is vulnerable to external shocks which could induce the need for widespread renewal. Oil refineries and pipelines have been in operation at high levels of capacity in excess of 90%,[37] while failures in certain distribution channels occur on a repeated basis periodically. As funding for oil and gas infrastructure is spearheaded by private investors and supermajors who seek to extract more of the resource, the pace of investment is closely coupled with the price of oil as a commodity. Policy makers looking to stabilise and regulate funding flows should look toward unlocking countercyclical funding sources that are more insulated from oil price fluctuations.

Resource Distribution: Drinking Water

The infrastructure supporting the delivery of clean drinking water to end users is in the form of a network of pipes, with an estimated lifespan of 100 years.

The infrastructure supporting the delivery of clean drinking water to end users is in the form of a network of pipes, with an estimated lifespan of 100 years. Utility performance management systems have averaged a pipe replacement rate of 0.5% per year, equating to almost a 200 year full refresh cycle for replacing the entire network completely. The lag in refresh policies for the water distribution infrastructure results in significant losses of potable water across the entire system, which amount to almost 15% of the water conveyed by the system.[38] Rectifying these systemic flaws would adduce a tremendous amount of cost savings to the system and also improve the quality of drinking water enjoyed by all end users. This is especially important for water, since it is a core amenity that is essential for survival.

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The development of water infrastructure in the United States coincides with the rising trepidation over the state of water quality, which eventually crystallized in the Federal Water Pollution Act of 1948.[39] This catered for a holistic overview of the sector by authorizing state and local governments to undertake comprehensive planning, technical services, research, and financial assistance for sanitary infrastructure from federal sources. Further revisions to the act evolved in 1965 as a response to allegations that the state indifference had prevented the standards prescribed at a Federal level from being established. The unresolved spectre of sewage contamination due to poor infrastructural integrity continued to affect water quality, compelling the introduction of the Safe Drinking Water Act in 1974[40] to regulate public water systems, which mandated scrupulous monitoring of contaminant levels at all levels of government with stern compliance enforced. Recent changes have taken place against a backdrop of increasing privatisation of utility industries to invoke the workings of the free market to stimulate efficiency in funding allocations. The 1987 Water Quality Act substituted the construction grant program with a system of subsidized loans using the Clean Water State Revolving Fund with the aim of easing reliance on federal funding. However, increased demand for clean drinking water has not managed to reverse the growth of federal funds.

Drinking water infrastructure is currently funded on a rate basis which is likely to cause underfunding, since the funding model will not be resized dynamically relative to growing needs. Declining allocations from state governments toward capital expenditure outlay and maintaining the quality of water pipes are likely to compound the severity of the problem. These are sometimes supplemented with federal sources such as State Revolving Funds administered through the Environmental Protection Agency, which is insufficient to bridge the funding gap.[41] While the tempering of demand growth trajectory as a result of water conservation efforts and efficiency savings might be a cause for optimism, it merely foreshadows greater challenges for infrastructure providers. A smaller pool of users subscribing to drinking water means that the fixed costs of providing infrastructure have to be accrue over a smaller paying base, which would require infrastructure providers to pass on the costs to consumers in the form of higher utility charges. To prolong the lifespan of the system, authorities need to start bolstering financial support to water infrastructure systems.

Infrastructure Strategy

Developmental Priorities

There is a particular emphasis on three priority areas, namely roads, public transit and energy systems, not only because these have more aggravated infrastructural inadequacies, but also because they are central conduits for the exchange of goods, services and manpower that underpin many of the integral economic activities that generate growth, boost productivity or create jobs.

Roads, as part of the transportation network, are a key enabler of economic growth distribution and workforce engagement. Compared to other transportation modalities that provide a similar means of connectivity over comparable distances, road construction has lagged substantially behind the level of utilization.[42] According to commonly utilized metrics, quality has also lagged behind other comparable regional systems that are placed on similar growth trajectories.

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Private Sector Led, Bottom Up Infrastructure Renewal

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With non-government sources of investment rising to the fore, the notion that the concentration and immediacy of short term gains necessitates brokering short term consensus across the sectors where they are sited is gaining increasing traction within policy circles. This points toward the heightened likelihood that infrastructure renewal will not just be funded, but more crucially originate from and be driven by bottom up sources. At the White House's Infrastructure Week[43] many of the conversations centred around the differences in local appetites for infrastructure projects of various types and tenors. A recurring theme was also how infrastructure projects would increasingly originate in smaller, more decentralized settings such as that of local government, gradually accumulating size and scale until they required federal resources. Discussions also revolved around the need to accommodate constituent demands within the scope of larger projects, and prominently featured more representatives of local interests from the National League of Cities, and the National Association of Counties.[44] These confirm our instincts that infrastructure strategy will unfold from in a bottom up, decentralized fashion.

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Government Driven Long Term Planning Considerations

Without investment in infrastructure, even against a backdrop of increasing labour productivity or lower raw material costs, economic growth will nonetheless be capped at an upper limit. The difficulty herein is that infrastructure often takes a long time to develop, unlike other resources which can be marshalled at short notice provided the necessary incentive structures and price gradients exist, hence this process needs judiciously drawn out ahead of time to ensure that the structures developed have incorporated a sufficient degree of flexibility to adapt to future economic needs. [45] This is particularly integral in the inclusion of emerging technologies within the construction of infrastructure with longer lifespans, which tend to be prohibitively costly in the earlier stages of implementation since the returns to these can only be realised in the long term.[46]

One way in which such a shift has crystallised is in the ubiquity with which the foundations for digital service provision are being woven into existing infrastructure verticals. Such projects have to be largely driven by government agencies, since they do not independently generate substantive returns through fee for service models, but put in place the requisite mechanics for profit oriented SaaS providers to garner revenue. For instance, to ensure compatibility and provide a conducive environment for network development across systems, policymakers are beginning to place greater emphasis on rolling out urban and rural broadband deployments as a scaffold that can bolster incremental efforts to automate low complexity operational procedures and anchor higher complexity manoeuvres, such as the eventual rise of autonomous vehicles as the dominant transit modality.[47]

Also, efforts to reinvigorate the water infrastructure system have begun to consciously import sensors and IoT ecosystems to track water security, as a means of providing external investors or project managers with a means of accessing such information when making urban planning decisions.[48] The singlemindedness with which digital service enablers are embedded in the current developmental pathways despite the lack of obvious profit theses are an exemplification of government's coordinated push to realise its broader vision of future proofing infrastructure. Despite the overwhelming tilt towards local sources in charting the course of infrastructure development, government still needs to bring to bear its longer planning horizon in driving policy imperatives with tangible public benefit that private providers may be too myopic to pursue.

Facilitating Skills Development and Employment Pathways

The primary impact of infrastructure investment on employment, would be through the injection of labour demand and immediate job creation within the infrastructure sector. Taken in the context of the Trump administration's proposal for a $1tn investment in infrastructure, this would entail the creation of at least 11M jobs over a 10 year horizon, temporarily altering the composition of infrastructure jobs in the workforce to account for 14% of all jobs, up from the present baseline of 12%.[49] Infrastructure spending policy thus needs to be cognizant of the impact of such distortions, and closely calibrate the impact of investment, coupling it with training opportunities with options for progression to ensure that labourers remain gainfully employed even after the construction projects conclude. Early policy responses which have been mooted include compact on the job training packages paired with fungible industry-wide credentials, supplementing the existing pool of training grants with federal financial aid, and aggregating larger cohorts of training participants through online learning platforms.[50]

Private Sector Involvement through Private Public Partnerships (PPPs)

At a juncture when federal funding for infrastructure development is at a historic low, and public sentiment is decidedly wary of increasing government reach through taxes acquire funding, the scale and efficiency of private sector funding make this a palatable option for addressing developmental requirements.[51] These inclinations are mirrored across the US with more states adopting multiple forms of PPP models,[52] resulting in the proliferation of varied payment structures at different stages of maturity. Going beyond traditional structures such as the concessional toll road, PPPs now run the gamut from waste management to social services, and have become so entrenched as to warrant the rise of a secondary market. The barriers to entry for PPP involvement are undergoing systematic erosion, as legislative provisions are permitting the agglomeration of smaller projects into larger vehicles capable of meeting investment targets are steadily being enforced.[53] This was most recently evinced in Pennsylvania's Rapid Bridge Replacement Project, which bundled 558 bridges together to reach a deal size of over $900M.

PPPs can emerge as an engine for change, given that they orchestrate resources in a more efficient manner while mitigating the tax footprint and financial burden on the public. The design of the system, which designates a large portion of construction and operational risks to private entities ensures that private players keep a watchful eye on service delivery and performance, leading to improved outcomes for all parties involved.[54] The National Council for Public-Private Partnerships (NCPPP) postulated that cost savings of 8.5% over the lifetime of an average PPP project when it was transitioned to a PPP structure from wholly public control,[55] with milestone projects achieving all around benefits for the parties involved, such as the 2004 leasing of the Chicago Skyway to Skyway Concession Company which culminated in an 11% reduction in operating costs and the provision of sufficient cash for the city to meet its debt service obligations.

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Also, the complexity of current projects which rely extensively on building reliable integrations with other infrastructure systems means that specialized expertise, which can more readily be found in the private sector, can be brought onboard. Given the mix of driving forces that permeates the stakeholder ecosystem, PPPs negotiate potential incompatibilities in interest by varying the degree of public oversight in relation to private sector led performance management. Government usually claims residual ownership rights, while the private firm finances the construction, maintenance or operation of the project, collecting revenue during a contract period.[56]

Kickstarting Follow on Private Sector Engagement through Asset Recycling

Asset recycling serves as a catalyst that unlocks private funding in support of projects where governments had put up considerable capital outlay, but are not experiencing a sufficiently high intensity of usage to earn a return on the original investment. These arrangements are especially useful if the asset is of strategic importance to the public agency, and is not fully suited for divestment.[57] In addition, these become the subject of renewed interest during periods of austerity, where they are able to latch onto private players interest in securing stakes in infrastructure which has already been constructed to get around concerns over the high level of public debt. Provisions for asset recycling, by way of independent bodies for arbitration and state level infrastructure funds, remain important for optimising public expenditure on assets throughout the economy, thereby unlocking additional sources of funding in the process.

Vice President Pence has notably caught on to the idea, lauding Australia's asset recycling model and emphasizing its achievement to help the Australian government accrue over $850M of budget savings in the 2016 cycle.[58] This signals a possibility the administration may include initiatives that facilitate asset recycling as part of its infrastructure strategy, as a viable countermeasure to the conventional approach of earmarking revenue funds for reliable infrastructure financing, which could be politically untenable.[59] The critical next steps for the administration to delve into would be in assessing the suitability of assets which may generate positive returns to government if included under such a scheme. The finer points of identifying assets which are suitable for this approach would need to be pre-empted. These include ensuring that private lessees possess adequate information to arrive at fair market valuation valuations, and that the fixed assets themselves possess sufficiently attractive revenue streams that warrant private investor attention.

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Feasibility Assessment

Limits on Bottom Up Funding Approaches

Empirical support has also undermined the purported strengths of bottom up funding, spearheaded by either civic organizations or private investors. The Congressional Budget Office discovered that due to variances in implementation, investments which did not originate from government failed to consistently increase the amount spent on infrastructure, or reduce project costs, two of its supposed goals. This led to undesirable instances where private funding with its higher return requirements became a costlier funding source than low yield municipal bonds.[60]

The authors of the report also concluded that PPPs would be superior options to conventional modes of operations such as the design-bid-build approach, finding that private financing would increase the fund quantums and yields, only in cases in which states or localities have chosen to restrict their spending by imposing legal constraints or budgetary limits on themselves, since project revenues were the sole source of funding for infrastructure and no measurable differences in fund deployment efficiencies existed across government and non-government entities.[61]

It is widely acknowledged that PPPs are far more suitable for financing certain infrastructure projects than others, yet adoption rates for this mode of financing have been hampered by a litany of regulatory and stakeholder induced obstacles. They have most commonly been applied to toll roads, where the goals of both private and public stakeholders are best met with the PPP as a facilitative vehicle. Mechanisms such as availability payments[62] structure arrangements whereby private partners have the appetite for and bear financial risk, while national agencies are well served by maintaining control over core parameters that the public interfaces with more frequently such as service quality. These lend themselves effectively to projects where a substantial upfront investment is required from backers, but have a long tailed payback horizon affected by substantial uncertainty. From 1989 to 2011, however, almost 99% of toll road expenditure was not supported by PPPs, suggesting that there are a number of political and operational barriers that stand in the way of PPP model mainstreaming, even though it is viable from a purely economic perspective.

Private Public Partnership Risks

While privatization could bring about efficiency gains, the liberal divestment of decision making authority to private players means that management control from the public sector is compromised, despite the public sector still being held accountable for project outcomes. This could result in additional difficulties in the policy space, should there be a need to insert policy objectives which run counter to profitability into infrastructure development. Hence, the conflation of private and public objectives through financial structures are not devoid of incremental risks. With government paving the way for curtailing private investor risk in projects through heavier public subsidies, tax breaks, federal loans and grants, there is now greater moral hazard clouding the management of such projects, increasing the likelihood that the taxpayers will bear greater costs arising in the form of overruns and bad debt.

Further to that, private entities may rely heavily on legally guaranteed modes of generating returns such as user fees, and may in fact be perversely incentivized to expend their competitive energies on erecting barriers barring potential market entrants from accessing these revenue streams instead of making processes more efficient.[63] This behaviour is seen most commonly in situations where many private investors lobby aggressively for noncompete clauses that limit or ban the development and maintenance of surrounding projects when brokering a deal on a project. Hence, more needs to be done to ensure that the returns from successful projects are distributed symmetrically. Private partners should not reap most of the reward at the expense of taxpayers, who are compromised when the project fails. One of the ways to ensure that the public providers do not get the short end of the stick is through mobilizing public scrutiny and applying it to project design.

Restricted Scope of Private Funding

Despite the widely acknowledged failings of public funding, funds originating from private sources do not necessarily provide a panacea. A key disadvantage is that the incentives motivating private participation are not broad enough to encompass all projects of public interest, thus, exclusive reliance on PPPs or private sources of investment will invariably result in inequitable discrimination against users who lack the ability to pay for the usage of such services.[64]

A large proportion of the nation's unmet infrastructure needs occur outside at the periphery of what the majority of private investors are interested in. These occur in the form of smaller projects involving the operation and maintenance of wastewater or waste management systems, which oftentimes do not generate sufficient returns that meet private investor requirements. Alternatively, private cost recovery mechanisms prove unsuited for large scale infrastructure projects which are carried out in rural areas, where the utilisation levels and purchasing power of dispersed populations of residents are inadequate to sustain continued maintenance or investment.[65]

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Policy Recommendations for Enabling Further Development

Our earlier analysis of the regulatory landscape reveals to us that the way ahead should encapsulate the following shifts in terms of how we approach infrastructure projects:

1. **Enhancing avenues for non-public sources to drive public projects**
2. **Streamlining project approvals and reducing infrastructure project risks**
3. **Deepening capital markets and promoting a more diverse ecosystem of players for infrastructure funding**
4. **Installing coordinating structures to decide on and drive coherent infrastructure strategies**

> **Apart from encouraging private involvement, government should also take an active role in determining how private enterprise should be involved.**

Enhancing Avenues for Non-Public Sources

While nonetheless a viable source of funding which helps bypass the manifold fiscal and political restraints associated with the procurement of public funding, PPPs are hampered from reaching their full potential by a combination of implementation and policy concerns associated with divergent objectives and misaligned incentives, which can hopefully be resolved through effective restructuring to counterbalance and downplay deleterious private motives with more assertive government intervention.

A key detriment cited for private participation or civic involvement in infrastructure projects is that they take on too narrow a view on what constitutes a good project, either from assuming perspective solely driven by profitability considerations, or having an internal calculus disproportionally dominated by short term, locality specific or identity tied benefits. The onus therefore lies on government, which has the capacity to take a centralized view and perceive the state of balance across sectors, to articulate what the priorities for infrastructure are, and shepherd the way in which these meet reality.[66]

To encourage private involvement, government should foremost attempt to level the playing field for private investors, by reducing additional costs or fees which could prevent them from enhancing return to a point that the project becomes feasible enough to undertake. A most direct means of doing so is through considering to renew the Build America Bonds program to increase liquidity in the secondary market, and allowing private activity bonds to benefit from low interest rates and tax advantages so as to broaden participation.

Apart from encouraging private involvement, government should also take an active role in determining how private enterprise should be involved. It can thus marshal the levers at its disposal to design choice architectures that place suitable developments in a more favourable light, herding private players towards developing on these. This could involve steering discussions toward projects which are more closely attuned with the political climate. For a start, instead of extending the status quo of granting tax exempt status to all government funded projects indiscriminately, taxation of funding options with varying roles for private involvement could be reshaped into a continuum that accounts for a set of policy considerations. These should grant equal consideration to parameters that do not figure in profitability assessments, such as social benefit, equity of access, long term cost benefit comparisons, adaptability of infrastructure to future refinements, and strategic importance of the project. Alternatively, contracts could also be designed to allocate additional financial rewards to private owners which have successfully prolonged lifespans or reduced life cycle costs of infrastructure.

PPPs have traditionally encountered greater success in political environments that are less deeply entrenched in partisan conflict, in jurisdictions such as the European Union or Canada. For instance, in the EU, political actors are beginning to come to terms with the flagging ability of the state[67] to support public service provision, and have converged at multiple platforms on the viability of PPPs as a means to avoid this decline.[68] A number of successful PPPs and associated best practices have been enshrined as case studies for subsequent reference, and the growing body of literature on implementation that meets the goals has been instrumental toward future successes. This contrasts with the US, which has not amassed a sizable quantity of prior successes due to a deeper cleavages in political alignment that prevent meaningful progress from occurring.

Streamlining Project Approval and Eliminating Uncertainties

One of the foremost impediments to eliciting private sector participation in infrastructure projects is simply the lack of clarity to potential investors over the availability of investment opportunities which are capable of guaranteeing returns desired over the horizon of interest for such players. While private sector participation and citizen involvement have picked up rapidly over the past decade, the scope of their engagement is still limited to traditional partnership options such as toll roads and bridges, and has yet to be diversified to sectors in dire need of funding or user input that may be less well publicised, such as highway construction, bus service provision or grid extension.

Standardization.

The management of PPPs will involve a number of processes that are common across projects, regardless of the sector they are sited in. This has resulted in the need for harmonising some of these practices into a standard process, ensuring that parties which lack experience in managing PPPs will be able to move up the learning curve quickly from experience gleaned from past projects. Knowledge that would benefit from standardization includes competency assessment guidelines for private contractors, cost evaluation, reporting frameworks for determining when government can intervene in contractor decisions, conditions that private investors need to accede to etc.

Basic legal protections will also need to be enacted to ensure that follow on investment will proceed, such as carving out a sound basis for the project to continue to be in operation, and political risk guarantees to insulate private partners from unforeseen tremors. For private investors or civilian partners, standardization of project assessment in the form of well codified guidelines and clear specifications breeds transparency and understanding, building confidence and a greater willingness to participate in these endeavours. Standardizing project assessment and development therefore becomes an integral process,[69] by reducing the volume of decisions and paperwork that have to be cleared by the program offices in deciding which projects are suitable for more detailed review.

Program Office.

A program office could be kickstarted to focus on gathering information for less popular projects and brokering higher quality matches between public agencies which have identified needs for infrastructure projects, citizens who want to play a more active role in ascertaining what infrastructural priorities exist in their counties, and private investors that span a host of different investment objectives and horizons.[70] For a start, the programme office should embark on a knowledge management effort in archiving and categorizing the entire historical universe of infrastructure projects that lend themselves well to PPP arrangements according to a number of key parameters including risk, profitability, capital outlay, political dependencies, sectoral exposure and deal complexity. Through distilling a heterogenous landscape into a few core archetypes, we maintain that this will considerably simplify the decision-making process for uninitiated stakeholders who might face difficulty in mapping their objectives to the corresponding project.

Aggregated Market Platform for Matching.

Funding should also be directed toward the development of an aggregated platform housing this repository, access to relevant government contacts for addressing queries, and a live 'project market' that aggregates RFPs for infrastructural needs across a variety of industries and clientele. This serves as a conduit for live, current information to be exchanged between project owners and investors, dissolving the egregious informational asymmetries that once have stood in the way better partnerships.[71] It also streamlines the process enroute to making a decision to invest in an infrastructure project, or selecting the right partner for a project that has highly esoteric needs.

Industry reviews analysing the US PPP space have assessed that there are sufficient interested investors, abundant capital, and adequate legislative support from governments to enable projects to be initiated.[72] However, projects are largely not succeeding quickly enough due to the lack of expertise devoted to reviewing how these deals are structured and proposing a suite of viable alternatives.[73] In addition to having offices to directly broker deals, founding a platform intended as a one stop shop for all PPP arrangement related information will accelerate interactions between project owners and investors, and will naturally create a market for expertise capable of parsing the legal, financial and technical intricacies of PPPs. This addresses barriers to key stumbling blocks that prevents deals from materialising.

In delivering a knowledge resource to a cloistered space which curtailed information access on multiple fronts, we seek to lower the likelihood of disappointments in the formation of partnerships, thereby helping to cultivate a more transparent ecosystem of potential partners and transactions.[74] The resultant robustness of the process helps earn the trust of the citizenry, ensuring that the project will proceed with without citizen led roadblocks.

Policy Experimentation

Beyond developing templates of best practices required to support infrastructure projects, government authorities need to acknowledge that they do not have a monopoly on the best ideas and will have to defer decisions beyond their domain of expertise to more nimble players. What government can do, however, is to develop enabling mechanisms which can facilitate the discovery of more best practices and ensure that these are adopted on the largest feasible scale.

Deepening Capital Markets

Ensuring that infrastructure developments are sustainable rests on a compact between society and industry, that political sentiment and profit motive will combine to generate durable, resilient funding streams to support the project over its lifespan. This requires a multi-pronged approach to anchor, where we discuss some pillars below.

Dedicated Funds.

Much of these hinge on developing a robust structure that can prevent other interests from encroaching upon infrastructure related funding, and prudently administering funds accruing from infrastructure usage with an avoidance of mission creep. At the federal and state levels, it is thus important to have funding safeguards that lock in a guaranteed set of public funding sources for infrastructure capacity renewal and expansion needs.[75]

Tax Quantum Reviews.

More importantly, policymakers need to institutionalize a system of reviewing these sources of funds and assess whether they have kept pace with the intended uses of funds. In the infrastructure domain, transportation networks are suffering from funding deficits as maintenance is funded from gasoline taxes, which have not expanded since 1993 despite the rising costs of maintaining older infrastructure. In the transportation domain for instance, current funding sources have to be augmented, where appropriations for the Transportation Investment Generating Economic Recovery (TIGER) grant program,[76] which pumped billions of dollars into a range of multimodal projects nationally could be increased.

R&D Tax Credits.

Government can also look at funding infrastructure research from multiple different angles. To achieve ensure that research can be commercialised, it could look at linking the disbursement of funding to the attainment of hard research milestones that it had set out to achieve. For instance, to ensure that experimentation delivers on a certain set of objectives, policy makers could introduce more R&D tax credits as to sway private providers or research agencies to delve into solutions to problems that already exist in the city.[77]

Loosening Restrictions on Private Sources.

While additional funding options beyond government are already gaining currency, they are oftentimes limited by the regulatory oversight of public agencies.[78] As increasing infrastructure is needed amidst declining federal support, restrictions on private funding should be relaxed in areas of most dire need. Measures such as the Water Resources Development Act are a step in the right direction as they provide greater certainty on the range of scalable financing options available in the short term for project owners, helping localities gain credit assistance more easily for projects that promote innovation. Similarly, policymakers could look into encouraging the wider use of private activity bonds by eliminating state volume caps for water projects.[79]

What government can do, however, is to develop enabling mechanisms which can facilitate the discovery of more best practices and ensure that these are adopted on the largest feasible scale.

Coordinating Bodies

National Infrastructure Bank.

President Obama had earlier proposed a national infrastructure bank to combine both public and private capital to fund improvements.[80] Many have envisioned the bank to function as a focused mechanism which will evaluate new investments impartially with market forces as a yardstick. As a platform, the bank could would be vested with powers to insure the bonds issued by state and local governments, provide subsidies to strategic areas of investment, and issue its own bonds. In this capacity, the bank will serve as a national clearinghouse that charts the direction for infrastructure development, and guides financing to avoid wasteful duplication. It is also likely to catalyse larger waves of follow on investment through verbalising its philosophy of wedding infrastructure development to broader economic enhancements.[81]This idea was first floated in 2008 with a proposed budget of $60B over 10 years by Senators Christopher Dodd and Chuck Hagel, and has seen renewed interest under the current administration, but is generally viewed with caution in policy circles since it threatens to immerse infrastructure funding decisions in partisan interests. The notion of the bank has also garnered a considerable amount of attention in the 114th Congress, taking the form of 5 disparate proposals.[82] These have rallied behind the position that the bank should be a wholly government owned corporation and focus on providing loans and guarantees in the domain of transportation and energy sectors, while diverging in terms of the initial magnitude of funding that the Bank should appropriate.

Nascent developments already exist under the ambit of the Department of Transportation which address some of the basic functions of an infrastructure bank, such as providing liquidity and transition financing to worthy projects that bring about net positive externalities. The Transportation Infrastructure Finance and Innovation Act (TIFIA) has funded at least 12 multimillion dollar projects dispersed across the United States, while the Railroad Rehabilitation & Improvement Financing (RRIF) has funded over $5.1B of rail road infrastructure development.[83] For other domains that deal with smaller projects, a patchwork of initiatives exists to cater for end user expenditure requirements. The Water Infrastructure Finance and Innovation Act, Federal Energy Management and Private Activity bonds all provide funding pipelines that can be calibrated and customised to individual user needs within specific domains. The challenge lies in pulling all these disparate strands together under the umbrella of a coherent strategy which allocates funding across sectors according to guiding principles. For instance, the implementation of a car-lite strategy by an infrastructure bank can be buttressed by increasing taxes on individual road users while subsidising buses / public transportation. The oversight and deconflicting of countervailing forces is possible only under the watchful eye of a coordinating infrastructure bank. As the administration plans to set in motion a trillion dollar infrastructure plan that will be funded by a plurality of stakeholders espousing varying interests, an infrastructure bank becomes critical in its role to promote synergies between funding deployments. The bank can also assume a more proactive stance in soliciting funding from the private sector.

The existence of a national infrastructure bank would also pave the way for a unified framework through which all infrastructure projects could originate from. This directly resolves one of the key bugbears by streamlining previously lengthy and opaque project approval processes, since lengthy and complex approval processes could deter investors who have a limited horizon for acquiring a specific project. This framework could dictate the minimum level of regulatory oversight required by each project, thus eliminating the need for projects to be held back by unnecessary, additional federal regulations that could result in further delays.

Test Beds for Infrastructure Solutions.

In markets characterised by intense competitive pressures, small firms often lack the appetite to proceed with research and development projects, due to the uncertainty of obtaining returns and the high capital outlays required in comparison which affect profitability. This creates policy space for local/ state governments to chart the research direction, and further rationalise across mutually exclusive spending priorities. They are better positioned to set aside test beds for infrastructure solutions using resources at their disposal, since they are most acutely familiar with pressing areas of need within their jurisdictions. With the weight of larger bureaucracy behind them, policymakers could also engineer regulatory sandboxes that enable a more rigorous and rapid solution evaluation process by setting aside spaces for users to engage solutions across a wide range of use cases.84 Projects such as autonomous vehicle usage or smart grids with peripheral generation and storage would benefit from a more rigorous user testing approach, since they operate on certain assumptions of user behaviour to function effectively.

> **The existence of a national infrastructure bank would also pave the way for a unified framework through which all infrastructure projects could originate from.**

Conclusion

While observing the infrastructure planning landscape, it is important to hold on to the thought that these projects are not executed within a vacuum.

Each project or funding strategy pursued will have knock on effects on a series of other policies in the social and economic domains, with profound consequences for future generations. Despite a conducive socio-political climate where there is now unprecedented public enthusiasm and untapped funding, we need to be equally cautious in determining how we would go ahead harnessing these incrementally, developing them in a manner that will ensure sustainable progress over the long run.

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