Not Everything Is Broken

The Future of U.S. Transportation and Water Infrastructure Funding and Finance

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Cover: The cover image, taken by U.S. Army Corps of Engineers photographer Mark Rankin, is of Chickamauga Lock and Dam, which is located seven miles North East of Chattanooga, Tenn., and was completed in 1940. The lock is owned by the Tennessee Valley Authority and operated by the U.S. Army Corps of Engineers. A project to replace the now-deteriorating lock began in 2003 and is scheduled for completion in 2023.

Preface

Federal investment in infrastructure has been receiving more attention than usual since the Trump Administration and new Congress took office in January 2017. Not surprisingly, the debate is largely about money: how to finance repairs, new roads, and other projects without adding to the deficit, either by direct public spending or tax credits. Less discussed but no less important are issues concerning the policies that support the mature and urban-centered economy that the United States has now—rather than the economy it had decades ago, when most of the current terms of federal engagement were set. These issues are the focus of this report.

We frame the infrastructure debate around the case for modernizing federal policies related to funding, finance, and project selection; recognizing the centrality of regional initiatives that transcend local government and state boundaries; and understanding different types of financing—public, private, and public-private partnerships. The premise is that if compelling public benefits can be articulated and financial incentives properly aligned on both the public and private sides, appropriate investment and maintenance will follow. Poorly targeted investment comes from poorly designed policy. Inadequate maintenance often is a symptom of management and governance issues. This report examines current policy and considers possible improvements. Our intended audience includes members of Congress and their staffs, and other public officials and their staffs at the local, state, and federal levels; private investors and organizations committed to public-private partnerships; and the interested public.

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RAND Infrastructure Resilience and Environmental Policy

This research reported here was conducted in the RAND Infrastructure Resilience and Environmental Policy Program, which performs analyses on urbanization and other stresses. This includes research on infrastructure development; infrastructure financing; energy policy; urban planning and the role of public-private partnerships; transportation policy; climate response, mitigation, and adaption; environmental sustainability; and water resource management and coastal protection. Program research is supported by government agencies, foundations, and the private sector.

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protection, public and occupational safety, energy policy, science and innovation policy, space, and telecommunications.

Questions or comments about this report should be sent to the project leader, Debra Knopman (Debra_Knopman@rand.org). For more information about the Infrastructure Resilience and Environmental Policy Program, see www.rand.org/jie/irep or contact the director at irep@rand.org.

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Summary and Recommendations

Infrastructure has become a popular topic, fueled by a widely held perception among the general public and many elected officials that the nation's infrastructure is crumbling as a consequence of age and underinvestment. In fact, not all transportation and water infrastructure in the United States is falling apart—far from it. While highway, bridge, and water system maintenance backlogs exist in many places, the data do not support a picture of precipitous decline in total national spending or in the condition of the assets. Rather, the U.S. infrastructure story is far more nuanced and challenging.

The purpose of infrastructure is to improve worker and business productivity and social welfare. Money alone will not accomplish this goal; policy changes will also be required. Large infusions of direct federal spending or tax credits to repair or build anew may do some good by stimulating demand for construction services—even if the projects do not advance long-term priorities or address differing needs across the country. The federal government should focus its policies on incentivizing increased public and private spending on maintenance and modernization where it is needed.

But increased spending will not fix what is broken in our approach to funding and financing public works—and not everything is broken. State and local governments are in the best position to make needed improvements in the way struggling public transit and most other infrastructure systems are governed. But the federal government has a role to play in more ambitious regional initiatives to benefit the nation as a whole. Understanding the particulars of where help and resources are needed should guide Congress, states, and cities in their deliberations on policy changes, tax changes, and budgeting.

Core to understanding the problem is knowing who or what is responsible for a failure to meet demand for improved infrastructure services. While the federal government has historically played a large role at times, state and local governments shoulder the majority of the burden. In 2014, state and local governments accounted for 62 percent of capital expenditures and 88 percent of operations and maintenance (O&M) spending for transportation and water infrastructure (Congressional Budget Office [CBO], 2015). While transportation and water infrastructure are rarely considered together from a policy perspective, these two large infrastructure sectors share characteristics that are particularly relevant in today's policy debate: dominant public ownership, extensive use of tax-exempt financing, and a tangled web of federal involvement.[1] These patterns stand in marked contrast to the energy, telecommunications, aviation, and freight rail sectors, which are dominated by private firms. In this report, we iden-

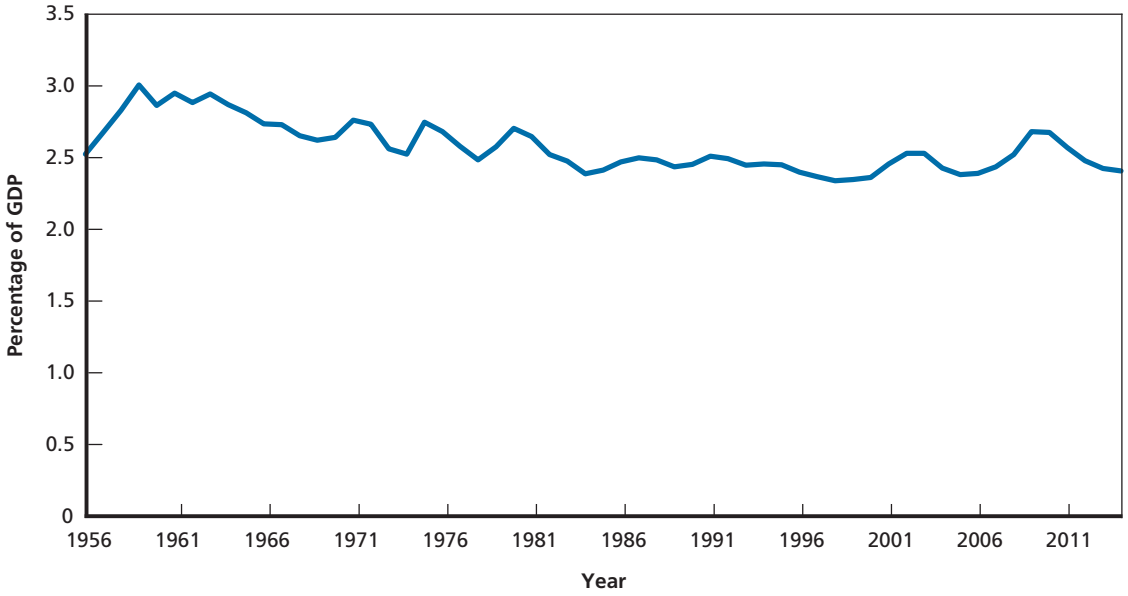
[1] We use definitions consistent with those applied by CBO (2015). Water infrastructure includes containment systems (dams, levees, reservoirs, and watersheds), sources of freshwater (lakes and rivers), and water utilities (supply and wastewater treatment facilities). Transportation infrastructure includes highways (including bridges and tunnels), mass transit, rail, aviation, and water transportation (ferries, inland waterways, and coastal ports).

tify the policies that promote and deter sustainment of and investment in U.S. transportation and water infrastructure and suggest steps to better align them to public priorities.

Over the past 60 years, public spending on infrastructure has generally tracked the growth of the U.S. economy. Total public spending on infrastructure as a share of gross domestic product (GDP), normalized in 2014 dollars, has been relatively stable since 1956, as shown in Figure S.1. Whether spending levels are adequate depends on the specifics.

Between 1964 and 1980, total public spending on highways decreased as a percentage of GDP and has been relatively flat since then. Spending on mass transit, rail, water resources, and water utilities as a percentage of GDP increased or remained relatively flat between 1980 and 2014, as shown in Figure S.2. Federal capital spending on highways has been declining for decades since the building of the Interstate Highway System in the 1950s and 1960s, even as total vehicle-miles traveled has been increasing. For both transportation and water infrastructure, total public spending and spending per capita generally rose until the 2008 financial crisis, and there is ample evidence that spending has picked up again in many places. By the end of 2016, municipal bond issues were at their highest levels ever, more than doubled from 1996; however, uncertainty in federal policy has driven bond issues down in 2017. Industry analysts project that spending in the water and wastewater utility sector alone will exceed $532 billion over the next ten years, a 28 percent increase over the previous decade (Nabers, 2016). If this new spending materializes at a rate of around 2.5 percent annually above inflation, the spending shortfalls in the water sector projected by the American Society of Civil Engineers (2013) and others would largely disappear. The U.S. Department of Transportation (DOT) projected that increasing spending on highways and bridges by around 2.8 percent

Figure S.1
Total Federal, State, and Local Spending on Infrastructure, 1956–2014, as a Share of Gross Domestic Product



SOURCE: CBO, 2015, Exhibit 3, p. 10, based on data from the White House Office of Management and Budget (OMB), the U.S. Census Bureau, and the U.S. Bureau of Economic Analysis.

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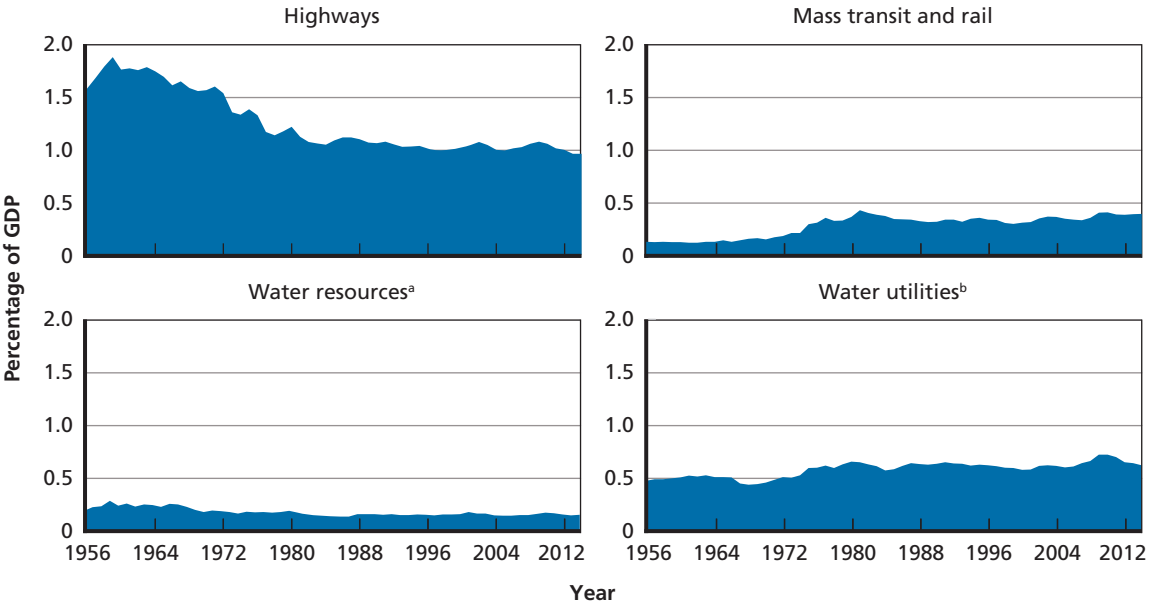
Figure S.2
Public Spending on Transportation and Water Infrastructure as a Share of Gross Domestic Product, by Type of Infrastructure, 1956–2014



SOURCE: CBO, 2015, Exhibit 15, p. 25, based on data from OMB, the U.S. Census Bureau, and the U.S. Bureau of Economic Analysis.
[a] Includes water containment systems (dams, reservoirs, and watersheds) and freshwater (lakes and rivers).
[b] Includes water supply and wastewater treatment facilities.
RAND *RR1739-S.2*

annually above inflation through 2032 would eliminate the projected maintenance backlog (DOT, Federal Highway Administration and Federal Transit Administration, 2016).

In fact, the perception that U.S. infrastructure needs are not being met, which animates so much of the debate over spending, requires reexamination. These "needs gaps" are calculated in different ways. For water infrastructure, some needs are derived from estimates of repair frequency required to maintain a regulatory standard, given factors such as population growth and age of the system. Other estimates use survey data to collect information on self-reported costs of planned future projects. The adequacy of pricing and cost-recovery methods across state and local governments can alter the view of needs as well. The bottom line is that needs assessments offer an unreliable guide for policy and priority setting.

State and local O&M spending for both highways and water infrastructure has risen steadily since at least 1956. The system of financing new and major rehabilitation projects through public borrowing and, to a much lesser extent, some version of public-private partnerships (PPPs) is generally working for projects that fall within single states and local jurisdictions and for which revenues are sufficient to cover debt service and ongoing O&M costs. Infrastructure tends to be well maintained and modernized in areas where local and regional economies are thriving, good governance is the rule, and revenue streams for sustainable O&M cost recovery are in place.

Elsewhere, problems persist that defy easy solutions:

- The federal Highway Trust Fund and the state funds for drinking water and wastewater treatment plants have not been operating on a sustainable basis for some time now.
- Congestion on some interstate highways and freight transportation systems hurts regional economies.
- Without operating subsidies, mass transit systems have a hard time paying their way.
- Critical infrastructure problems that cross jurisdictional lines, like the proposed Gateway rail tunnel under the Hudson River between New Jersey and New York, are proving difficult to resolve through existing governance arrangements.
- Communities with declining tax bases struggle to maintain their roads, bridges, and water systems and repay their debts to bond holders.
- Some communities are at risk of flooding from structurally compromised dams and levees, coastal communities are at risk from rising seas and changing patterns of precipitation, and many communities are vulnerable to flooding from undersized and aging storm water systems.

Each place has its own blend of issues with infrastructure maintenance or investment, economics or governance. Dysfunction arises from many sources. An across-the-board ramp-up of federal spending is unlikely to solve the infrastructure problems that need fixing—regardless of whether the money comes through direct funding, tax credits to private developers, or a combination. Lasting changes will require thoughtful consideration of targeted spending priorities, policy constraints, and regional differences.

Though state and local governments are responsible for many pieces of this mosaic, Congress could take a number of steps in conjunction with states, local governments, and the private sector to improve the condition, funding, and sustainability of U.S. infrastructure (see text box).

To maintain stable financing for infrastructure, **Congress should preserve the federal tax exemption on interest earned from municipal bonds for at least the next decade.** During this period, lawmakers should **reinstate taxable Build America Bonds (BABs) and experiment with other financing alternatives**. The aim is to draw as much capital into infrastructure as the market demands without the distortion of tax policies that favor one class of investors over another.

Tax-exempt municipal bonds are an inefficient means of subsidizing local government borrowing for infrastructure projects. Still, the $3.7 trillion market for these bonds provides stable financing to local governments. In the interest of continuity, tax-exempt municipal bonds should be kept while alternative funding mechanisms are given a chance to develop. Congress successfully experimented with BABs in 2009 and 2010. These offer one potential alternative. BABs can be structured to be revenue-neutral. Public pension funds and other investor classes receive no benefit from municipal bonds' tax exemption because they have either no or low tax liabilities. But BABs would allow their "patient" capital to be put to work funding low-risk infrastructure projects with long payback periods and competitive returns.

Therefore, BABs should be reinstated for a ten-year period with the assurance that the subsidy, at whatever level set by Congress, will be honored over the life of the bonds. At the end of the ten-year period, Congress should assess the impacts on state and local infrastructure spending and the federal budget and determine whether to maintain the status quo, make BABs permanent, or cap or eliminate the municipal bond exemption.

Ten Recommendations to Congress on Infrastructure

Tax-Exempt Bonds

Preserve the federal tax exemption on interest earned from municipal bonds for at least the next decade. Tax-exempt municipal bonds are needed to give state and local governments continued stable access to capital while alternative financing mechanisms are developed.

Taxable Bonds

Reinstate Build America Bonds with taxable interest for a ten-year period and experiment with other financing alternatives. Draw as much capital into infrastructure as the market demands without the distortion of tax policies that favor one class of investors over another.

Sustainable Revenues for Transportation

Support further state experimentation with approaches to mileage-based fee collection, with an eye toward transitioning to a new federal system that more effectively links revenue collection to highway use.

Long-Term Priorities

Target longer-term projects likely to produce significant national benefits. Fund transportation and water improvements that will increase productivity and resilience over merely "shovel-ready" projects.

Capital

Focus on capital investment, including major investments in renewal of aging infrastructure and new infrastructure incorporating advanced technologies. Make life-cycle cost analysis and sustainability of investments through appropriate pricing and cost recovery a condition of future federal transportation and water funding for state and local governments.

Maintenance

Prioritize maintenance of federal assets, such as mission-critical military bases, dams, levees, locks, national parks, and other vital federal infrastructure.

Resilience

Make resilience to natural disasters and adaptation to rising seas, increasing flood frequency, and other changing climate impacts a condition for capital spending for the purpose of reducing future federal spending on disaster assistance.

Efficiency

Streamline the regulatory review process among multiple federal agencies. Efficiencies can be gained while honoring environmental and safety standards.

More Efficiency

Consolidate the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation into an integrated national water resource agency.

Innovation

Fund competitive grants for research, development, and deployment of new technologies. Expand existing grant programs to stimulate innovation in engineering, construction, maintenance, and operations of transportation and water systems.

"Shovel-ready" projects are not necessarily priority projects. Rather than using "shovel-ready" as the criterion for federal capital investment in nonfederal assets, as was done in the 2009 stimulus package, Congress should instead target longer-term projects likely to produce significant national benefits. Congress should work with the White House, states, and local governments to generate a list of regional infrastructure investments that would increase productivity and bring demonstrable improvements in transportation and water services. Each proposed project should undergo rigorous, transparent benefit-cost and life-cycle analyses to enable ranking of projects based on consistent estimates of multistate or national-level net benefits. For example, passenger connections among rail, transit, and airports and freight connections among trucks, rail, and ports are critical nodes in the U.S. transportation infrastructure. Improvements could offer real economic gains in the form of higher economic productivity. Priority should be given to projects with compelling multijurisdictional health, safety, and environmental benefits and to those state and local governments that work together to identify their top priorities for federal capital spending. Federal funding would be conditional on regional sponsors securing matching funds from any combination of public and private sources, including user fees and taxes when appropriate.

The federal government should focus its capital investment on major investments in renewal of aging infrastructure and new infrastructure for the coming decades. To this end, Congress should make life-cycle cost analysis and sustainability of investments a condition of future federal transportation and water funding. Not everything that has ever been built warrants perpetual maintenance. Some infrastructure may need to be dismantled in response to changing demographics, economics, or public priorities. Under our system of federalism, state and local governments are empowered to make their own choices on these matters. However, federal infrastructure spending should be conditional on state and local governments demonstrating their ability to maintain new or renovated assets. Assuming existing infrastructure is worth maintaining, more capital spending enabled by the federal government in the absence of sustainable O&M funding for existing assets will make matters worse for local governments struggling to make payments on existing debts.

Congress should place its highest maintenance priorities on vital federal assets. The federal government has a responsibility to properly maintain its own vast infrastructure managed by the U.S. Department of Defense, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the National Park Service, and other agencies with resource management and national security responsibilities. Priorities for direct federal spending should be set based on public safety, national security, and national economic and environmental benefits. Examples include mission-critical military bases and federally owned dams, levees, locks, and national parks and recreation areas around national forests, wildlife refuges, and historic sites.

Congress should require each agency to report on its estimate of funding needs over the next 25 years to sustain the infrastructure under its jurisdiction. Agencies should be required to describe the analytical process by which they have chosen whether to maintain, recapitalize, perform only minimal maintenance, or divest their holdings. This would be the foundation of a federal capital budget to be updated on an as-needed basis.

Congress should condition capital funding on state and local governments' efforts to incorporate resilience to natural disasters and adaptation to rising seas and other climate trends. The dollar value of damage from extreme weather events has quadrupled in real terms over the past four decades. New spending creates an opportunity to make design changes in old infrastructure or rethink infrastructure concepts entirely to meet new condi-

tions. Following the lead of many states and cities, Congress should embed resilience guidelines in federal infrastructure investment through statutory means. Well-executed resilience measures have the potential to constrain or reduce spending on the growing federal cost of disaster assistance, which the U.S. Government Accountability Office (GAO) estimated to have been at least $277 billion between fiscal years 2005 and 2014, and is likely to rise in the future (GAO, 2016).

Congress should support state and local governments in their development of common standards for structuring public-private partnerships. The U.S. experience with PPPs in the realm of transportation and water infrastructure has been mixed, with success largely hinging on the skill of state and local negotiators in balancing the benefits and financial risks to the public. From the perspective of private investors, the market for such investments is fragmented and fraught with political risks and uncertainties in project timing. Navigating different rules across the states is a burden on investors and adds to political uncertainties. The federal government could provide technical assistance and help with tax issues and permitting processes.

The federal government should streamline regulatory approval processes involving multiple federal agencies while honoring applicable environmental, health, and safety standards. Consensus-building around major infrastructure investment is a challenging business in a democratic society when multiple public objectives are in play—and often in conflict with one another. As part of the U.S. system of checks and balances on government power, administrative processes are designed to enable stakeholders to engage, review, and intervene in regulatory decisions on grounds of protecting health, safety, and the environment. Trying to circumvent public participation and undermine widely supported protections and standards in the name of speeding up infrastructure projects can result in delay or gridlock. But sometimes multiple agencies regulate sequentially and without coordination. Experience has shown that efficiencies can be gained by consolidating information gathering and organizing collaborative, concurrent public outreach and review processes among agencies, as recommended in 2015 by the Build America Investment Initiative Interagency Working Group.

Congress should end the historical division of the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation and consolidate them into a single federal water resource agency. Consolidation would impose consistency in exercising the federal role in water infrastructure and its maintenance; enable a more integrated and fair approach to water resource management in partnership with states, local governments, and other stakeholders; and bring the water infrastructure programs of the two agencies under the same congressional oversight. Consolidating the transportation modal administrations into a more unified and integrated U.S. Department of Transportation also might be more efficient, but would likely be more difficult to implement because of the multiplicity of private and public interests and regulatory responsibilities served across the various modal administrations. Government reorganizations come with large costs. These costs need to be carefully weighed against the potential benefits of consolidating technical expertise and encouraging integrated water resource and transportation management.

Congress should place some big bets on research, development, and deployment of new technologies to support infrastructure construction and maintenance. We propose an infrastructure research agenda that would build on the competitive peer-reviewed grant mechanisms already in place with the Transportation Research Board. This should be expanded into an integrated infrastructure research program that crosses sectoral lines and

coordinates the needs and resources of individual agencies across the federal government. The agenda would stimulate the development of new concepts of provisioning of infrastructure and improve building methods and materials, engineering designs, cost-effectiveness and efficiency, and all aspects of system operations.

Widespread adoption of newer construction methods, more durable and sustainable materials, and sensor technologies could have a profound effect on the calculus of infrastructure maintenance. Advances have been made in new materials that could extend the lives of roads, bridges, and pipes. New road coverings have been developed and are in use elsewhere in the world. Sensors could help pinpoint maintenance needs and operational concerns. Road technologies must adapt to the age of driverless vehicles. Smart roads, long a dream of transportation experts, are not far away: We already have ground-penetrating radars and embedded sensors that can report on the condition of infrastructure in real time. Current policies and funding mechanisms will require changes to encourage more transitional experiments and pilot projects.

Improving the capacity to govern and make analytically supportable decisions across jurisdictional lines ought to be a research priority as least as high as those topics above relating to new technologies. Research in the social and behavioral sciences could help to inform changes in how local, state, and regional governmental bodies tackle the difficult cross-jurisdictional decisions on infrastructure operations and investment.

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CHAPTER ONE

Introduction

Infrastructure has become a popular policy topic, fueled by warnings that the nation's infrastructure is "crumbling."[1] Government underspending is usually cited as the cause of deteriorating highways, bridges, rail lines, dams, and water supplies (Appelbaum, 2017). The typical remedy is to increase public spending, with the federal government leading the way (Office of Hillary Rodham Clinton, 2017; Donald J. Trump for President, Inc., 2017). An alternative to new federal funding, advocated for a time by President Donald Trump, is to provide tax credits to private investors.[2]

Many economists and public officials, joined by the construction industry and trade unions, say that rebuilding or building new infrastructure will stimulate the national economy by boosting demand and increasing efficiency, put people back to work, and revitalize cities and towns (Myers-Lipton, 2009, 2015). At a time of historically low interest rates and low fuel costs, which lower construction costs, infrastructure spending is an attractive proposition. Other economists caution, however, that some of these prospective benefits are likely to, at best, be modest and short-lived, and, at worst, lead to misallocation of capital—particularly in a mature economy whose networks of highways, rail, and other infrastructure have largely been built out (Popper and Gates, 2016). They point out that what is needed most is basic maintenance and repair of the infrastructure we already have and plans to raise enough money to keep it viable in the long term (Jaffe, 2016).

Largely missing from the current debate are clear and compelling answers to three fundamental questions:

- Why is demand for better-maintained infrastructure and new investment not being met under current policies, funding, and market conditions?
- What are efficient and equitable ways to identify and act on regional and national infrastructure priorities?

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[1] Typical headlines: "Falling Apart: America's Neglected Infrastructure" (Kroft, CBS News, November 23, 2014; "America's Infrastructure Is Crumbling: Shortfalls in Investment will Lead to Fewer Jobs, Gridlock, and Inevitable Catastrophe," (Dennison, *Slate*, October 7, 2013). The opening phrase of then-President-elect Trump's infrastructure plan was "Transform America's crumbling infrastructure" (Donald J. Trump for President, Inc., 2017).

[2] Then-President-elect Trump stated that $8 billion in "infrastructure tax credits" will generate $226 billion in private investment in infrastructure (Donald J. Trump for President, Inc., 2017). President Trump's fiscal year (FY) 2018 budget calls for $200 billion in "new" direct spending and $206 billion in budget cuts to existing infrastructure programs (The White House, Office of Management and Budget [OMB], 2017). In late September 2017, the President told members of Congress that he was abandoning this plan (Newmyer and Paletta, 2017).

- What strategies are likely to improve on current practice, and what policy changes, primarily at the federal level, could remedy some of the problems identified?

In this report, we seek to answer these questions in a way that can inform federal and state efforts to modernize outdated policies and stimulate productive investment. This report is not a catalogue of national infrastructure needs—which it turns out are difficult to estimate in the absence of clear policy and evaluation criteria. Rather, we examine the status of and trends in infrastructure spending and policies that promote or deter investment, and consider actions that could better align policies to public infrastructure priorities. To the extent that demand for more and better-maintained infrastructure *is* outstripping supply, we hypothesize that this is a symptom of pricing and other policies in need of change, as well as local economic conditions.

We focus on transportation and water infrastructure for three reasons. First, most spending on transportation, water, and wastewater infrastructure is done by the public sector, and these are the structures whose status dominates the public debate about underinvestment. The private sector's role is diverse but limited, ranging from loaning money to governments to finance construction to footing the bill in exchange for the ability to collect user fees or other benefits. (In contrast, private investors dominate infrastructure spending for energy, telecommunications, and freight rail.) Second, transportation and water are the sectors in which the federal government has historically played a dominant role in funding, policy, and regulation. Third, Congress and the states tend to treat transportation and water infrastructure policy and funding as separate issues, but we aim to show that there is value in comparing and contrasting the federal role in these sectors and asking whether their differences can still be justified. Finally, the White House and Congress are considering omnibus tax and spending proposals that would apply across infrastructure types.

The next section of this chapter describes how issues related to infrastructure are typically framed according to varying perspectives. We then briefly describe the analytic methods used to delve deeper into the problem, and outline the remainder of the report.

U.S. Infrastructure: What *Is* the Problem?

The problem with infrastructure in the United States is often cast as one of underinvestment: Public and private spending is less than it should be, given the known benefits of improved economic productivity that would accrue. In 2014, the Department of the Treasury painted a grim picture of the consequences of underinvestment (U.S. Department of the Treasury, Office of Economic Policy, 2014, p. 1; footnotes are from the original):

> The costs of underinvestment in infrastructure are massive. Drivers in the United States annually spend 5.5 billion hours in traffic resulting in costs of $120 billion in fuel and lost time.[3] U.S. businesses pay $27 billion in additional freight costs because of the poor conditions of roads and other surface transportation infrastructure.[4] The electric grid's low resilience leads to weather-related outages that cost the U.S. economy between $18 bil-

[3] National Economic Council and President's Council of Economic Advisors, 2014.

[4] National Economic Council and President's Council of Economic Advisors, 2014.

lion and $33 billion each year, on average.[5] Due to continuing deterioration of water systems throughout the United States, each year there are approximately 240,000 water main breaks resulting in property damage and expensive service interruptions and repairs.[6]

These numbers matter because persistent underinvestment in infrastructure could be a drag on the U.S. economy.

The American Society of Civil Engineers (ASCE) estimates that there exists a $2.1 trillion gap between spending and "need" for transportation infrastructure and a $257 billion gap for water infrastructure for 2016 through 2025 (ASCE, 2016).[7] ASCE further estimates that failure to make the investments it identifies will trim $4 trillion off of the U.S. gross domestic product (GDP) between 2016 and 2025. ASCE also suggests that the burden of the underinvestment falls disproportionately on the most disadvantaged communities, with an average annual loss of $3,400 per household (ASCE, 2013b). These losses, according to ASCE's researchers, come from higher costs of goods and services, lower employment due to increased business costs, and slower commutes for individuals.

The Department of the Treasury's and ASCE's numbers are of course conditional on many assumptions, most importantly on how much of existing U.S. infrastructure actually warrants continued maintenance, how much should be substantially rehabilitated or rebuilt, and how much new investment should be made to support economic growth and increased productivity. Each of these assumptions requires deep knowledge of the particulars of the infrastructure itself, the community and region where it exists, and larger economic and technological conditions and trends. The past is not necessarily prologue when it comes to maintenance and investment in infrastructure.

Who Pays for Public Works, and Why?

Core to understanding the infrastructure problem in the United States is understanding who or what is responsible for the investment and maintenance and how we know whether the United States as a whole or cities, states, and regions in particular are spending too little, the right amount, or too much. Markets answer these questions for the vast majority of investments in the economy, but the kinds of infrastructure we call "public works" cannot always meet a market test that would make them attractive to private investors. When they do, there is no compelling reason for scarce public capital to displace abundant private capital, as long as public interests are served and protected in the process—a critical caveat. Public works projects, at their best, generate benefits across a broad set of public objectives, but these benefits can be diffuse and difficult to monetize. This defining feature of public works is also a challenge: Partial or even full cost recovery is achievable through user fees, but in many places this is politically unpalatable (World Bank Group, Public Private Partnership in Infrastructure Resource Center, 2016; Ivory, Protess, and Palmer, 2016).

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[5] President's Council of Economic Advisors, U.S. Department of Energy, and White House Office of Science and Technology, 2013.

[6] U.S. Department of the Treasury and U.S. Department of Transportation, Build America Investment Initiative Interagency Working Group, 2015.

[7] ASCE defines transportation infrastructure as including surface transportation, airports, and rail. ASCE defines water infrastructure as including water and wastewater infrastructure, levees, dams, inland waterways, and marine ports. ASCE's definitions of transportation and water infrastructure differ from CBO's definitions.

In the United States, infrastructure has been financed and built with public funding, private capital, and, in some cases, a mix of funding sources. State and local governments currently shoulder the largest burden: In 2014, 62 percent of capital expenditures for transportation and water infrastructure and 88 percent of spending on operations and maintenance (O&M) came from state and local governments (Congressional Budget Office [CBO], 2015).

While some infrastructure can be financed privately when revenue streams can be readily identified and tapped to pay bond- or shareholders (common practice for the heavily regulated sectors of electricity, telecommunications, rail, and water distribution), the vast majority of transportation- and water-related projects produce more diffuse economic and social benefits that cannot be fully or easily captured through direct charges, taxes, or user fees (U.S. Department of Transportation [DOT], Federal Highway Administration, Office of Innovative Program Delivery, 2013; DeGood, 2016). In these cases, federal, state, and local governments increasingly turn to general revenues collected through income, sales, and other types of broad-gauge taxes to fund these investments directly or through provision of tax credits (Henchman, 2014). The justification is that all taxpayers indirectly gain from broad economic benefits that accrue from a project.

Patterns of finance and funding of infrastructure are diverse, as illustrated by a few examples. Most of Interstate 95 was built with 90 percent of its funding from the federal Highway Trust Fund, fed by taxes on motor fuels collected from motorists throughout the country, and 10 percent state trust funds and general revenues. Other parts of I-95 are old toll roads, financed and built by states before the Federal-Aid Highway Act of 1956 (Pub L. 84-627) was passed (Weingroff, 2015). The rebuilding of the earthquake-damaged Bay Bridge between San Francisco and Oakland was funded by tolls on motorists using bridges in the Bay Area and additional general funds from the State of California; no federal money was used (California Department of Transportation, 2016). The federal government subsidizes intercity passenger rail (Amtrak). The renovation and modernization of Washington, D.C.'s Union Station in the 1980s was funded through the largest public-private partnership (PPP) undertaken up to that time (National Council for Public-Private Partnerships, no date).

City water supply and distribution systems are typically financed using municipal bonds paid from fees on residents and businesses based on their water use (U.S. Conference of Mayors, Mayors Water Council, 2007; Copeland, 2016). The federal government's role in city water supplies is minimal in the eastern United States—but dominant in the western states through the massive public works projects of the U.S. Bureau of Reclamation (BOR) and its provision of municipal water supplies for cities including Phoenix, Denver, Las Vegas, and Salt Lake City (Reisner, 1986).

Ownership and maintenance arrangements are similarly diverse. Some infrastructure is operated and maintained by public agencies, and others by private firms. In Allegheny County, Pennsylvania, operation of the Pittsburgh Water and Sewer Authority was outsourced to a French company called Veolia (Lurie, 2016), an arrangement that has since ended. In contrast, the county's sewer authority (ALCOSAN) functions as a consortium of 83 jurisdictions in the county, including Pittsburgh. Bridges are maintained by many local jurisdictions. The freight rail lines running through Pittsburgh are in private hands, whereas waterways around the city are maintained by the U.S. Army Corps of Engineers (USACE).

Pinning down who is responsible for spending or underspending on infrastructure is more complicated as a matter of public policy than first meets the eye.

Often-Cited Supply-Side Issues

Many arguments have been advanced over the years to account for the perceived inadequacies of transportation and water infrastructure. Some of these arguments relate to constraints on the supply side.

Concerns About the National Debt

Infrastructure is expensive. Over the past several decades, debates framed around the adequacy of public spending on infrastructure have soon become arguments about raising taxes or increasing the deficit. However, there are economic costs to focusing on the size of public expenditure to the exclusion of closer scrutiny of policies and practices that impose a drag on investment (Berman, 2015; Hornyak, 2013; Morrow, 2016).

It took the financial crisis of 2008 to spur the last spike in spending on infrastructure. In 2009, the Obama Administration reached agreement with Congress on a $787 billion stimulus package that became known as the American Recovery and Reinvestment Act of 2009 (ARRA; Pub L. 111-5).[8] President Trump initially proposed spending $200 billion in direct federal spending, cutting more than $200 billion in existing infrastructure programs, and offering as much as $800 billion in tax credits on infrastructure (Viser and McGrane, 2017), but has since tempered his expectation of a significant role for private-sector investment. Under very different economic conditions in 2017 than those that prevailed in 2009, some members of Congress have expressed concerns about substantial new direct public spending and instead favor large tax cuts to stimulate broader demand throughout the economy (Viser and McGrane, 2017).

Red Tape

For years, many advocates of increased infrastructure spending, as well as academics, have maintained that lengthy local, state, and federal environmental reviews of major projects impede construction and are a cause of underspending. They argue that "streamlining" regulatory review processes to reduce the number of decision points at all levels of government would speed planning and construction.[9] However, one person's bureaucratic delay is another person's legitimate processing to vet large public spending projects for compatibility with community values, environmental protection, health, and safety.

Political Reluctance to Seek Full Cost Recovery

The decision to raise mass transit fares, bridge tolls, or water rates to meet operating expenses and cover capital improvements is almost always politically fraught, particularly when disassociated from routine adjustments for inflation. To avoid these choices and spread the costs over a larger population, local and state officials increasingly revert to using general revenue funds that come from broad-based taxes (Henchman, 2014). Yet, reliance on sales taxes and other general revenues to pay for infrastructure imposes a proportionally larger burden on lower-income residents.

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8 See Grabell (2012) for more detail.

9 On February 24, 2017, President Trump signed Executive Order 13777, directing all federal agencies to create task forces to recommend repeal, replacement, or modification of existing regulations (O'Keefe, 2016; Mandel and Carew, 2013; U.S. Department of the Treasury and U.S. Department of Transportation, Build America Investment Initiative Interagency Working Group, 2015).

Often-Cited Demand-Side Issues

Discerning what is needed to increase productivity and social benefits from what is desired—the demand side of infrastructure—is a problem for the public and private sectors. Emerging technologies such as driverless vehicles, shifts in populations that alter driving and expectations for mobility, and changing economic conditions within regions can affect forecasts of the timing and volume of demand for transportation services. Uncertainties in demand can have a large effect on the economics and risk profile of a proposed project and consequently dampen the support of public officials and investors.

The Difficulty of Forecasting Demand

In ordinary and well-functioning markets, suppliers discern demand signals through consumers' willingness to pay and respond accordingly. But when communities or businesses want infrastructure, their demands are filtered through often complicated and multilayered governance arrangements and competing public goals and preferences—rarely with clarity. Forecasting demand, cost, and willingness to pay for new or improved infrastructure is a highly uncertain business, with an unimpressive track record (Flyvbjerg, Bruzelius, and Rothengatter, 2003). For technical reasons, cost and demand forecasts are characterized by large errors. It has been documented that where public funds are available in competitive situations, demand forecasts are influenced by the desire to compete effectively by demonstrating higher demand and lower cost than might be justified by prudent forecasters (Jahren and Ashe, 1990). In addition, demand for transportation services, for example, can vary over the lifespan of infrastructure as new technologies and business models emerge, demographics shift, and the nature of work changes (Flyvbjerg, 2012).

In the absence of clear market signals, public agencies and organizations develop needs assessments as surrogates for demand. Assessing needs in a technically credible, consistent, and unbiased way is difficult. Federal law requires infrastructure-funding agencies, such as the U.S. Environmental Protection Agency (EPA) and the Federal Highway Administration, to conduct needs assessments (EPA, no date-d; DOT, Federal Highway Administration, 2015), but the U.S. Chamber of Commerce and professional, trade, and lobbying groups, such as ASCE, also conduct such assessments (O'Keefe, 2015). Agencies and organizations generally employ their own methods and assumptions and, not surprisingly, reach different conclusions about what is needed.

Needs assessments rely primarily on "business as usual" projections of maintenance and rehabilitation of the current stock of infrastructure. But the assumption that business will remain as usual must be questioned. In the early 20th century, state and federal governments were unprepared when automobile ownership surged. There simply were not enough roads for all the cars. In the late 20th century, Rust Belt cities saw some infrastructure fall into disuse because of economic changes and demographic shifts. Needs assessments must account for changing business models, technologies, and demographics (for example, car-sharing services, transportation network companies, self-driving vehicles, and the movement of young people back into urban areas). The value of extending existing infrastructure versus other alternatives must be assessed anew for each place. This is difficult, but it is the basis for sound national needs assessments.

Insufficient Interagency Coordination and Dysfunctional Regional Governance

Insufficient regional coordination and dysfunctional governance arrangements can stand in the way of implementing big, multijurisdictional projects. For example, the proposed Gateway tunnel between New York and New Jersey has stalled, even though it is the very model of an interstate project for which the Port Authority of New York and New Jersey was conceived (Wachs and Frankel, 2017; Davis, 2017).

Absence of National or Regional Priorities

Unlike China or the European Union, the United States lacks a vision of how infrastructure can enhance economic growth and productivity, and, in the absence of such a vision, priorities are difficult to articulate. Neither the executive nor legislative branch of the federal government has published lists of infrastructure projects of national significance as they did, for example, in the mid-20th century for major water resource development and construction of the Interstate Highway System. When Congress considered major infrastructure spending in the context of the ARRA stimulus package in 2009, it was not guided by a national priority list. Rather, projects were pursued piecemeal through separate agency and sectoral programs. They were funded by different mechanisms and did not compete for capital on their merits. Funding flowed through the states, with no comprehensive national strategy.

More promising are the most recently passed major pieces of authorizing legislation for transportation and water infrastructure: the Fixing America's Surface Transportation (FAST) Act of 2015 (Pub L. 114-94) and the Water Resources Development Act (WRDA) of 2016 (Pub L. 114-322, Title I). The FAST Act, the first long-term transportation funding bill enacted in a decade, provides more than $305 billion in funding for FYs 2015 through 2020 (DOT, Federal Highway Administration, 2016). The FAST Act largely continues programs that have been in existence for some time, by funding well-established mechanisms, such as the federal Highway Trust Fund. Notably, the act boosts investments in freight movement corridors, it uses better measurements of performance to manage the national transportation system, and it continues commitments made in earlier acts to the streamlining of environmental reviews and the enhancement of project delivery. The 2016 WRDA singled out harbor-deepening projects for "ports of national significance."

After the 2016 election, the *New York Times* published an example of what a national priority list might look like. It included the $24 billion Hudson River rail tunnel, $65 billion for California's high-speed rail project, and a $20 billion sea wall for Miami, among other megaprojects (Stewart, 2016). Selection criteria were not provided.

Resilience to Natural Disasters and a Changing Climate

Rising sea levels and changes in rainfall patterns are already upon us (U.S. Global Change Research Program, 2014). More than 40 percent of the U.S. population lives in counties along coasts, and that number is expected to increase (National Ocean Service, no date). Transportation and water infrastructure in coastal areas are already at risk (U.S. Global Change Research Program, 2014, Chapter 25: Coasts). The U.S. Government Accountability Office (GAO) recently estimated federal disaster costs to be at least $277 billion between FYs 2005 and 2014 (GAO, 2016). Further, the dollar value of damage from extreme weather events has quadrupled in real terms over the past four decades (National Oceanic and Atmospheric Administration, National Centers for Environmental Information, no date). These costs are likely to increase over time unless measures are taken to reduce risk (GAO, 2016). The uncertainty is

not whether these climatic trends will persist but how soon they will threaten the economic viability of coastal communities unless action is taken. Resilience activities throughout the United States have expanded significantly over the past decade (Georgetown Climate Center, no date), and resilience is now an integral feature of planning and design of new infrastructure and rehabilitation of existing facilities in some places. Simply rebuilding old infrastructure to its previous design specifications may no longer suffice. Indeed, in many inland locations, for example, bridges already are being raised to accommodate higher flood levels (McFetridge, 2017).

Some states and cities seek to lower emissions of carbon dioxide and reduce energy use in buildings, transportation systems, and agriculture.[10] While climate policy at the national level is in flux, efforts to reduce emissions at the state and local levels have been gaining momentum in recent years and will likely have a significant impact on future demand for and design of infrastructure. Many regions will, for example, demand more investment in mass transit, new road systems for autonomous vehicles, and storm surge and flood control works for areas facing increasing flood risk.

NIMBYism

Meanwhile, some communities reject proposed infrastructure projects—the "not in my backyard" (NIMBY) problem. Advocates of "cutting red tape" face opponents who want to stall projects and citizens who want technically credible environmental review, which takes time. Attempting to speed things up by circumventing public engagement often leads to delays as stakeholders seek legal and administrative remedies. At the same time, there are clearly inefficiencies that could be reduced without circumventing standards or the fundamentals of settled administrative law, particularly when multiple federal agencies have jurisdiction over the same project but run separate and disjointed processes of their own. An early example of this model was implemented in the landmark 1994 Bay Delta accord when four federal agencies, the State of California, municipal water suppliers, environmental organizations, and agricultural interests came together on a single regulatory review process to consider major changes in how water would be allocated in California, affecting the San Francisco Bay and the delta formed at the confluence of the Sacramento and San Joaquin rivers (Rieke, 1996).

Misallocation of Capital

Unintended consequences of policies can lead to a misallocation of capital, whether public or private.

Bias Toward Capital Spending over Operations and Maintenance

The federal government long ago established policies that favor federal investment in new infrastructure over spending on O&M. If state and local governments wanted the federal capital, their taxpayers needed to shoulder lifetime maintenance of whatever was built. This created an incentive to "go large" with the initial investment to garner near-term economic and political benefits but downplay the life-cycle costs of operations, maintenance, and repair. For example, in 2009, the ARRA funded 259 green infrastructure projects worth more than $209 million. However, a 2013 EPA report found that only 59 percent of these projects

[10] For example, California's Sustainable Communities and Climate Protection Act of 2008 requires its metropolitan planning organizations (MPOs) to incorporate carbon emissions reductions in their land use and transportation plans (Institute for Local Government, 2015).

had dedicated sources of O&M funding (EPA, Clean Water State Revolving Fund, 2013). Buses are another example. The federal government pays for 80 percent of many new buses to replace ones that are more than 12 years old but provides little funding to maintain buses. Not surprisingly, transit operators do less maintenance than ideal and are quicker to replace buses at age 12 (DOT, Federal Transit Administration, no date)—a waste of tax dollars.

Short-Term Perspective

Keynesians view investment in infrastructure as an effective countercyclical measure to prime the demand pump during economic downturns. This was the essence of President Franklin Delano Roosevelt's New Deal and Works Progress Administration (WPA), with its focus on getting people back to work during the Great Depression.[11] Presidents and Congress are often tempted to rekindle a WPA-like program, but without a thoughtful strategy, a short-term mindset could jeopardize longer-term nationwide growth and productivity gains. The focus on "shovel-ready projects" in the ARRA of 2009, for example, diverted attention from projects with greater long-term returns on public investment (Holtz-Eakin and Wachs, 2011).

Regional Competition and Conflict

Investments that might be good for the nation as a whole, however defined, will inevitably benefit some regions more than others. Port improvements are one common example of this phenomenon. Some investments that are top priorities for one region might simply transfer economic activity from another region with little to no net national benefit (McDonnell and Kitroeff, 2016). However, investment based solely on a net national economic benefit criterion would be politically unpalatable, so, in the name of regional equity, federal funding is distributed among regions and states using allocation formulas and, to some degree, earmarking of appropriations.

Legal Constraints on Public and Private Capital Flows

The federal tax code allows interest income accruing to holders of municipal bonds to be exempt from taxation. This lowers the cost of borrowing for cities but sometimes displaces private financing. State tax codes prescribe acceptable forms of PPPs, some of which also inhibit the flow of private capital into infrastructure investment (Bipartisan Policy Center [BPC], 2016). Some states also constrain the ability of local governments to levy property taxes or to retain sales tax and other tax receipts, thereby reducing their ability to generate sufficient revenues to maintain existing facilities according to best practices (Oregon Secretary of State, 2017).

Public Expectations of Infrastructure Investment

At its most basic level, investment in infrastructure is desirable to support long-term economic development and increase economic efficiency (Glaeser, 2012). Public expectations are

[11] Proponents usually add that such spending will have the further salutary effect of creating many new jobs in the construction trades. For example, according to the National Association of Manufacturers, without major improvements to our transportation systems, "the United States will lose more than 2.5 million jobs by 2025" (National Association of Manufacturers, 2016). Near-term job creation through construction of infrastructure projects is politically compelling but, economically, a questionable proposition at best. See Copeland, Levine, and Mallett (2011); Encyclopedia Britannica (2013).

broader. Throughout the United States' history, the federal government also has used investments in infrastructure to spur regional development and mitigate economic disparities among regions.[12] For example, it is no accident that per capita transportation funding in the ten least densely populated states is about twice the per capita funding in the ten most densely populated states.[13] Further, in recent decades, the public has grown to expect that infrastructure will be designed to harmonize with communities, the physical environment, and natural systems.

For example, the Clean Air Act (1963, Pub L. 88-206); the National Environmental Protection Act of 1969 (1970, Pub L. 91-190); the Clean Air Extension Act (1970, Pub L. 91-604); the Federal Water Pollution Control Act, commonly known as the Clean Water Act (1972, Pub L. 92-500); and other laws require that public infrastructure protect and improve air and water quality and protect and restore critical habitat and ecosystems. As a result of such legislation, the BOR and the USACE have spent the better part of the past 30 years "reverse engineering" their major 20th century water resource projects (e.g., dams on the Colorado River, the Everglades, and the lower Mississippi River) to mitigate the damages their projects have caused to natural systems.

Other federal laws, regulations, and executive orders require that federally funded projects promote and protect public safety, reduce risks, and increase resilience to rising seas and flood waters. States such as California and New York and many cities and counties are increasingly concerned about adapting to climate change and becoming more resilient to extreme weather events (Georgetown Climate Center, no date). Through federal executive action (prior to 2017) and some state laws, federally funded or permitted facilities also were required to reduce carbon emissions.[14]

These mandates are a tall order, and achieving them all requires public agencies to look beyond a simple return on investment. The multiple goals also explain why so many infrastructure projects cannot attract private capital. The public-sector challenge is to provide enough investment in infrastructure to meet these noneconomic goals, but not so much that it crowds out private investment or diverts public capital from more efficient and effective uses.[15]

Approach to Analysis

Our objectives in this study were to understand why demand for better-maintained infrastructure and new investment is not being met under current policies, funding, and market conditions; identify efficient and equitable ways to act on regional and national infrastructure priorities; suggest strategies that are likely to improve on current practice; and recommend policy changes, primarily at the federal level, to remedy some of the problems identified. To accomplish these ends, we drew on existing data and analysis to the extent possible.

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[12] Examples include the BOR bringing water and agricultural development to the Great American Desert; the Tennessee Valley Authority bringing cheap electricity and flood control to an impoverished region; the Appalachian Regional Commission; and the USACE bringing inland waterways, flood control, and water supply to the Mississippi and Missouri valleys, the Gulf Coast, and much of the southern United States.

[13] "Over the last twenty years, transportation funding for the ten most densely populated states has been half as much, on a per capita basis, as funding for the ten least dense states" (Glaeser, 2012, p. 266, quoting from Glaeser and Gottlieb, 2008).

[14] The White House, Executive Order 13514 (*Federal Leadership in Environmental, Energy, and Economic Performance*), Executive Order 13693 (*Planning for Federal Sustainability in the Next Decade*).

[15] See, for example, consequences of over-investment in infrastructure in China (Kalish, 2016).

We first identified the features of transportation and water policies and programs that exert a strong influence on priority setting, project evaluation, and funding and finance. Next, we examined the supply side for infrastructure. We reviewed government documents and other credible sources that report on the status and trends in spending for transportation and water infrastructure in the United States over the past 60 years or so. Spending does not tell us about the particulars of supply—what was built and when or how well it was built to meet future needs—but it does provide a measurement of public-sector commitment to both capital investment and O&M. On the demand side, we examined the value, inconsistencies, and limitations of needs surveys against the backdrop of urbanization, technological innovations, and other forces mediating demand for infrastructure services.

We also examined the federal decisionmaking processes that match supply with demand, however imperfectly estimated. We reviewed scholarly papers, government reports, and policy studies from policy research organizations with bearing on the federal approach to selecting and funding transportation and water infrastructure projects. Next, we summarized recent initiatives being taken by federal, state, and local governments and recommendations that have been proposed over the years. We then evaluated these in light of the weaknesses identified in current policies, and we used this evaluation to identify the most promising options for Congress and the Executive Branch.

How This Report Is Organized

In Chapter Two, we present an overview of status and trends in public and private spending for transportation and water infrastructure from the early 1950s to present. Chapter Three summarizes the different flavors of funding and financing models used by the public and private sectors to construct and maintain transportation and water infrastructure. Our interest is in understanding how these models function and the various supply, demand, and misallocation issues that appear to impede the provision of beneficial and sustainable infrastructure.

In Chapters Four and Five, we look at the policy and program structures of federal transportation and water infrastructure, respectively; review their priority-setting processes, project selection, and evaluation methods; and consider how these programs square with the broad set of public goals now in play. We also examine why most assessments of funding needs in these sectors are unreliable measures of demand for public and private investment. We further consider the difficulties of providing infrastructure in these sectors as a consequence of regulatory requirements and funding and financial constraints. In sum, these chapters support the argument that targeted changes in public policy are needed, both to draw in private-sector funding where possible and to rationalize public-sector investment to meet future needs. In Chapter Six, we consider some of the more significant recent changes in policy and practices across all levels of government in the United States. Some of these initiatives are still too early in their implementation to allow us to draw definitive conclusions about their efficacy, but others show signs of promise and could be candidates for scale-up. We identify other proposed policy options that could sharpen demand signals, streamline the supply of projects, and reduce the prevalence of costly misallocation. We also look at promising practices employed in other highly developed nations. Finally, in Chapter Seven, we conclude with a synthesis of our findings and recommendations to policymakers.

CHAPTER TWO

Status of and Trends in Spending on Transportation and Water Infrastructure

Given the prominence of the underspending argument in the national debate, this chapter focuses on the transportation and water sectors, where government has historically played the dominant role. We use definitions consistent with those applied by the Congressional Budget Office (CBO, 2015). Water infrastructure includes both resources and utilities:

- Resources: water containment systems (dams, levees, reservoirs, and watersheds); sources of freshwater (lakes and rivers); and rivers, canals, and harbors, which are typically improved and maintained by the USACE
- Utilities: water supply and wastewater treatment facilities.

Transportation infrastructure includes

- highways, bridges, and tunnels
- mass transit
- rail
- airports and aviation facilities
- water transportation (such as ferries, inland waterways, and coastal ports).

For purposes of this study, for transportation infrastructure, we focus primarily on highways and mass transit, which account for about 80 percent of total public expenditures on transportation (CBO, 2015).

Some projects within these categories are in private hands or operated by private companies on behalf of the public, but they nonetheless represent the sectors in which federal, state, and local governments remain most deeply involved in governance, project selection, funding, and maintenance. In contrast, energy, telecommunications, and many port facilities are critical infrastructure that are largely in private hands and, as such, controlled by market forces, albeit under regulatory oversight.

Color of Money

We distinguish between capital and O&M spending because they are treated differently in public programs, bond markets, and by investors and the public. Drawing on CBO's definitions, *capital* refers to outlays for the purchase of new structures such as highways, dams, and wastewater treatment facilities; equipment, such as buses and railcars; and improvement and

rehabilitation of structures and equipment already in place. *Operation and maintenance* refers to the costs of providing necessary operating services (e.g., air traffic control system); maintaining and repairing existing capital; and other infrastructure-related programs (e.g., highway safety programs, research and development [R&D]). The latter category is significant in transportation, where lessening loss of life, injury, and damage to property are among the principal motivations for investment. Historically, the federal government has participated directly in R&D, as well as funding research at universities and other institutions, because new transportation technology, databases, and regulations operate across all states and affect private companies nationwide.

We have chosen to conform to CBO's definitions to enable us to take advantage of its relatively recent compilation of public spending. However, from a policy perspective, unlike CBO, we believe that R&D should be treated as a separate category. Spending on R&D is fundamentally different in economic terms than capital or O&M spending on specific infrastructure in specific places. Historically, federal and state support for R&D has been a vitally important contributor to innovations and improvements in technology, policy, and practice in transportation and water infrastructure.[1] Its benefits are broadly shared among the states, and its effects long-lasting.

The distinction between capital and O&M has implications for planning, cost estimation, budgeting, financing, and tax policy. Figure 2.1 shows where different kinds of decisionmaking and spending occur in the life cycle of an individual project. Decision point #1 represents the process of either a public- or private-sector entity making a choice to invest in a particular infrastructure project. Historically, the federal government has focused its decisionmaking at this stage in the realms of transportation and water through omnibus authorization bills. Subsequent to the initial investment, construction, and initiation of the project, funding is required to sustain the project's operations through routine maintenance.

At decision point #2, policymakers can opt to extend the life of an existing project or facility, rebuild it completely,[2] or effectively decommission it by withholding additional capital for repairs or modernization. Recent examples of removal include San Francisco's Embarcadero Freeway (Preservation Institute, 2007c), Portland's Harbor Drive Freeway (Preservation Institute, 2007b), and Milwaukee's Park East Freeway (Preservation Institute, 2007a). Or policymakers may simply put off the decision for another year—or decade—because the other options are too contentious or expensive. However, delay has consequences, leading to either increasing costs for repair and rehabilitation or an increasing likelihood that the project will become unusable. Decisions at this stage are further complicated by the need to consider

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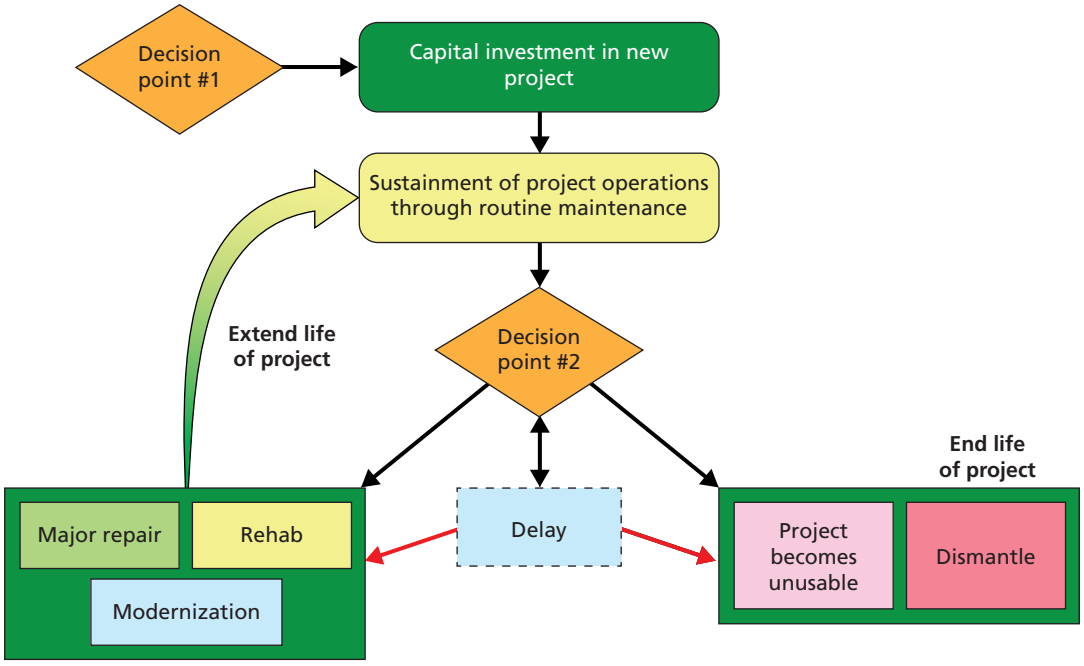
[1] Federal support for water resource research has largely been through the U.S. Geological Survey's National Research Program, the National Science Foundation, state-based Water Resources Research Institutes, the USACE's Institute for Water Resources, the U.S. Department of Agriculture, the Department of Defense, and other federal agencies (Vaux, 2005; National Research Council, Committee on Assessment of Water Resources Research, 2004).

The majority of transportation-related research is funded by "modal administrations" within DOT, which also directly operates some research facilities, such as the Turner Fairbank Laboratory in Virginia and the Volpe Center in Cambridge, Massachusetts. DOT also funds a large program of university transportation centers. Other R&D funding, primarily from the states, comes through the Transportation Research Board within the nongovernmental National Research Council. States receive federal funding for research and then "pool" that funding through action by the Standing Committee on Research of the American Association of State Highway Transportation Officials (AASHTO), which directs it to the Transportation Research Board.

[2] As an example, New York State chose to completely rebuild the Tappan Zee Bridge, now called the New NY Bridge, across the Hudson River (New York State Thruway Authority, no date).

Figure 2.1
Project Life Cycle

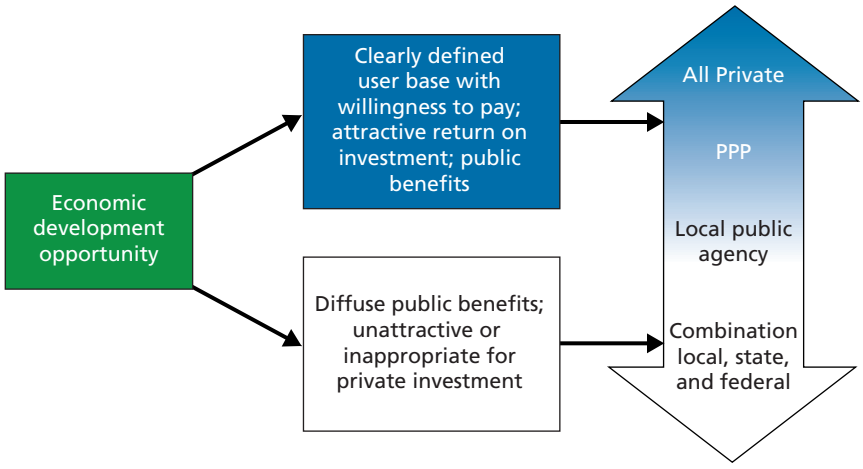


RAND *RR1739-2.1*

a broader set of public goals related to equity, resilience, and climate change. The numerous contingencies and options at this decision point go a long way to explaining why infrastructure needs assessments, discussed in later chapters, are so problematic.

Decisions about project selection are made in the context of available funding and financing alternatives from public and private sources. Figure 2.2 shows that within these broad

Figure 2.2
Infrastructure Funding by Public and Private Sectors



NOTE: PPP = public-private partnership.

RAND *RR1739-2.2*

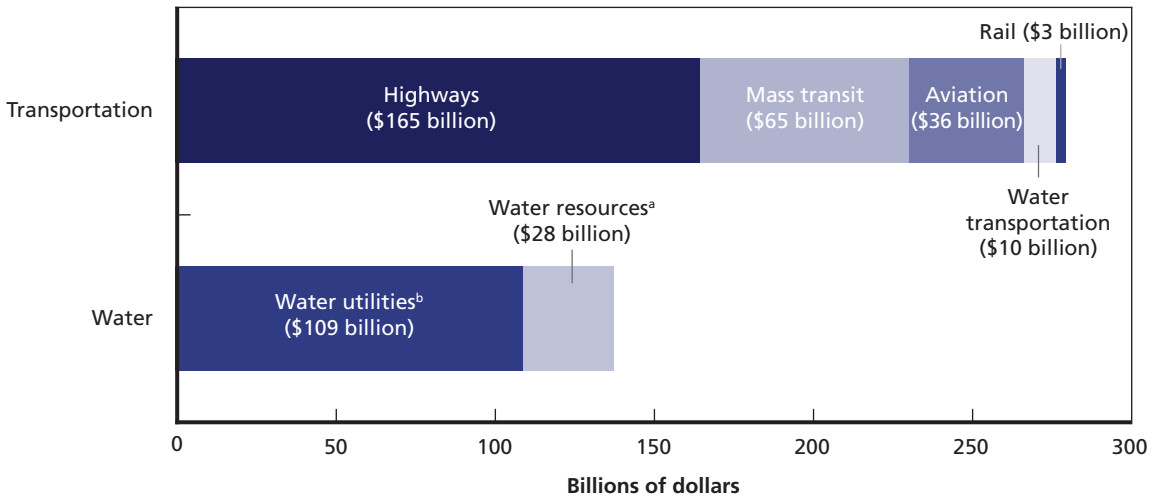
categories are many different types and blends of funding options. On the public side, the primary funder can be federal, state, or local government. It can also be some combination of those three or a regional authority that spans jurisdictions, such as the Port Authority of New York and New Jersey. Project funding can come through public borrowing, primarily tax-exempt municipal revenue bonds, user fees, or from appropriations of general tax funds generated from sales, property, or income tax receipts. Private funding and financing can come from any number of sources, including banks, investment funds, and other pooled capital. Whether funding or financing comes from public or private sources, the investor needs a return on capital, typically in the form of a revenue stream. Whether tolls are "acceptable" in a political or institutional context may end up determining whether a given facility is deemed appropriate for private investment rather than the intrinsic attributes of the facility itself. Chapter Three discusses funding and financing in more detail.

Public Spending on Transportation and Water Infrastructure: 2014

In 2014, federal, state, and local governments spent a total of $416 billion on capital and O&M for both transportation and water infrastructure. As shown in Figure 2.3, transportation accounts for about 60 percent of this total, with spending on highways accounting for the largest portion. Given the large role of the private sector in rail transportation, it is not surprising that this is a very small component of direct public spending.

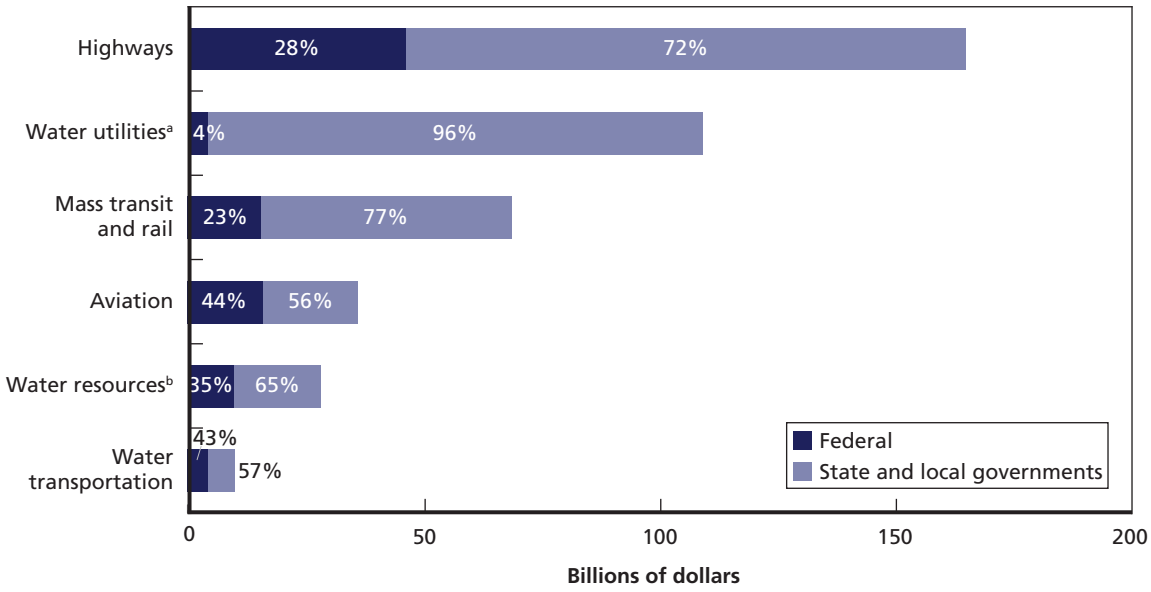
The split in spending between the federal government and state and local governments, shown in Figure 2.4, varies widely across the different infrastructure types. State and local governments account for 96 percent of spending on water utilities and more than 70 percent of spending on highways, mass transit, and rail. In contrast, the federal share is notably larger in

Figure 2.3
Public Spending on Transportation and Water Infrastructure, 2014



SOURCE: CBO, 2015, Exhibit 1, p. 8, based on data from OMB and the U.S. Census Bureau.
[a] Includes water containment systems (dams, reservoirs, and watersheds) and freshwater (lakes and rivers).
[b] Includes water supply and wastewater treatment facilities.
RAND *RR1739-2.3*

Figure 2.4
Public Spending on Transportation and Water Infrastructure, by Type, 2014



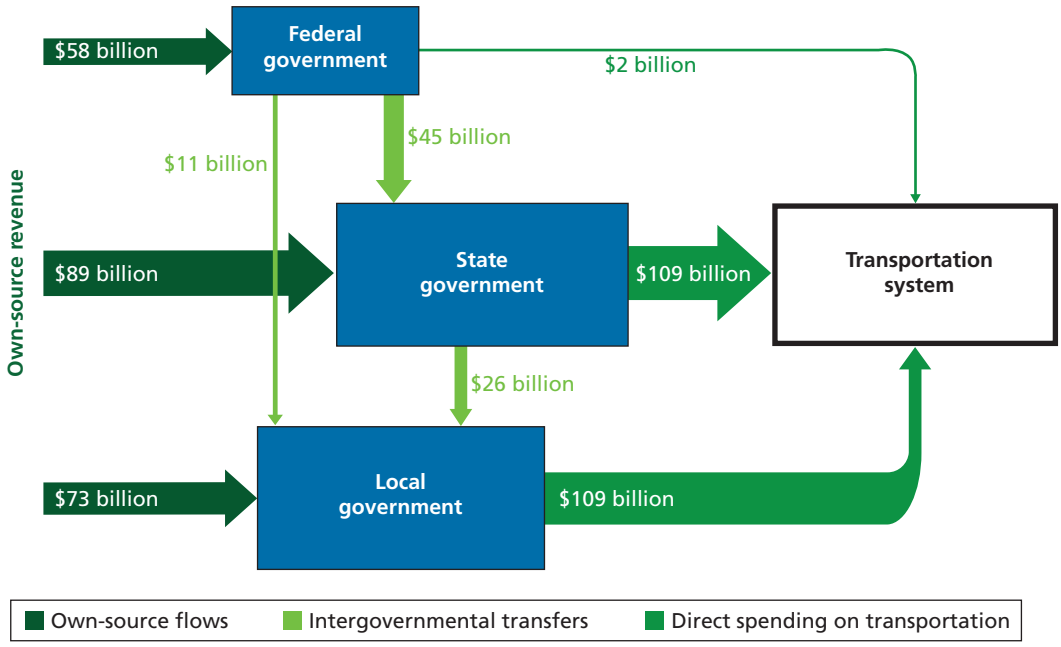
SOURCE: CBO, 2015, Exhibit 18, p. 28, based on data from OMB and the U.S. Census Bureau.
[a] Includes water supply and wastewater treatment facilities.
[b] Includes water containment systems (dams, reservoirs, and watersheds) and freshwater (lakes and rivers).
RAND *RR1739-2.4*

aviation, water resources, and water transportation. A 2015 study by the Pew Charitable Trusts provides further details about the funding shares among the different levels of government, as shown in Figure 2.5. Intergovernmental funding flows from the federal to state level, as well as from the state to local level, contribute a portion of the total funds spent on transportation, but the majority of total money spent comes from local governments' own-source funding.

The proportion of spending by level of government on capital versus O&M varies considerably, as shown in Figure 2.6. The federal government was responsible for almost 40 percent of capital spending on transportation and water infrastructure in 2014, in contrast to its 12 percent share of O&M. Viewed another way in Figure 2.7, the federal government's dominant support is for capital expenditures, while state and local governments spend most of their money on O&M.

The emphasis on capital spending by the federal government is not an accident. Many members of Congress view federal funding for O&M as "free money" that translates into higher wages and fringe benefits for workers in those areas. They further assume that state and local governments will spend more wisely on capital projects because they know they will be responsible for O&M in the future. This arrangement was explicit in the Federal-Aid Highway Act of 1956, which specified that the federal government would not contribute to operations once the system was built.

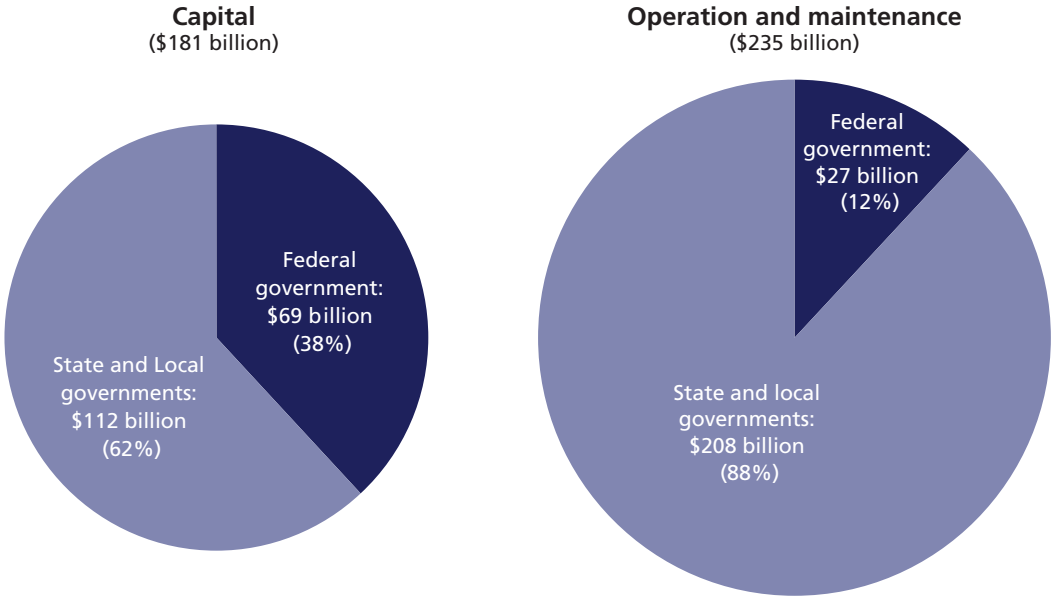
Figure 2.5
Surface Transportation Funding Flows Among Levels of Government, 2012



SOURCES: Pew Charitable Trusts, 2015, based on data from the U.S. Census Bureau (2014) and OMB's Public Budget Database. Used with permission.

RAND *RR1739-2.5*

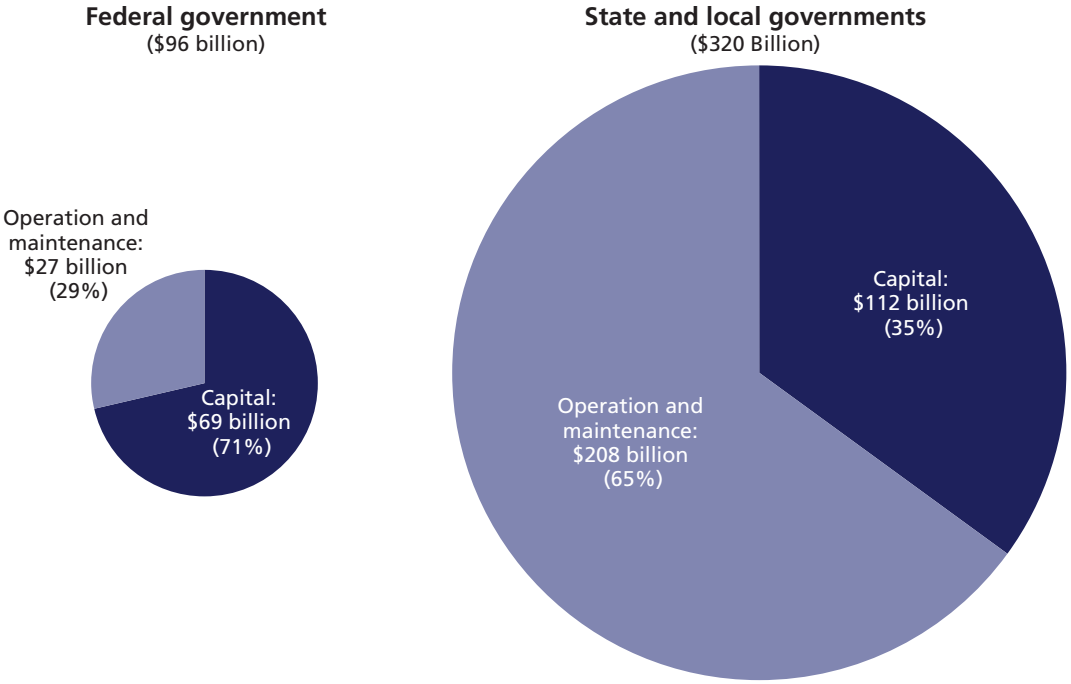
Figure 2.6
Shares of Public Spending on Transportation and Water Infrastructure, by Category, 2014



SOURCE: CBO, 2015, Exhibit 4, p. 11, based on data from OMB and the U.S. Census Bureau.

RAND *RR1739-2.6*

Figure 2.7
Shares of Public Spending for Capital and the Operation and Maintenance on Transportation and Water Infrastructure, by Level of Government, 2014



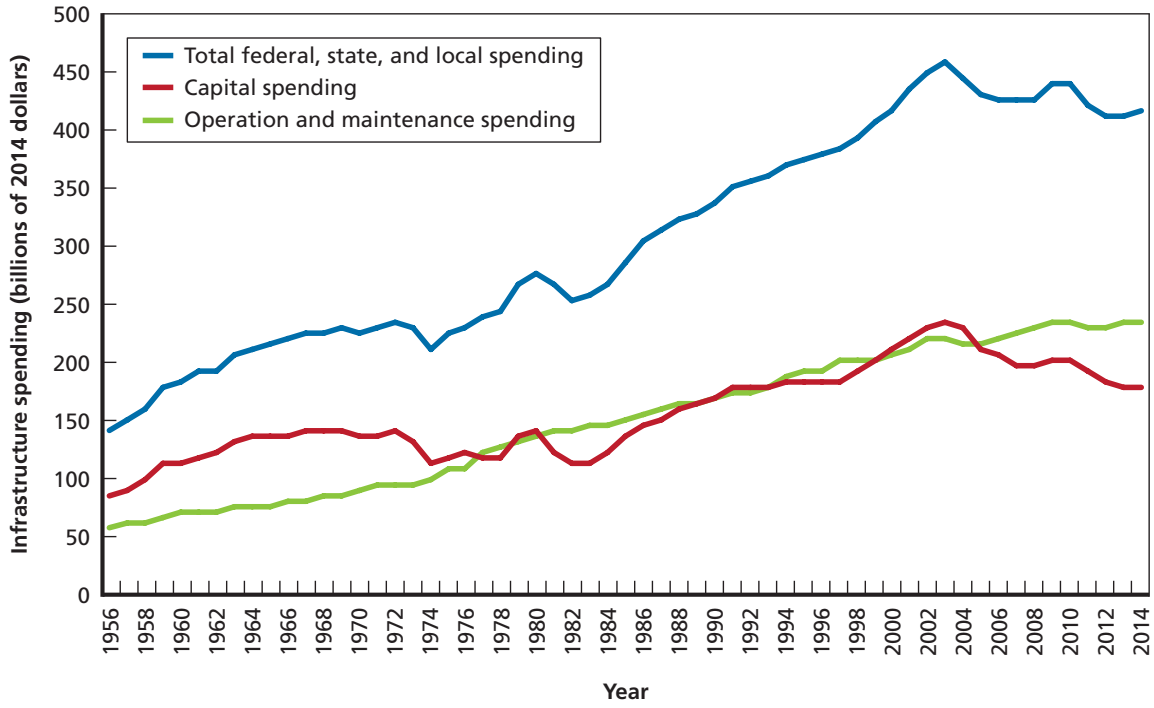
SOURCE: CBO, 2015, Exhibit 6, p. 13, based on data from OMB and the U.S. Census Bureau.
RAND *RR1739-2.7*

Trends in Public Spending on Transportation and Water Infrastructure

CBO assembled a consistent data set on public infrastructure spending dating back to 1956, when the Federal-Aid Highway Act was enacted (CBO, 2015). We focus on public spending by all levels of government for transportation and water infrastructure only. All amounts have been converted to their equivalent in 2014 dollars. The trends in Figure 2.8 are clear: Capital spending—which is primarily federal spending—has been on the decline since around 2002, with the exception of the bump between 2009 and 2010 from the ARRA stimulus package following the 2008 financial crisis. Other noticeable dips in capital spending occurred around the recession in the mid-1970s and significant budget cutting during President Ronald Reagan's first term in office. In contrast, spending on O&M has been on the rise, and that is mostly local and state spending. What is not known is how much steeper the slope of the O&M spending line should be, commensurate with the increase in capital stock that occurred during the second half of the 20th century.

When total public spending on transportation and water infrastructure is viewed as a share of GDP, as shown in Figure 2.9, the trend has been relatively stable over the past 60 years. However, when viewed by infrastructure type, as in Figure 2.10, the decline in spending on highways is significant, while spending on other infrastructure types has been relatively flat for decades, including for mass transit. U.S. transit use is generally higher now than any time since 1956, outpacing population growth, although trips dipped slightly in the first quarter of 2017 (American Public Transit Association, 2017b; Schmitt, 2017).

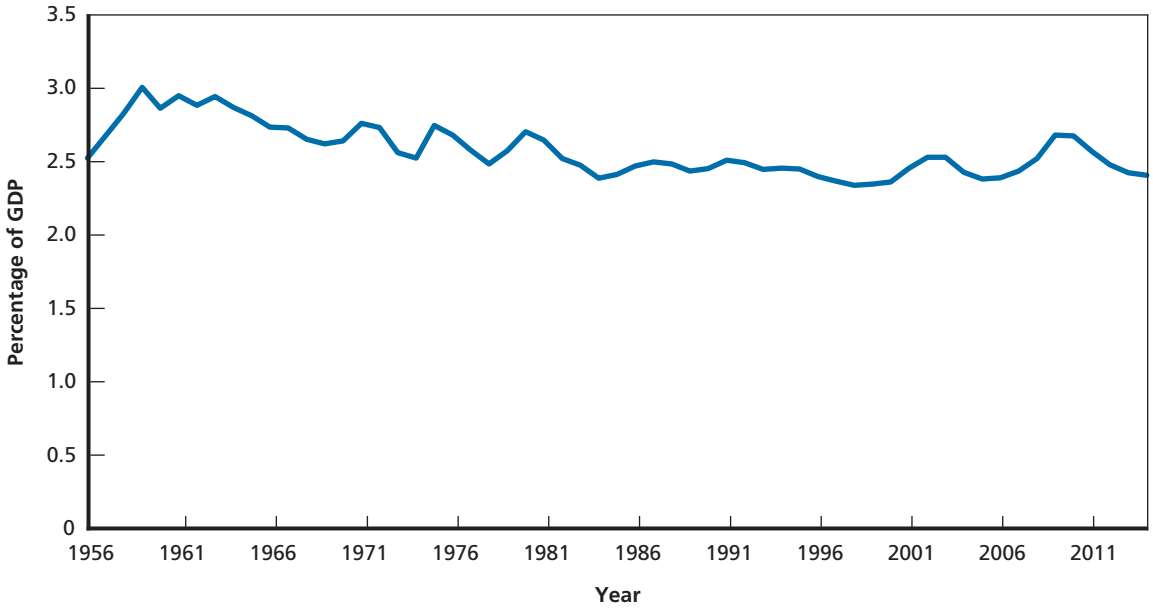
Figure 2.8
Total Federal, State, and Local Spending on Transportation and Water Infrastructure, 1956–2014



SOURCE: Data from CBO, 2015.

RAND *RR1739-2.8*

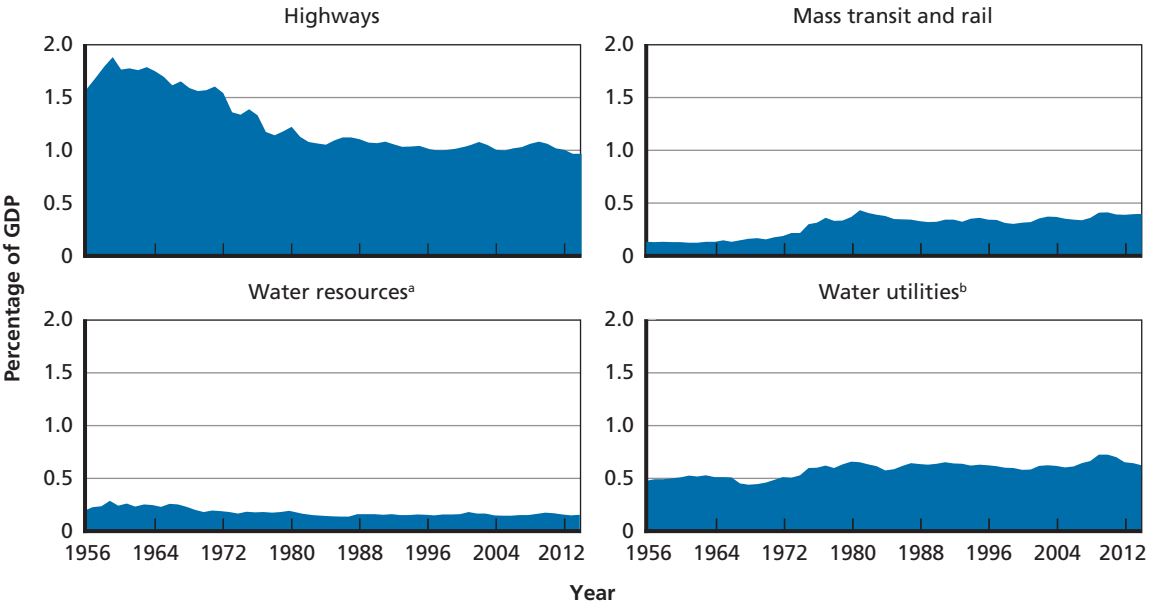
Figure 2.9
Total Federal, State, and Local Spending on Transportation and Water Infrastructure, as a Share of Gross Domestic Product, 1956–2014



SOURCE: CBO, 2015, Exhibit 3, p. 10, based on data from OMB, the U.S. Census Bureau, and the U.S. Bureau of Economic Analysis.

RAND *RR1739-2.9*

Figure 2.10
Public Spending on Transportation and Water Infrastructure as a Share of Gross Domestic Product, by Type of Infrastructure, 1956–2014



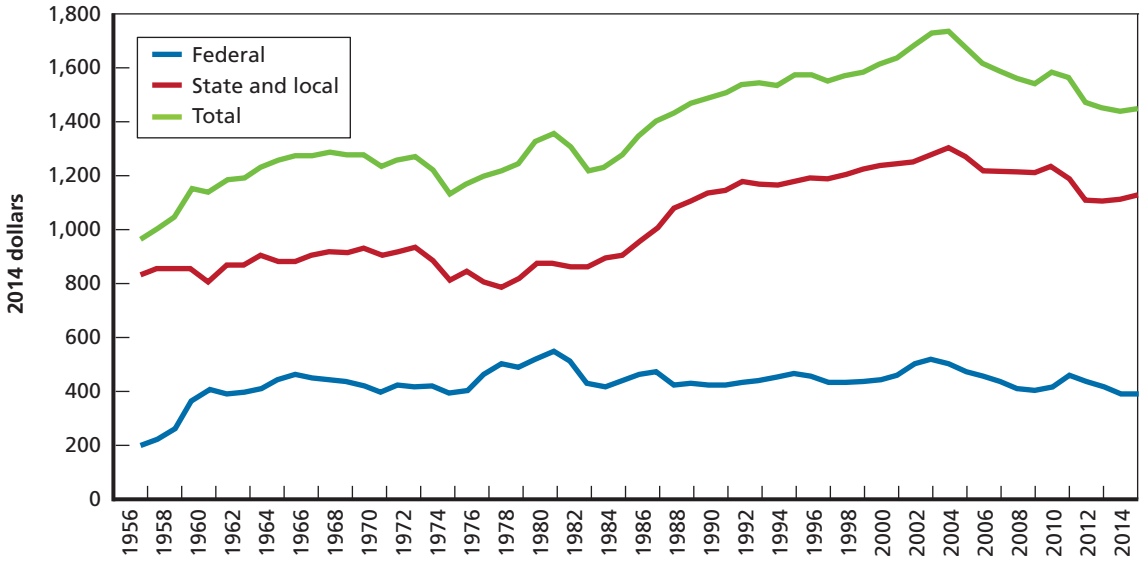
SOURCE: CBO, 2015, Exhibit 15, p. 25, based on data from OMB, the U.S. Census Bureau, and the U.S. Bureau of Economic Analysis.
[a] Includes water containment systems (dams, reservoirs, and watersheds) and freshwater (lakes and rivers).
[b] Includes water supply and wastewater treatment facilities.
RAND *RR1739-2.10*

The trend in total public spending per capita in Figure 2.11 shows a downward turn beginning around 2003–2004, well before the 2008 recession, but federal per capita spending has remained relatively flat since 1980.

As shown in Figure 2.12, federal spending patterns have changed little in six decades, even while the U.S. economy and population nearly doubled. The exceptions are the bump provided by the federal highway program in the late 1950s followed by federal (EPA) assistance for waste water treatment plant construction through the Clean Water Act's construction grants program in the late 1970s and early 1980s. From 1956 to 2014, the U.S. economy grew by 156 percent, from $6.4 trillion in 1980 to $16.4 trillion in 2015 (expressed in 2009 dollars; U.S. Department of Commerce, Bureau of Economic Analysis, no date), and the population increased by 88 percent from 169 million to 318 million people (U.S. Census Bureau, 2017). In contrast, Figure 2.13 shows that state and local governments increased their capital spending up until the early 2000s but have been mostly decreasing their expenditures since then. They have steadily increased their O&M spending over this period, but, as with Figure 2.8, we cannot say whether the slope of the O&M spending line is keeping up with actual O&M needs or whether it ought to be much steeper, given the increase in capital stock over this period.

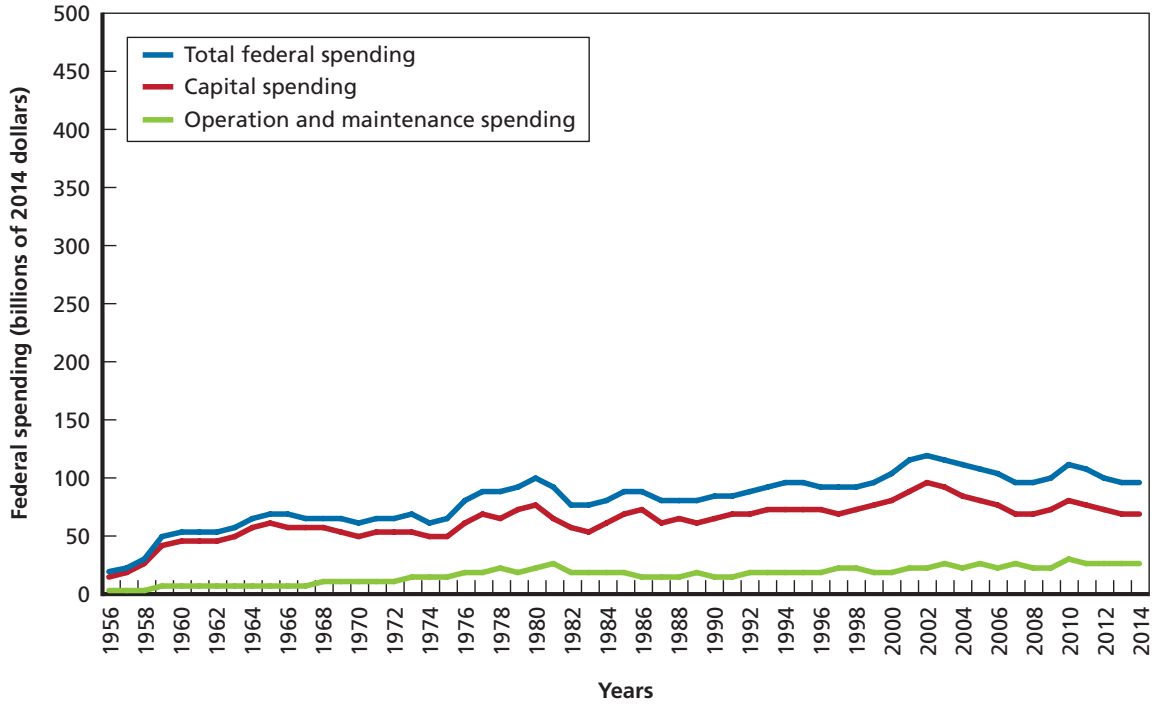
State and local government capital spending since the early 2000s reflects the cycle of growth, recession, and recovery, as seen in Figure 2.14 in the trends in issuance of municipal bonds (U.S. Department of the Treasury, Office of Economic Policy, 2014), the primary means by which local governments finance infrastructure. Bond issues dropped by more than 30 per-

Figure 2.11
Per Capita Federal, State, and Local Spending on Transportation and Water Infrastructure, 1956–2014



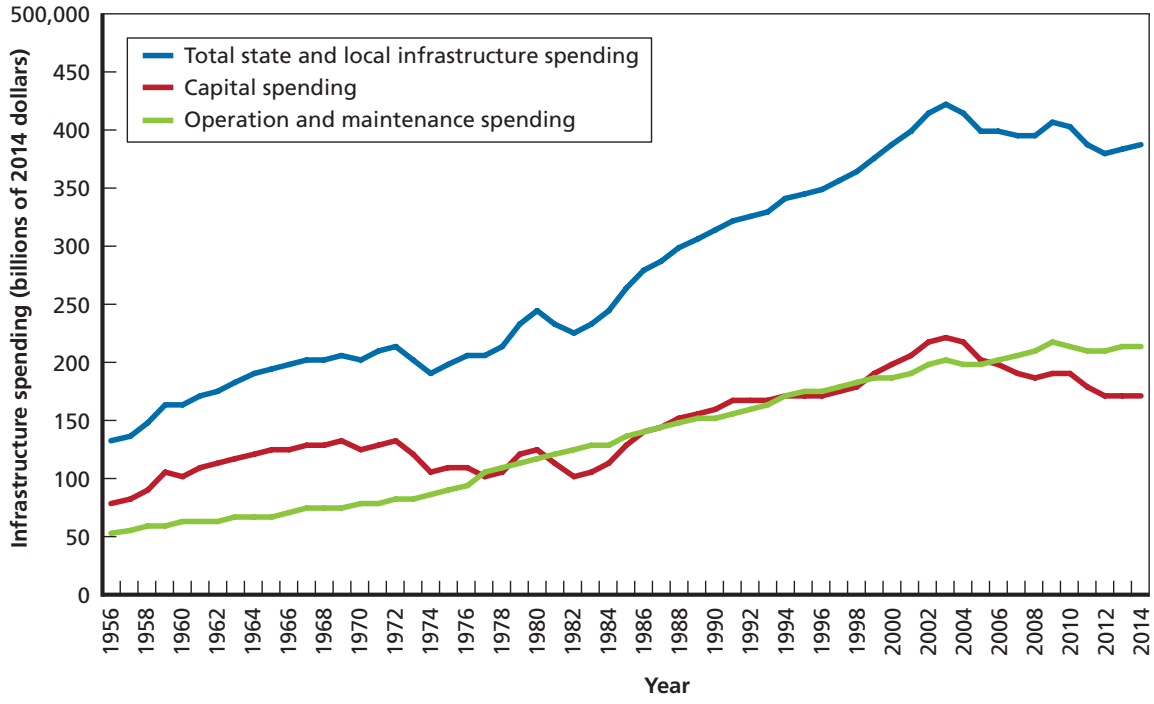
SOURCE: Milsap, 2016, using data from CBO (2015) and the U.S. Census Bureau. Used with permission.
RAND *RR1739-2.11*

Figure 2.12
Total Federal Spending on Transportation and Water Infrastructure, 1956–2014



SOURCE: Data from CBO, 2015.
RAND *RR1739-2.12*

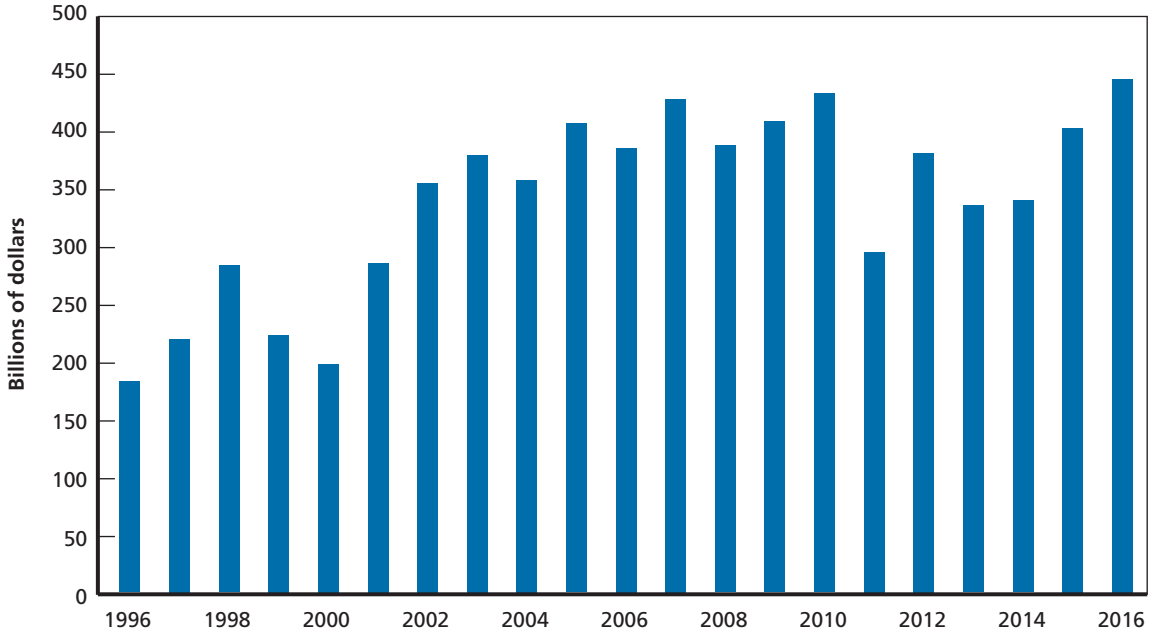
Figure 2.13
Total State and Local Spending on Transportation and Water Infrastructure, 1956–2014



SOURCE: Data from CBO, 2015.

RAND *RR1739-2.13*

Figure 2.14
Municipal Bond Issuance in USD Billions, 1996–2016



SOURCES: Data from Securities Industry and Financial Markets Association, 2017a.

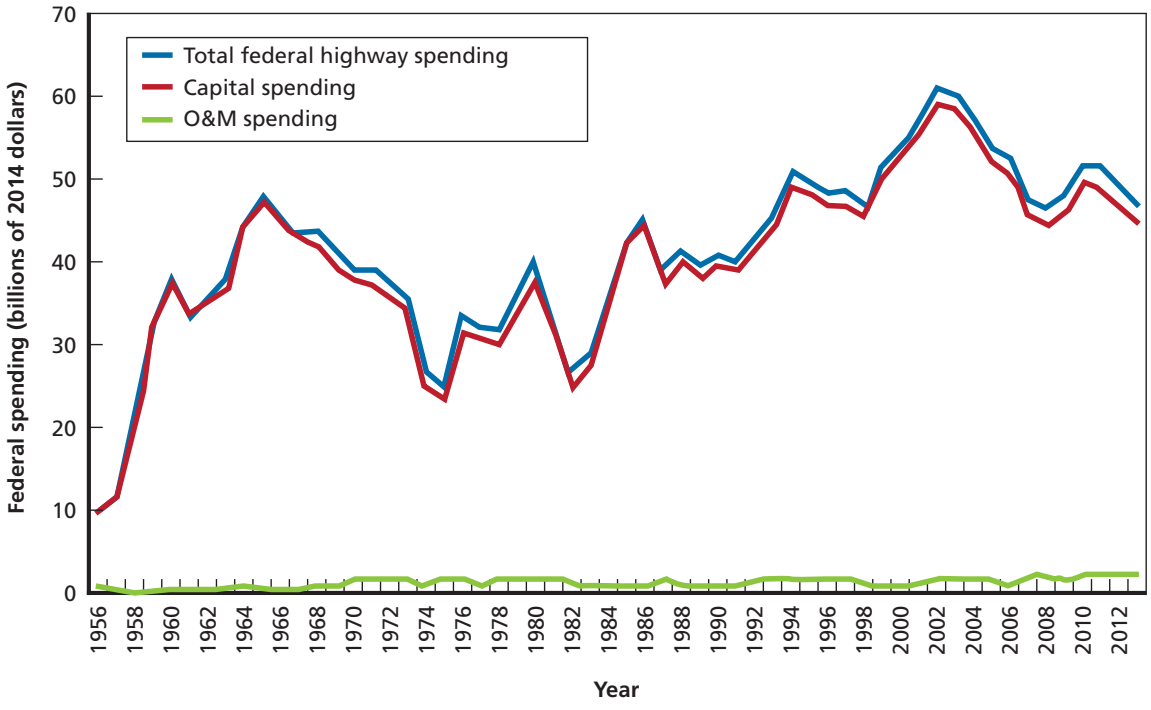
RAND *RR1739-2.14*

cent after 2010 but bounced back to record highs in 2016, twice as high as in 1996 (in current dollars; Securities Industry and Financial Markets Association, 2007a). Uncertainty regarding congressional action on infrastructure spending and tax policy has driven bond issues down in 2017 to date. Interest on these bonds is exempt from federal taxes, making them attractive and competitive to investors who qualify for the tax breaks.

Trends in Public Spending on Highways and Mass Transit

Nearly all federal spending on highways between 1956 and 2014 was in the form of capital expenditures, as shown in Figure 2.15.[3] Spending on new highway construction soared following the Federal-Aid Highway Act of 1956, declined from the mid-1960s to the mid-1970s, and peaked at nearly $60 billion in 2002–2003. Total federal capital spending in 2014 was around $45 billion. We cannot say definitively whether this decline in capital spending represents true disinvestment or underinvestment in highways, but the academic literature suggests that the decline is consistent with the "built out" nature of our national highway system (Shatz et al., 2011; Mamuneas and Nadiri, 2006). Support for this view can be found in returns on invest-

Figure 2.15
Total Federal Spending on Highways, 1956–2014



SOURCE: Data from CBO, 2015.
RAND *RR1739-2.15*

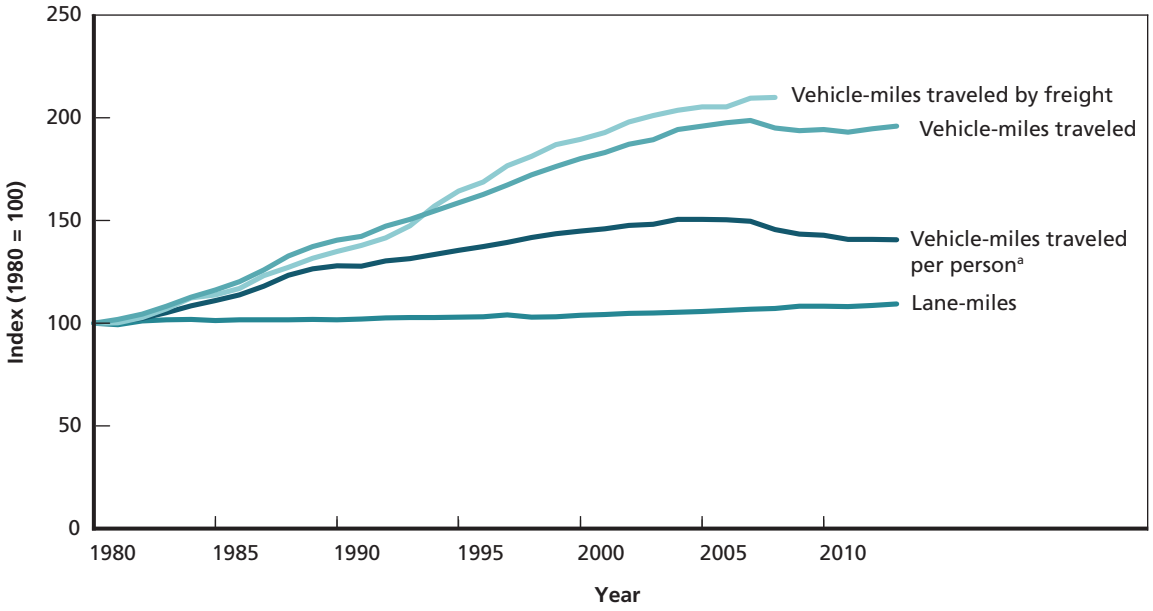
[3] Because of its land management responsibilities in national parks, national forests, and other public lands, the federal government spends directly on operations and maintenance. It also transfers some money to states for O&M. No federal transit funds are for O&M.

ment in highways, which fell from 35 percent in the 1950s to 10 percent in the 1980s and even less now (Popper and Gates, 2016).

However, while it is true that the national highway system is "built out," it is also the case that some roads are more than 70 years old. Many are functionally obsolete, and some are both obsolete and in poor condition. In its 2016 report on the conditions and performance of highways, bridges, and transit, DOT estimated that the share of travel on federal-aid highway pavement rated as poor in quality was 16.7 percent in 2015, up from 14.7 percent in 2002 (DOT, Federal Highway Administration and Federal Transit Administration, 2016). Capital investment needs do not end when a system is completed, and, indeed, some elements of the surface road network need to be "recapitalized" beyond routine O&M (Poole, 2013). This could include, for example, a targeted set of highway capacity expansion projects where congestion is highest (Shatz et al., 2011).

Trends in vehicle-miles traveled (VMT) and VMT per person, shown in Figure 2.16, leveled off for about a ten-year stretch and then increased again over the past five years, correlated strongly with falling gasoline prices. From 1936, VMT and GDP grew in lockstep, except during World War II.[4]

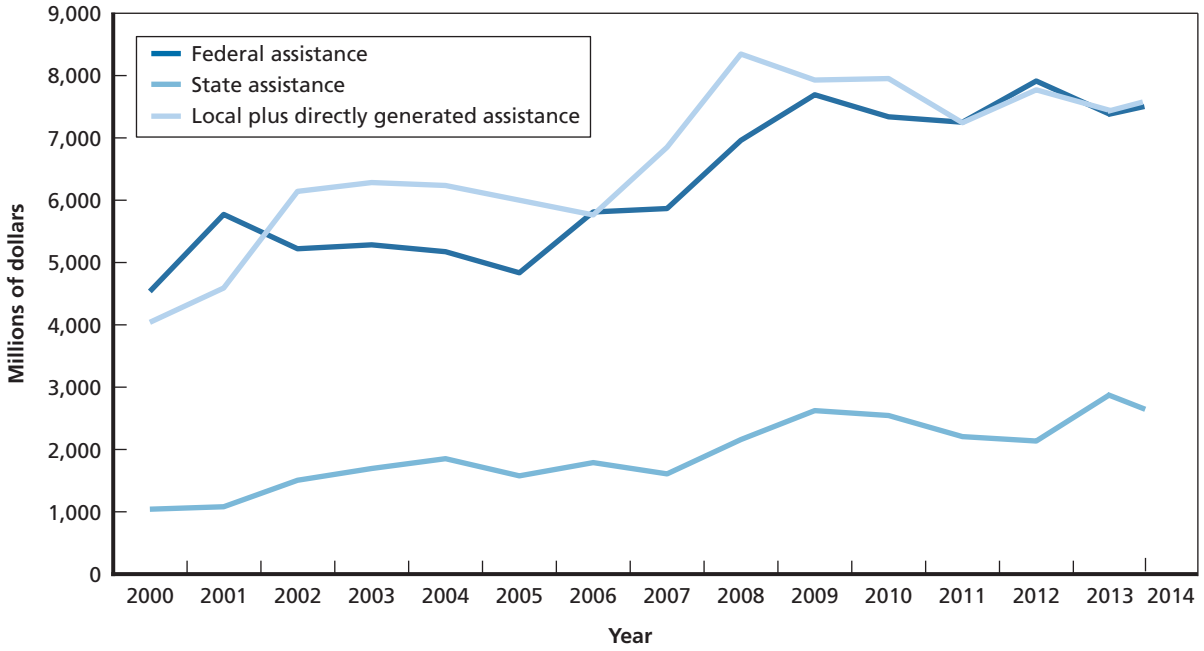
Figure 2.16
Trends in Vehicle-Miles Traveled



SOURCE: CBO, 2016, Figure 1-4, p. 10, based on data from the Federal Highway Administration, the Bureau of Transportation Statistics, and the U.S. Census Bureau.
NOTE: Because of a change in the Federal Highway Administration's methodology, data for freight vehicle-miles traveled after 2008 are not comparable with the information from earlier periods, so they are not separately reported in this figure. Data for vehicle-miles traveled and vehicle-miles traveled per person include both passenger and freight vehicles.
[a] The amounts show are based on the population residing in the United States.
RAND *RR1739-2.16*

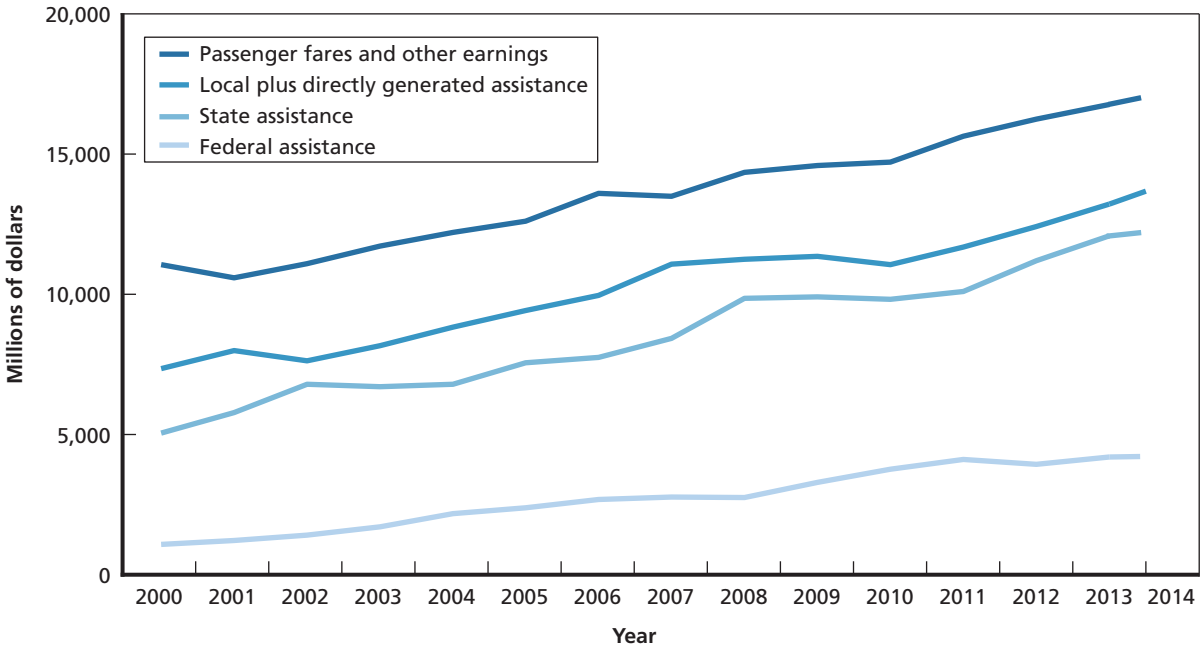
[4] DOT *Traffic Volume Trends* reports (DOT, Federal Highway Administration, Office of Policy and Governmental Affairs, multiple years); DOT, Office of Public Affairs, 2017; Ecola and Wachs, 2012, Figure 1 and preceding discussion.

Figure 2.17
Growth in Capital Funding for Mass Transit by Source, 2000–2014



SOURCE: American Public Transit Association, 2017a, Figure 12, p. 30. Used with permission.
RAND *RR1739-2.17*

Figure 2.18
Growth in O&M Funding for Mass Transit by Source, 2000–2014



SOURCE: American Public Transit Association, 2017a, Figure 13, p. 30. Used with permission.
RAND *RR1739-2.18*

Capital and O&M spending on mass transit have increased since 2000, as show in Figures 2.17 and 2.18, as ridership generally continues to grow (American Public Transit Association, 2017a). The federal share of capital funding grew by more than 66 percent from 2000 to 2014, and states' share doubled. All levels of government have been increasing their spending on O&M. Having said this, a number of the nation's largest transit agencies, notably the Washington Metropolitan Area Transit Authority and the New York City Transit Authority, are struggling to maintain their aging systems. While each system has its own form of dysfunction, they share issues in governance, management priorities, and sustainable revenue models (Kalikow, 2017; Esteban and Muyskens, 2017).[5] However indispensable these mass transit systems may be, their fares cover, on average, only about 35 percent of operating expenses (Min, 2017).

Trends in Public Spending on Water Utilities

We distinguish spending on water resource infrastructure (e.g., dams, reservoirs, waterways) from water utilities that deliver drinking water and wastewater services. As shown in the bottom left panel of Figure 2.10, spending on water resources as a share of GDP has remained unchanged for the past 50 years, after peaking in the 1950s and 1960s. However, many of the old systems are reaching the end of their engineered lifetimes and will need significant maintenance and modernization (National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, 2011).

Federal spending on water utilities, shown in the top panel of Figure 2.19, peaked in the mid-to-late 1970s, when it required local governments to build more advanced wastewater treatment plants to reduce pollution into the nation's waterways in compliance with the Clean Water Act. State and local capital spending on water utilities dipped after the 2008 financial crisis, as shown in the bottom panel of Figure 2.19.

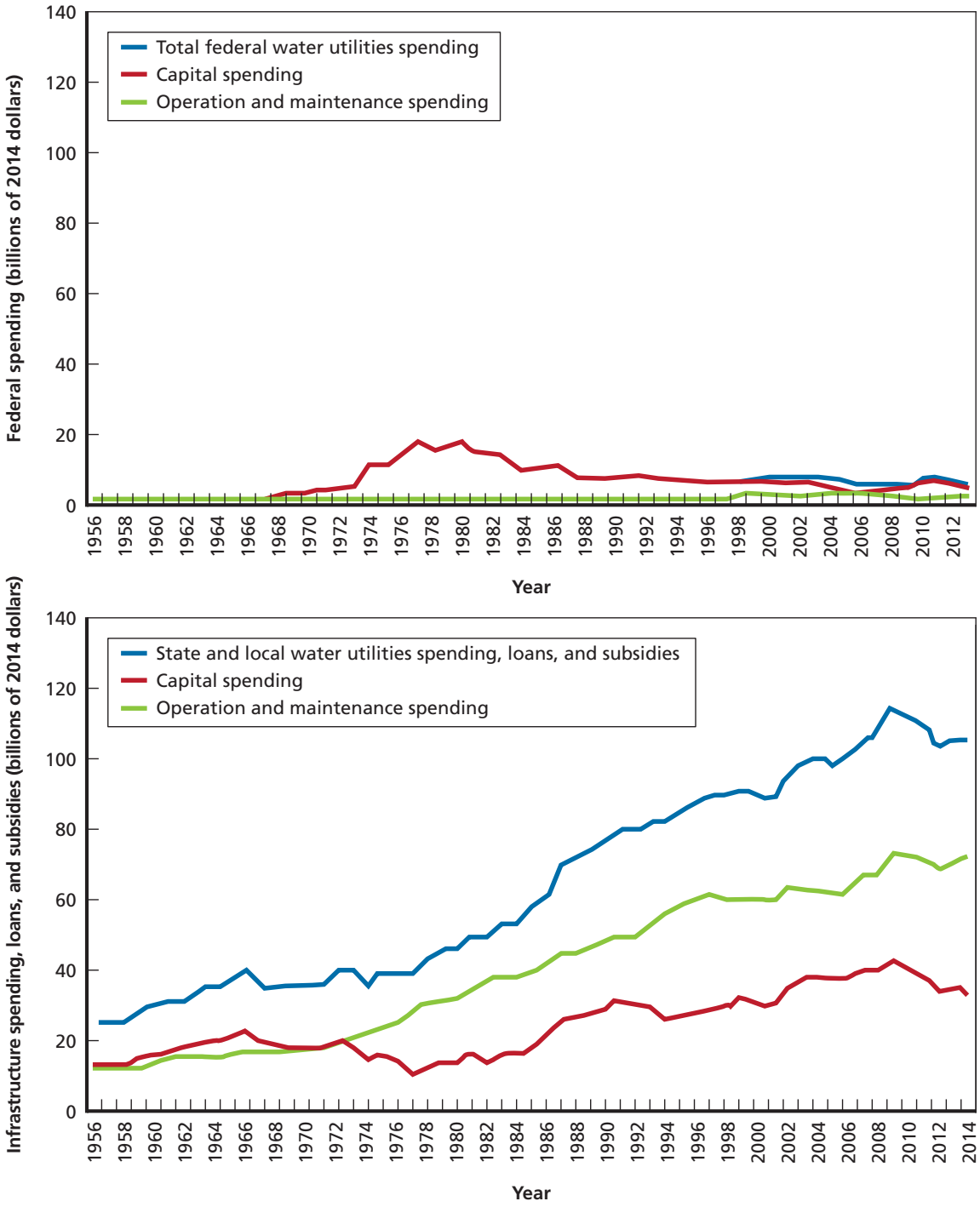
Trends in Private-Sector Spending on Transportation and Water Infrastructure

Private investment in transportation and water infrastructure is relatively minor (Engel, Fischer, and Galetovic, 2011). Table 2.1 shows that in 2014, private investment made up only about 3 percent of total expenditures on transportation and water, with most of the private funding dedicated to rail (Gayer, Drukker, and Gold, 2016). These numbers show how unattractive transportation and water projects have been to domestic and foreign investors, in part due to government policies. In the UK, private investors poured $50 billion into transportation infrastructure over the past 15 years, compared with only $10 billion in the United States over the same period (Engel, Fischer, and Galetovic, 2011).

Even so, interest in private spending through PPPs is growing. PPPs are attractive to public entities because they are able to receive a large portion of the financial investment up

[5] Kalikow chaired New York's Metropolitan Transportation Authority from 2001 to 2007; his op-ed in the *New York Times* is titled "The M.T.A. Has Enough Money."

Figure 2.19
Federal Spending (top) Versus State and Local Spending (bottom) on Water Infrastructure



SOURCE: Data from CBO, 2015.

RAND *RR1739-2.19*

Table 2.1
Total Expenditures on Transportation and Water Infrastructure, 2014 (in billions of 2014 dollars)

	Public						
	Federal						
	Direct Expenditure	Grants and Loan Subsidies	Total Federal	State/ Local	Total Public	Private	Total
Highways	1.5	44.9	46.4	118.3	164.7	0.0	164.7
Rail	0.3	2.7	3.0	N/A	3.0	9.7	12.7
Mass transit	0.2	12.3	12.5	52.9	65.4	0.2	65.6
Aviation	12.9	3.2	16.1	20.0	36.1	1.0	37.1
Water transportation	4.2	0.1	4.3	5.6	9.9	0.3	10.2
Water resources	9.8	0.1	9.9	18.3	28.2	0.0	28.2
Water utilities	0.0	4.4	4.4	104.5	108.9	0.8[a]	109.7
Total	28.9	67.7	96.6	319.6	416.2	12.0	428.2

SOURCE: Gayer, Drukker, and Gold, 2016; data on public investment from CBO, 2015; data on private investment from U.S. Department of Commerce, Bureau of Economic Analysis, 2015, Table 5.7S: Investment in Private Structures by Industry.

NOTE: Total expenditures include capital investment and O&M costs.

[a] Includes waste management and remediation services.

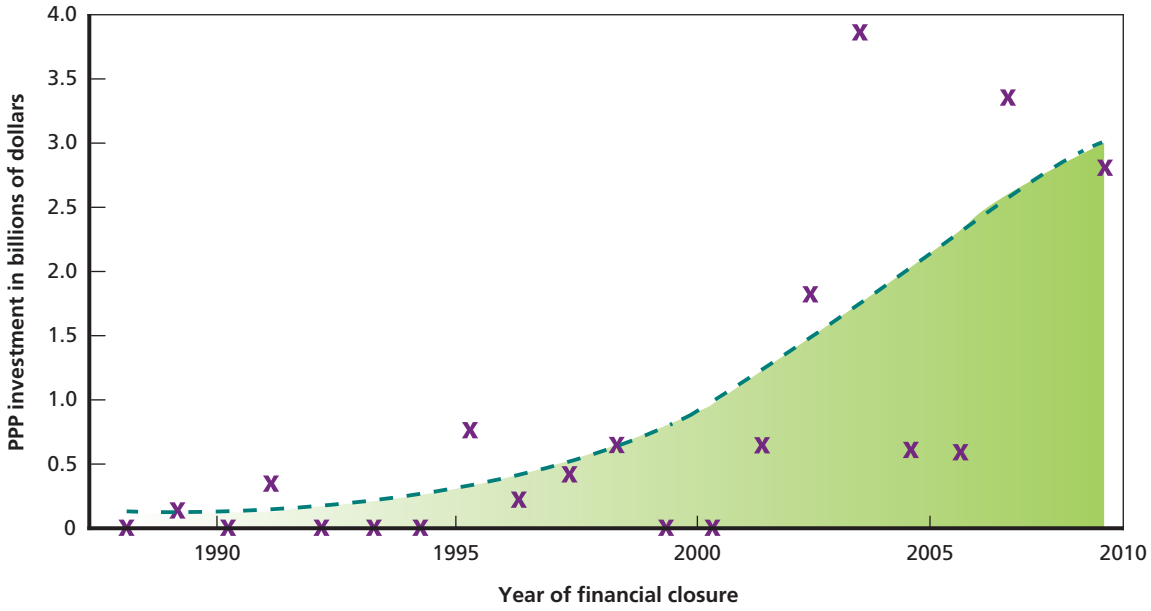
front and transfer some development risk, and PPPs are attractive to private funders who seek stable, long-term returns on investments (National Conference of State Legislatures, 2016).

Figure 2.20 shows the trend for PPP transportation investment between 1988 and 2009. Each X marks a specific combined public and private investment, and the dashed line represents a regression model of the trend in the data. The trend appears to show that investment is rising and may eventually become more significant in the future, especially as states adopt more laws allowing PPP transactions (Engel, Fischer, and Galetovic, 2011). However, the amounts are below 1 percent of total public spending on transportation. PPPs are further defined and discussed in Chapter Three.

Findings

The federal government's transportation and water infrastructure spending is predominantly on capital, while state and local governments shoulder the burden of both capital and O&M spending. Trends show a marked decline in total capital spending for both transportation and water infrastructure, mostly since the 2008 economic downturn, but an increase in total O&M spending. However, these trends alone cannot be unambiguously interpreted as adequate or inadequate. Looking at spending as a share of GDP across infrastructure types, a decline is most pronounced for highways. For all transportation modes, capital spending has been trending upward since the 1950s. O&M also has steadily increased, but the adequacy of the increase likely varies from place to place (CBO, 2015).

Figure 2.20
Public-Private Partnership Investment in the U.S. Transportation Sector



SOURCE: Engel, Fischer, and Galetovic, 2011, based on data from Public Works Financing and other sources. Used with permission.

RAND *RR1739-2.20*

Spending on water resource infrastructure peaked in the 1950s and 1960s but has since held steady. Still, many of those facilities are coming to the end of their expected lifetimes. Even though Congress ended its grant program to states for wastewater treatment plants more than 20 years ago, many state and local governments continue to rely on periodic infusions of capital from the federal government into state revolving loan funds. A similar revolving fund program was established to help local governments pay for drinking water treatment infrastructure. The decline in federal funding for water and wastewater treatment infrastructure reflects congressional decisions to scale back involvement.

Taken as a whole, evidence of federal underspending on infrastructure from a national perspective appears to be strongest for highways, which have generally been a state and local responsibility. As federal capital spending declined in recent years, state and local governments picked up most of the slack. Local investment in water utility infrastructure was set back by the 2008 recession, as shown by the steep decline in issuance of municipal bonds from 2010 to 2011, but bond issuances bounced back to record levels by 2016. Many water utility systems appear to be keeping up with their O&M needs, but many others are not, as discussed further in Chapter Five. In sum, public spending on infrastructure varies across type and place. The evidence on public spending does not support a broad claim of national disinvestment. Private funding of transportation and water infrastructure is less than 1 percent of total funding.

CHAPTER THREE

Infrastructure Funding and Finance Mechanisms Currently in Use in the United States

In this chapter, we compare current U.S. practices for funding and financing transportation and water infrastructure. Rarely are these two major sectors viewed through the same lens, even though they constitute the largest draw on public infrastructure funding and share common characteristics from an investment perspective. We are interested in illuminating the incentives and disincentives presented by these various arrangements, and their influence on levels and types of investments.

We discuss these mechanisms within four broad categories of funding and financing sources: federal; state, local, and tribal governments; banks, investment funds, and pension funds; and other nongovernmental sources. We distinguish between funding—money received from a source without expectation of payback—and financing—money received from a lender with the expectation of payback, usually with interest or other benefits, such as ownership or development rights.

Who Ultimately Pays for Infrastructure?

Regardless of whether an infrastructure project is funded or financed, the same two sources ultimately pay for it: users and taxpayers. Lenders and investors may provide financing, but ultimately users and/or taxpayers repay them. In the simplest terms, funding and finance mechanisms differ by how, when, under what conditions, and to whom these users or taxpayers pay for infrastructure. Taxpayers may sometimes also be direct beneficiaries of an infrastructure project, but not always. Depending on the funding and financing mechanism used, beneficiaries may also include bondholders, shareholders, and various individual and institutional investors, including public pension funds.

Users

Users of roads, bridges, water supply, and most other infrastructure are accustomed to paying tolls, water bills, train or bus tickets, and other types of fees.[1] User fees are a desirable form of cost recovery from infrastructure investment when beneficiaries can be clearly identified, their usage can be unambiguously measured, and the administrative and transaction costs of collecting fees are a small proportion of revenue flows expected. Heavily traveled roads, for example, can be financed by monetizing the expected future revenue stream from tolls. User

[1] For example, see the International Toll, Bridge, and Turnpike Association (2015).

fees can boost efficiency by varying the price by time, location, or type of user. But user fees are not always appropriate when widespread usage is socially desirable and benefits are spread broadly across a community.

Taxpayers

Funding for capital or O&M may come from general tax revenues or from a set-aside pool of money funded by a specific tax for a dedicated purpose. State and local governments also borrow money in bond markets, with the debt paid back by future taxpayers or future user fees. Historically, either or both of two conditions have generally been used to justify taxpayer-funded infrastructure: (1) a project generates large and diffuse net benefits for the local, regional, or national economy, and/or (2) collection of fees or tolls from individual beneficiaries is impractical or costly. However, collecting from users is now much easier, as Global Positioning System (GPS) trackers allow local jurisdictions to collect fees within their boundaries, although such pricing still faces obstacles, including concerns about privacy and data security.

Lenders and Other Private Sources

Bankers, private investors, pension funds, and a host of other groups all could invest in infrastructure outside of the municipal bond market, but they rarely do. Other financing arrangements include bonds, loans, rights to charge user fees, purchase of ownership, and development rights. For example, a developer may be willing to help pay for infrastructure in exchange for exclusive rights to build homes or businesses nearby, because land and buildings will sell at a higher price if the nearby infrastructure is built. Depending on negotiated terms, lenders or investors may bear some risk of loss if future revenue falls short of expectations, with more risk commensurate with higher potential returns on investment.

Federal Models for Funding

The federal government has many ways to spend money. Congress appropriates funds directly to agencies that then disburse those funds themselves, through state and local governments, or through contracts, grants, and cooperative agreements. As an alternative to collecting and redistributing tax revenue toward a particular purpose, Congress has modified the federal tax code to allow individuals and businesses to take tax credits and deductions for designated expenditures, and thus lower their tax liabilities—for example, by investing in solar or wind energy.[2] For this reason, the White House Office of Management and Budget (OMB) deems tax credits and tax deductions to be equivalent to expenditures. In addition to appropriations and tax expenditures, there is also a spectrum of loans and loan guarantees backed by the full faith and credit of the federal government. These too can sometimes be considered tax expenditures under congressional budget rules.

In this section, we provide a brief overview of these various federal mechanisms for allocating funds toward infrastructure, focusing on their relevance to spending on transportation and water infrastructure.

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[2] Established originally in the Energy Policy Act of 2005 and later extended several times by Congress, most recently in December 2016 (U.S. Department of Energy, no date).

Direct Investment Through Authorization and Appropriation

Authorization and appropriation is a two-step process used by Congress to allocate money. In the first step, most committees in the House and Senate are responsible for legislation that "may create or continue an agency, program, or activity as well as authorize the subsequent enactment of appropriations" (Heniff, 2012). Authorizations typically extend over multiple years. Table 3.1 summarizes the primary authorizing committees in Congress responsible for federal transportation and water resource infrastructure programs.

In the second step of the legislative process, Congress is supposed to enact annual appropriations bills to fund authorized agencies, programs, and activities. House and Senate rules are designed to enforce the distinction between authorizations and appropriations so that, in most cases, funds cannot be appropriated to an agency, program, or activity that has not been authorized (Heniff, 2012). The House and Senate each have an Appropriations Committee,

Table 3.1
Congressional Authorization Committees Responsible for Major Federal Transportation and Water Infrastructure Programs

Committee	Transportation Agencies/Programs	Water Agencies/Programs
House Transportation and Infrastructure Committee	Federal Highway Administration Federal Transit Administration Federal Aviation Administration Federal Rail Administration	U.S. Army Corps of Engineers National Oceanic and Atmospheric Administration
House Committee on Natural Resources		U.S. Bureau of Reclamation National Oceanic and Atmospheric Administration U.S. Fish and Wildlife Service
House Committee on Energy and Commerce		U.S. Environmental Protection Agency
House Committee on Science, Space, and Technology		National Oceanic and Atmospheric Administration
House Financial Services Committee		Community Development Block Grants (Housing and Urban Development Department)
House Agriculture Committee		Natural Resources Conservation Service and Rural Utilities Service
Senate Committee on Environment and Public Works	Federal Highway Administration	U.S. Environmental Protection Agency U.S. Army Corps of Engineers National Oceanic and Atmospheric Administration (partial) U.S. Fish and Wildlife Service
Senate Energy and Natural Resources Committee		U.S. Bureau of Reclamation
Senate Commerce Committee, Science, and Transportation	Federal Aviation Administration Federal Rail Administration	National Oceanic and Atmospheric Administration (partial)
Senate Banking, Housing, and Urban Affairs	Federal Transit Administration	Community Development Block Grants (Housing and Urban Development Department)
Senate Agriculture Committee		Natural Resources Conservation Service and Rural Utilities Service

and each committee has 12 subcommittees that cover the entire federal budget, with infrastructure programs spread across most of them. In recent years, separate annual appropriations bills have proved difficult to pass, and Congress has resorted to omnibus spending bills and continuing resolutions.

Other committees of the House and Senate also play important roles related to infrastructure. The House Ways and Means Committee and the Senate Finance Committee control tax policy and all of the decisions about tax rates on income and capital gains, as well as exemptions, credits, and deductions that shape investor behavior with respect to infrastructure investments. A large part of transportation expenditures is not appropriated; instead, allocations from the Highway Trust Fund, kept separate from general tax revenues, are spent using what is called "contract authority" (DOT, Federal Highway Administration, Office of Policy and Governmental Affairs, 2017). There are many more details underlying congressional jurisdiction, but, for our purposes, the point is that legislative responsibility is widely dispersed, making policy development across the many committees difficult to coordinate. Within the Executive Branch, OMB plays a critical coordinating role.

Formula Grants

Formula grants are allocations to states or their subdivisions in accordance with distribution formulas prescribed by law or administrative regulation for activities not confined to a specific project. Examples are the annual distributions from the Highway Trust Fund by DOT to states and the U.S. Department of Housing and Urban Development's Community Development Block Grant (CDBG) Program to all 50 states and more than 1,200 local governments, some of which is used to fund transportation and water infrastructure. These programs defer to state and local governments to determine how funds are to be spent. Federal departments and agencies have little or no authority to ensure that funds are directed to the projects that best advance national objectives.

State Revolving Funds

Many states have established State Infrastructure Banks (SIBs) to facilitate state and local financing of highway and transit projects through direct loans and other credit programs. SIBs are typically capitalized with federal-aid surface transportation funds, matched with state funding on an 80/20 basis (DOT, Federal Highway Administration, Office of Innovative Program Delivery, no date-a). Federal support for SIBs has been limited to two pilot programs.

A similar mechanism is used for water infrastructure. The two largest funding mechanisms for local water and wastewater utilities are state revolving loan funds established through federal legislation. The 1987 amendments to the Clean Water Act (33 U.S.C. 1383) established the Clean Water State Revolving Fund (CWSRF), which addresses needs for wastewater and storm water management. The 1996 Safe Drinking Water Act (Pub L. 93-523) authorized the Drinking Water State Revolving Fund (DWSRF). Federal grants programs preceded both revolving loan funds. Revolving funds involve both federal- and state-level funding.

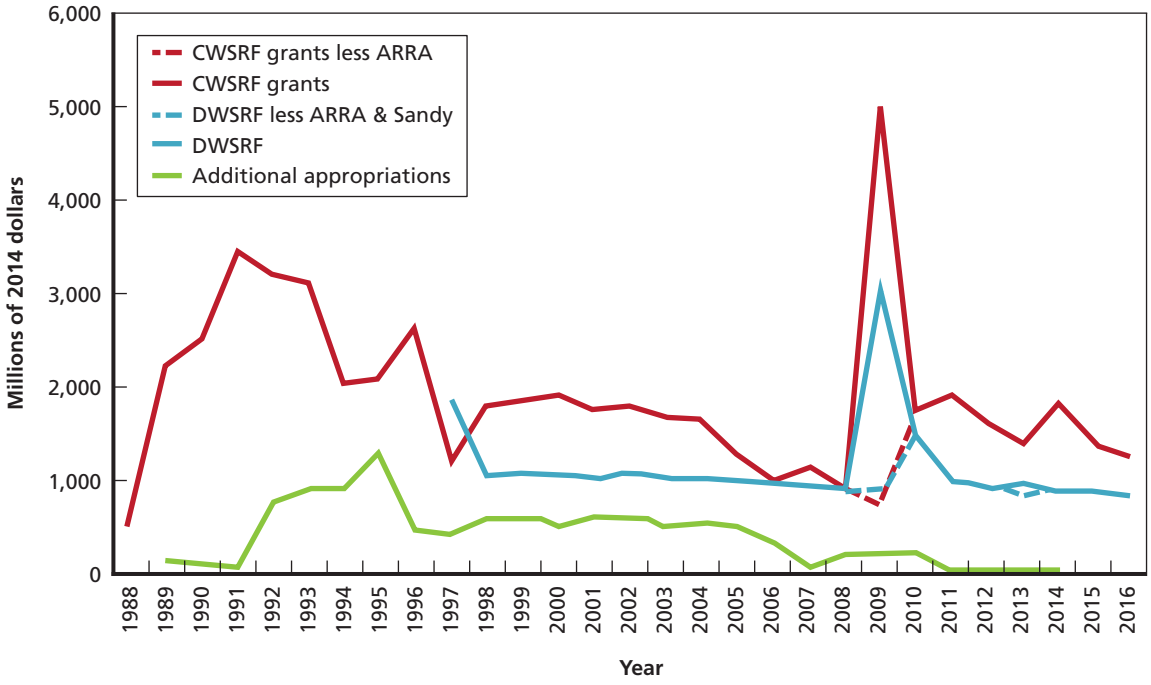
Each state provides funding to match a portion of a federal grant, and the combined amount capitalizes what effectively is an infrastructure bank for that state. The infrastructure bank makes low-interest loans to eligible projects within that state. Loan repayment replenishes its capital so the infrastructure bank can make low-interest loans to new projects. Although states largely determine which projects get funded, the ARRA required a minimum portion of the funds in the CWSRF to be loaned to green infrastructure, water or energy efficiency

improvements, or other environmentally innovative investments (EPA, Office of Inspector General, 2010). The Clean Water Act provides sufficient authority (aside from the special and limited terms of the ARRA) to enable loan guarantees, as opposed to direct loans, from CWSRF to be used for watershed protection, efficiency, and green infrastructure projects in addition to financing publicly owned wastewater treatment plants. States such as New York and Iowa have been making creative use of these authorities (Curley, 2016).[3]

The federal government pumps additional funding into the state revolving funds (SRFs) each year, although year-to-year spending has been uneven, as shown in Figure 3.1 (Gies, 2012). States review and rank proposed projects according to their own priorities and within 11 categories of projects eligible for assistance (EPA, no date-b). Unevenness in capitalization across states occurs in part because states also have authority to determine the specific terms of the loans, including when to forgive loans or offer other subsidies. If the funds become depleted, new revenue needs to be injected into the SRF to stay in business.

A 2015 GAO report examined the factors affecting the ability of states to sustain the CWSRF and DWSRF programs (GAO, 2015). It found that demands for loans can vary by

Figure 3.1
Federal Spending on State Revolving Funds and Other Appropriations for Water Infrastructure Grants



SOURCES: CWSRF and DWSRF data are from EPA (2016) and EPA (2017). Data on additional spending on water infrastructure via appropriations, covering 1989–2014, are from Copeland (2014a) and Tiemann (2017).
NOTE: Hurricane Sandy struck New Jersey, New York, and other places along the northeast on October 29, 2012, leading Congress to enact a $50 billion aid bill in 2013 for infrastructure repair and other purposes.
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[3] As an example, New York State's SRF guaranteed loans of another state agency to support green energy projects that would reduce nitrogen emissions from other electricity generating facilities. Airborne nitrogen is a major contributor of pollution of water bodies and eligible within CWSRF's guidelines.

state depending on economic conditions; environmental factors; availability of other, more favorable loan programs; administrative requirements; and the bond market. When communities are unable to repay their loans from the state SRF, the overall balance in the SRF declines, and less funding is available to loan out for new projects without an infusion of federal assistance. The requirement to charge below-market interest rates and limit interest revenue from investments also reduces the amount that can be recouped by the SRFs when projects are undertaken. However, even with continued strong demand, some SRFs continue to carry unobligated balances for extended periods, allowing valuable federal dollars to go unused. This problem could possibly be remedied by improving cash flow management and increasing financial transparency (GAO, 2015, pp. 35–36).

Loan Programs

In 1998, Congress enacted the Transportation Infrastructure Finance and Innovation Act (TIFIA; Pub L. 105-178, Title I, Subtitle E, Chapter 1) credit program, offering federal loans, loan guarantees, and lines of credit to state and local governments to fund certain transportation infrastructure.[4] TIFIA provides state and local governments with access to lower-interest loans than would otherwise be available. It does not offer grants. Costs are typically borne by state and local taxpayers or user fees. As described in DOT's 2014 report to Congress on TIFIA, the federal government is a "patient investor" whose long-term perspective can make otherwise unattractive investments more appealing (DOT, 2014). As of January 2017, TIFIA has supported $26 billion in loans to 64 different projects (DOT, 2017a). Table 3.2 breaks down the sources of loan repayment. Of the 61 loans in the TIFIA portfolio as of December 31, 2015, 10 were fully repaid and 51 remained open (DOT, 2016b). Projects backed by TIFIA represent about 10 percent of total capital funding for transportation in the United States from all sources.[5]

Table 3.2
Sources of TIFIA Loan Repayments

Type of Revenue Pledge	# of Active Loans
Taxes	12
Tolls	11
Managed lanes	9
Other project revenues	7
System pledge	6
Availability payments	6

SOURCE: DOT, 2016b.

[4] TIFIA was first authorized in 1998 (23 U.S.C. Chapter 6, Sections 601–609; DOT, Federal Highway Administration, Office of Innovative Program Delivery, no date-b; DOT, 2014).

[5] Drawing on the data in Table 2.1 of $230 billion in 2014 (in 2014 dollars) in spending on highways and mass transit, TIFIA-induced investment of $26 billion is about 10 percent of the total. Note that Table 2.1 does not record these PPPs as private expenditures.

The 2015 FAST Act decreased funding for TIFIA from $1 billion in FY 2015 to $275–$300 million per year for FY 2016 through FY 2020, although it does permit some use of rants and excess funds from other sources (DOT, 2016b).[6] According to a DOT report to Congress, "[h]istorically, and based on the most current estimates, each $1 of TIFIA program funds will support a loan of approximately $14 and result in infrastructure investment of up to $40, when taking into account other state, local, and private-sector investments" (DOT, 2016b).

Building on the TIFIA model, Congress passed the Water Infrastructure Finance and Innovation Act (WIFIA; Pub L. 113-121, Title V) program in 2014. The EPA describes WIFIA as a program that "accelerates investment in our nation's water infrastructure by providing long-term, low-cost supplemental loans for regionally and nationally significant projects." Funds can be used on a wide range of projects, including conveyance, treatment, desalination, recycling, aquifer recharge, and even property acquisition. The first $20 million of funds were not appropriated until December 2016 (EPA, no date-c; American Water Works Association, 2016). WIFIA can provide loans to state, local, and tribal governments for all projects eligible for CWSRF and DWSRF, and other water-related projects. WIFIA borrowers also can include corporations, trusts, joint ventures of various kinds, and SRFs. This program has the potential to take advantage of the water utility industry's very low loan default rate of 0.04 percent and the possibility of substantially leveraging the federal investment. According to the Congressional Research Service, "if only an average 10% subsidy cost is charged against budget authority, a $20 million budgetary allocation theoretically supports $200 million in loans" (Ramseur and Tiemann, 2017). The credit-rating agency Fitch estimates that one WIFIA dollar can yield as much as $50–$100, depending on the credit quality of the applicant (FitchRatings, 2017, p. 1).

Earmarking

Now in disfavor, congressional authorizations and appropriations for specific named transportation and water projects, known as earmarks, were a time-honored way for members of Congress to bring federal funding to their districts and states. In 2007, and again since 2011, earmarks were banned for two reasons. First, the obvious: Funds were being allocated based on the political benefits to members of Congress rather than based on needs as assessed by the EPA or DOT.[7] However, even in the absence of earmarking per se, Congress often directs funds to specific uses and thus limits their applicability to broader purposes. Second, there was a concern that earmarks for infrastructure, typically in the form of grants (that is, with no requirement for payback), limited the availability of federal funding to the SRF funds (loans), and hence deterred state and local governments from becoming self-sufficient with respect to infrastructure finance (Copeland, 2006). Figure 3.1 shows the spiky nature of aggregate federal spending on water infrastructure via SRFs and congressional earmarks for water infrastructure, shown by the green line.

Trust Funds and Excise Taxes

Revenues from individual income taxes are designated as "federal funds," which means they can be appropriated toward any authorization. Other sources of tax revenue can be directed to

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[6] Funding decreased for TIFIA for somewhat complicated reasons related to a build-up of unobligated balances, DOT's inability to process and obligate funds, and the pipeline of projects ready to spend the funding. See Davis (2015).

[7] For examples, see Engstrom and Vanberg (2010) and Copeland (2006).

trust funds for use only on specifically authorized programs or activities. For example, payroll taxes, which are paid partially by the employer and partially by the employee, go toward the Social Security Trust Fund and the Hospital Insurance Trust Fund for use by the Social Security and Medicare programs, respectively.

While income and payroll taxes account for the vast majority of federal tax revenue, they are not the only revenue source. A smaller source of federal tax revenue is excise taxes, which are an additional tax levied on the sale of certain products, such as gasoline, tobacco, and liquor. Trust funds can be used to tie excise tax revenue to particular programs or activities. The Highway Trust Fund, established in the Federal-Aid Aid Highway Act of 1956, receives revenue from the 18.4-cents-per-gallon tax on gasoline and the 24.4-cents-per-gallon tax on diesel fuel (and other related excise taxes). Only Congress has the authority to raise these taxes, and there is no mechanism for automatic adjustments for inflation.

Tax Exemptions

Congress also uses the federal tax code to implement national policy by giving tax credits and deductions[8] to individuals and firms in return for making certain expenditures, such as for R&D, renewable energy development, fossil energy development, energy efficiency, and literally thousands of other types of expenditures.

Most relevant for infrastructure, municipal bonds issued by local governments pay investors interest that is exempt from federal taxation. All states waive state income taxes on interest payments, as well. Tax-exempt bonds are very popular with states, cities, counties, and other entities, because they enable those governments to borrow money for qualified projects at lower interest rates than other financing options. Indeed, municipal bonds are the dominant form of financing local infrastructure, with $446 billion of municipal bonds issued in 2016 (First Trust Advisors, 2017).[9] Total municipal bonds outstanding peaked at $3.9 trillion in 2010 and, as of the end of 2016, are at around $3.8 trillion (Securities Industry and Financial Markets Association, 2017b). Municipal defaults are rare relative to corporate defaults, despite some notable recent examples. In 2013, only 0.107 percent of municipal issuers defaulted, compared with 2.1 percent of corporate issuers (Standard & Poor's Ratings, 2017). According to a 2014 Department of Treasury report, between 1970 and 2011, "this differential has been even higher: roughly 12 percent on the corporate side versus approximately 0.3 percent for municipal debt" (U.S. Department of the Treasury, Office of Economic Policy, 2014).[10]

Some tax policy experts argue that municipal bonds are an inefficient means of allocating infrastructure investment (Greenberg, 2016). They assert that the exemption encourages *overinvestment* by state and local governments, costs the federal treasury more than state and local governments gain in the form of lower interest payments, and mainly benefits the higher-income households that claim the tax break. Because the main incentive for purchasing these lower-yielding bonds is that the interest is tax-free, 75 percent of municipal bonds are held directly or indirectly by individual taxpayers. The remaining bonds are held by insurance companies and commercial banks, although their total holdings of these bonds are limited by

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8 A tax credit reduces a taxpayer or firm's tax liability on a dollar-for-dollar basis. A tax deduction lowers taxable income at the taxpayer or firm's marginal tax rate (Internal Revenue Service, no date).

9 Half of the bond issues from the states of California, New York, Texas, Pennsylvania, Illinois, Ohio, and New Jersey (Greenberg, 2016).

10 Data on municipal bond default rates drawn from Pylypczak (2011).

tax regulations. Organizations such as public pension funds that do not pay taxes have little incentive to invest in tax-exempt bonds, where the return on investment is less attractive than taxable opportunities (U.S. Department of the Treasury, Office of Economic Policy, 2014).

After years of debate, the United States still lacks a political consensus on whether municipal bonds should be the financing method of choice for local governments or whether there should be a federal subsidy at all. Other countries manage to build and maintain their infrastructure without tax-exempt municipal bonds. The U.S. Treasury Department argues for eliminating the exemption because of its inefficiencies and to remove the exemption's distortionary effects on capital flows and increase tax revenues in the process (U.S. Department of the Treasury, 2017). Were Congress to lower tax rates across the board, demand for such bonds would weaken.

Tax Credits

Tax credits that directly reduce tax liabilities are a blunt instrument. They spur investors to identify opportunities that meet a market test of profitability, albeit at a lower rate of return than they would expect for a taxable investment. But these are not necessarily the projects from which the public benefits most.[11] The most attractive investments, from a private investor's perspective, are those with easily tapped revenue streams, regardless of the public benefits. New tax credits also can have the unintended consequence of displacing investments that would have been made without them. Tax credits also can be transferred among parties, making them difficult to track. Thus, valuable public capital in the form of tax credits risks being deployed less effectively than with more-targeted mechanisms.

State and Local Funding and Finance

More than three quarters of U.S. infrastructure spending occurs at the state and local levels. State and local governments typically borrow the large upfront construction costs, which are then paid back over time using revenue from taxes or user fees. There are several ways in which this borrowing and repayment can occur.

Bonds

Local government bonds are effectively crowd-sourced loans that are typically repaid over 30 years. Bonds may be paid back by future tax revenue, user fees collected after the infrastructure is operational, or both. The most common type of bond is the tax-exempt municipal revenue bond discussed in the previous section. Tax-exempt municipal bonds have been local governments' overwhelming favorite financing mechanism in the past (National Association of Clean Water Agencies and the Association of Metropolitan Water Agencies, 2013). At the same time, they carry the risk of growing municipal debt collateralized with revenue streams that may or may not be available, depending on the economic fortunes of the local governments involved

[11] In practical terms, the Internal Revenue Service will not be equipped to "pre-approve" the use of tax credits to ensure consistency with national or even local benefits or even compliance with whatever rules are put in place; only through audits after the fact would the Internal Revenue Service be in a position to identify potential fraud or abuse.

(U.S. Securities and Exchange Commission, 2016).[12] Not all municipalities are disciplined about applying the revenues generated from infrastructure investments to pay bondholders (Braun, 2016).

Because tax-exempt bonds cannot be used for infrastructure that directly benefits the private sector, another class of tax-exempt bonds was created called Private Activity Bonds (PABs) (DOT, Federal Highway Administration, Office of Innovative Program Delivery, no date-d). PABs are used by state and local governments for infrastructure with both private-sector involvement and public benefit, such as airports, docks and wharves, and sewage facilities. Over the years, efforts have been made to increase the attractiveness of these bonds by providing various financial benefits to potential purchasers and by removing constraints, such as borrowing cap restrictions.[13] It should be noted that TIFIA provides lower cost of capital and flexible terms to entice more PPPs, and PABs are often a critical part of PPP arrangements. Critics, including CBO, argue that direct subsidies would be more efficient than PABs; eliminating PABs could increase revenues by $31 billion by 2023 (CBO, 2013).

Another type of bond is a "direct pay" bond. These are taxable bonds issued by state and local governments for which the federal government subsidizes a percentage of interest payable on the bond (U.S. Department of the Treasury, no date). For example, if the bond issuer borrows $1 million at a 5 percent interest rate, the lender receives $1.05 million, assuming a term of one year. If the federal government pays 20 percent of the interest, then the state or local government that issued the bond pays only $1.04 million and the federal government pays $0.01 million. The state or local government that issued the bond effectively paid a lower interest rate, and lenders receive an interest rate competitive with market rates. Build America Bonds (BABs), created by the 2009 ARRA when the municipal bond market was ailing, are one example of a popular direct pay bond.[14] In justifying their introduction, the U.S. Treasury noted:

> These bonds are designed to attract investment in U.S. infrastructure from banks and insurance companies, as well as public pension funds and foreign investors that are not subject to U.S. income tax, and so are unlikely to invest in traditional tax-exempt municipal debt. (U.S. Department of the Treasury, Office of Economic Policy, 2014)

During the life of the program (April 2009 through December 2010), 2,275 BABs were issued with a total value of $181 billion. BABs represented 23.1 percent of the total dollar value of municipal bonds borrowed during the life of the program (U.S. Department of the Treasury, no date). Some policy experts have advocated for a revival of BABs, albeit subsidized at a lower rate than the 2009–2010 period (Puentes, Sabol, and Kane, 2013; Eizenga, 2011). The viability of these types of bonds in the future will depend in large measure on assurances to investors

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12 "In 1945, there was less than $20 billion of municipal debt outstanding. In 1960, there was $66 billion of municipal debt outstanding. In 1981, there was $361 billion of municipal debt outstanding. Today, investors hold approximately $3.7 trillion of municipal debt" (U.S. Securities and Exchange Commission, 2016).

13 Section 11143 of Title XI of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU; Pub L. 109-59) amended Section 142(a) of the Internal Revenue Code to add highway and freight transfer facilities to the types of privately developed and operated projects for which PABs may be issued.

14 There are three types of Build America Bonds (BABs): direct pay BABs, tax-credit BABs, and recovery zone economic development BABs (U.S. Department of Treasury, no date).

from Congress that the subsidy will be sustained over the lifetime of the bonds. That was not the case with the short-lived BABs.

Another type of bond used by SIBs and specific to highways is called a Grant Anticipation Revenue Vehicle (GARVEE). The idea is for a state to offer a method of financing construction in anticipation of a federal-aid grant in the future, and then using the grant in part to pay financing costs (DOT, Federal Highway Administration, Office of Innovative Program Delivery, no date-c).

A relatively new type of bond based on "pay for performance" is called an Environmental Impact Bond and was recently used to support a "green infrastructure" project in Washington, D.C. (DC Water, 2017). The $25 million infrastructure bond is being used to reduce storm water runoff into local waterways. A preliminary study was conducted to predict the amount of runoff that will be reduced. If post-construction monitoring finds the reduction in storm water is significantly less than expected, investors will pay the city $3.3 million. If post-construction monitoring finds the reduction in storm water is significantly greater than expected, the city will pay the investors $3.3 million (Goldman Sachs, no date). The idea is to reduce DC Water's downside risk if these investments underperform, but reward investors if they overperform. Tying payments to outcomes can shift risk from state and local governments to the private sector, which can be efficient in many cases. The approach requires outcomes that can be objectively measured using independent methods agreed to in advance by all involved parties.

Direct Spending from General Revenues

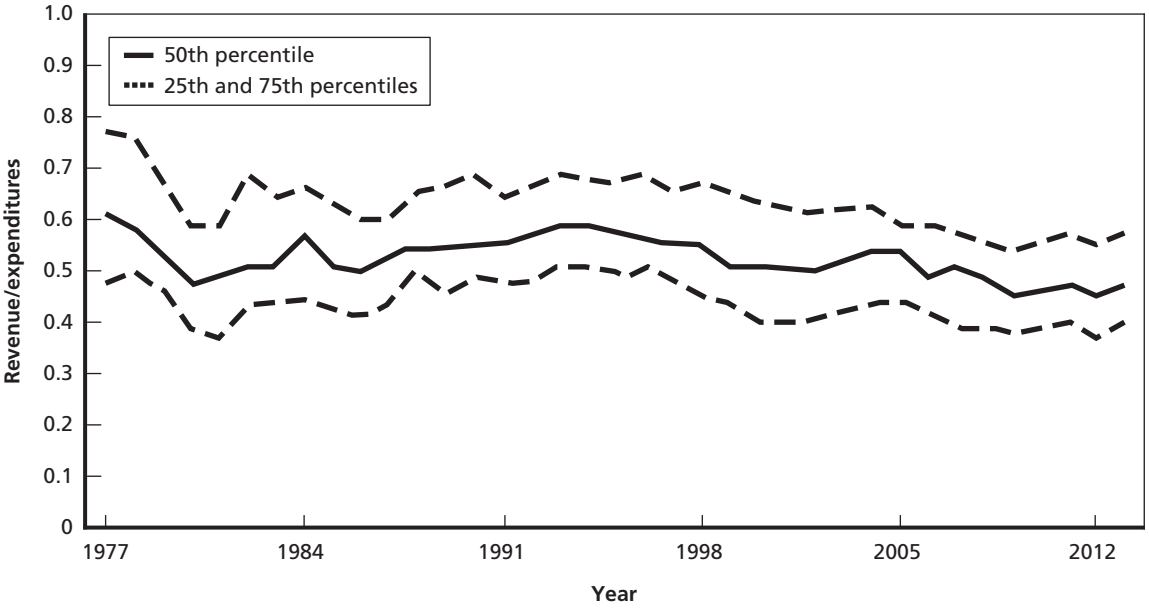
General revenues are derived from income, sales, and property taxes—sources not directly related to the use to which they are put, unlike some sales and excise taxes that are linked directly to transportation or other improvements. General revenues are essentially put into a common pool, out of which state and local governments pay for public safety, education, and health care, among many other public demands (Boschetti, 2014).[15] Figure 3.2 presents the fraction of state and local highway expenditures potentially covered by user fees and fuel taxes. In many states, most of the revenue from these sources is directed toward transportation infrastructure, such as highways and bridges, but may be used for mass transit, bicycle paths, trails and walkways, and other transportation-related projects (Herr, 2009). Additional costs must be covered by general revenue or transfers to the state from the federal government. In other words, Figure 3.2 provides a very rough estimate of the fraction of highway costs paid by user fees versus taxpayer dollars. To the extent that infrastructure projects are financed by user fees, the available funds reflect the demand for that infrastructure. When deciding how to allocate general revenue funds, legislators must rely on other, often less direct measures of demand for various infrastructure projects. On average, about half of the costs of highways are covered by user fees rather than general funds, but the ratio varies widely across states.

Rationale for Public-Private Partnerships

Another method of financing the costs of building and maintaining infrastructure is to have the private sector pay construction costs up front in exchange for the right to collect a revenue

[15] Also see publications from the "Center for Transportation Excellence" for extensive data about sales taxes used all over the country for transportation funding (Center for Transportation Excellence, no date-a).

Figure 3.2
State and Local Revenue from Transportation-Specific Sources as a Fraction of Total State and Local Expenditure on Highways



SOURCE: U.S. Census Bureau state and local finance data, accessed via Tax Policy Center (no date).
NOTES: The figure displays the 25th, 50th, and 75th percentiles (by state) for the ratio of total highway-relevant revenue to expenditures on highways. Here highway-relevant revenue includes local and state revenue from motor fuel taxes, motor vehicle and motor vehicle operators' licenses, and tolls or other revenue from highway operation. Our methodology is intentionally similar to the 2011 estimates in Henchman (2014).
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stream over time generated from the services provided by the infrastructure. Operating franchises are another common arrangement, and these do not cover construction costs up front. Such agreements are PPPs, and the details vary widely regarding who owns or is responsible for what aspects of the infrastructure, and for how long. For example, in a build-own-operate transaction, a contractor pays to construct, maintain, and operate a facility in exchange for the associated revenues. In some PPP structures, the private sector owns the infrastructure, while in other cases the government leases the infrastructure to the private sector for a number of years. In other PPP structures, the public entity may sell rights to a private partner to collect revenue from new or previously constructed infrastructure in exchange for covering operation and maintenance. In other PPPs, the government may pay a private firm for providing a service.[16]

Private-sector involvement in building or maintaining infrastructure is not always in exchange for revenue from the infrastructure. In some cases, the private sector may be contracted to provide a specific service, such as O&M, in exchange for a fixed or performance-based fee. In another case, known as developer financing, "the private party (usually a real estate developer) finances the construction or expansion of a public facility in exchange for the right to build residential housing, commercial stores, and/or industrial facilities at the site" (GAO, 1999).

[16] A useful graphic of the common flavors of PPPs in the United States can be found in Table 2.2 of BPC (2016).

The role of private finance in public infrastructure is complicated. First, as a baseline condition, any owner of infrastructure, public or private, needs to be fully accountable to the public in its compliance with applicable environmental and other safety and health standards. Second, the question of how financial risk is shared between the public and private partners in a PPP is not settled policy in the United States. Indeed, 17 states still lack enabling legislation to form PPPs (BPC, 2016, Figure 4.2, p. 40).

Private funding of major infrastructure has a long and mixed history in the United States: Investments in canals failed as private railroads, with considerable help from the government, displaced them. For example, in 1862 the federal government encouraged the Union Pacific and Central Pacific railroads to extend their networks westward by granting them "alternating sections" of land that they could sell or develop for profit that helped finance their railway investment (Ambrose, 2000). Today, most port facilities (but not the harbors themselves), railroads, and energy systems also are provided through private investment. In some states, private investment in roads was forbidden by legislation, but that is now changing (BPC, 2016). With mixed success, the private sector has gone into the business of building and operating highways, such as with build-operate-transfer transactions. In 2012, the Chicago City Council established the Chicago Infrastructure Trust to raise private capital for public works (Greenfield, 2013). The trust is proceeding slowly as it deals with concerns among the public about the level of accountability and transparency in decisionmaking and risk acceptance, problems that are discussed in the next section. Meanwhile, with congressional approval, DOT has created the "Build America Bureau" to foster collaborations with the private sector (DOT, 2017b).

These initiatives demonstrate that the public sector is now actively inviting the entry of the private sector, which has always been a willing party as long as money could be made. The problem has been that most infrastructure projects do not produce revenue in excess of costs.

Risk Sharing

In addition to levying new taxes or raising tax rates to pay for infrastructure, governments may assume that a project, perhaps a new bridge that connects an underdeveloped area to a central business district, will raise property values or increase the amount of taxable wages earned in the future. Methods such as "value capture taxation" seek to collect revenue based on these increases in land values (Chapman, 2017). Value capture taxation, popular in Australia and other places, has been slow to take hold in the United States, but the concept is receiving more attention as a means of augmenting other financing sources for transportation. It includes such approaches as transit impact fees, property tax increment financing, special assessment districts, and increased property taxes (Moliere, 2017).

An important aspect of risk sharing in PPP arrangements relates to which party bears the risk of financial losses if, for example, revenue from tolls or fees is lower than forecast or declines over time as alternative travel options become available. An example is a 2011 PPP that secured a contract to construct a tunnel in Norfolk, Virginia. Authorities are planning to build a parallel tunnel to alleviate major traffic congestion in the region, but the 2011 PPP with a Swedish construction company included a "noncompete" clause that requires local jurisdictions to compensate the company for any lost revenue resulting from traffic diverted to a new tunnel (Laris, 2016). Private investors have demonstrated more skill in shielding themselves from financial risk than their public-sector counterparts. Many projects have had to be restructured when debt could not be repaid by underperforming assets. Often, in transportation at least, the public agency guarantees the private return through "availability payments," whereby

the concessionaire receives a periodic "availability" payment from the public partner based on the availability of a facility to deliver service at a specified performance level.

A more positive example of risk sharing is the plan for the California High Speed Rail, often called a PPP. The public sector is to spend $70 billion to build it and then turn it over to a private operator/franchisee to run it.[17] The private sector ultimately is expected to have "skin in the game" by sharing some of the risk associated with the system's performance, which it would not have if it simply contracted to operate a system.

Constraints on Funding and Financing at the State and Local Levels

Many states are subject to tax and expenditure limitations (TELs) set by their own legislatures, which restrict the amount of revenue state and local governments can spend or raise. Figure 3.3 shows TELs only as they apply to state expenditures and state revenues.[18] Although TELs come in a variety of forms, most "tie annual spending limits to a combination of the inflation rate and the population growth rate. They typically involve the disposition of surplus state revenue, and are used as mechanisms to cap the rate of increase in specific tax rates, most often property tax rates" (Hill et al., 2006). There is intense disagreement about the impacts of TELs. Proponents cite the ability of well-constructed TELs to limit the size of government (New, 2001). Opponents argue that "TELs are largely ineffective and that state officials can circumvent them by raising money through fees" (Kousser, McCubbins, and Moule, 2008), that TELs may raise borrowing costs (Poterba and Reuben, 1999), and that TELs harm overall economic growth through mechanisms such as encouraging underinvestment in infrastructure (Deller, Stallmann, and Amiel, 2012; Deller et al., 2013).

While TELs explicitly limit infrastructure funding, they also impose *de facto* restrictions on infrastructure finance options. A major limitation on private-sector involvement is the complexity of policies and regulations defining ways in which the private sector can be involved in infrastructure finance. Private investors are loath to invest in infrastructure until clear ground rules governing the PPP are in place. At the same time, these rules vary state-by-state and election-by-election (BPC, 2016), rendering a "patchwork of legal environments and procurement practices" that limits PPP investment because of the uncertainty and hence risk to investment returns. This is referred to as *procurement risk*. Many, including a U.S. Treasury–led task force, have recommended better coordination of regulations (U.S. Department of the Treasury, Office of Economic Policy, 2014; BPC, 2016). This high degree of uncertainty in securing political and regulatory approvals makes the estimate of return on investment highly uncertain, as well.

Local government procurement practices present another barrier to PPPs. This barrier arises from the confluence of two factors: (1) the absence of a requirement in local bid documents to estimate the project's revenue stream based on full- and life-cycle cost recovery principles, and (2) the differences in costs between tax-exempt financing available to public borrowers and the higher market-rate financing available to the private sector. Public and private parties need to be able to generate an attractive rate of return, net of borrowing costs. In the vast majority of local procurements, where 95 percent of spending on water infrastructure

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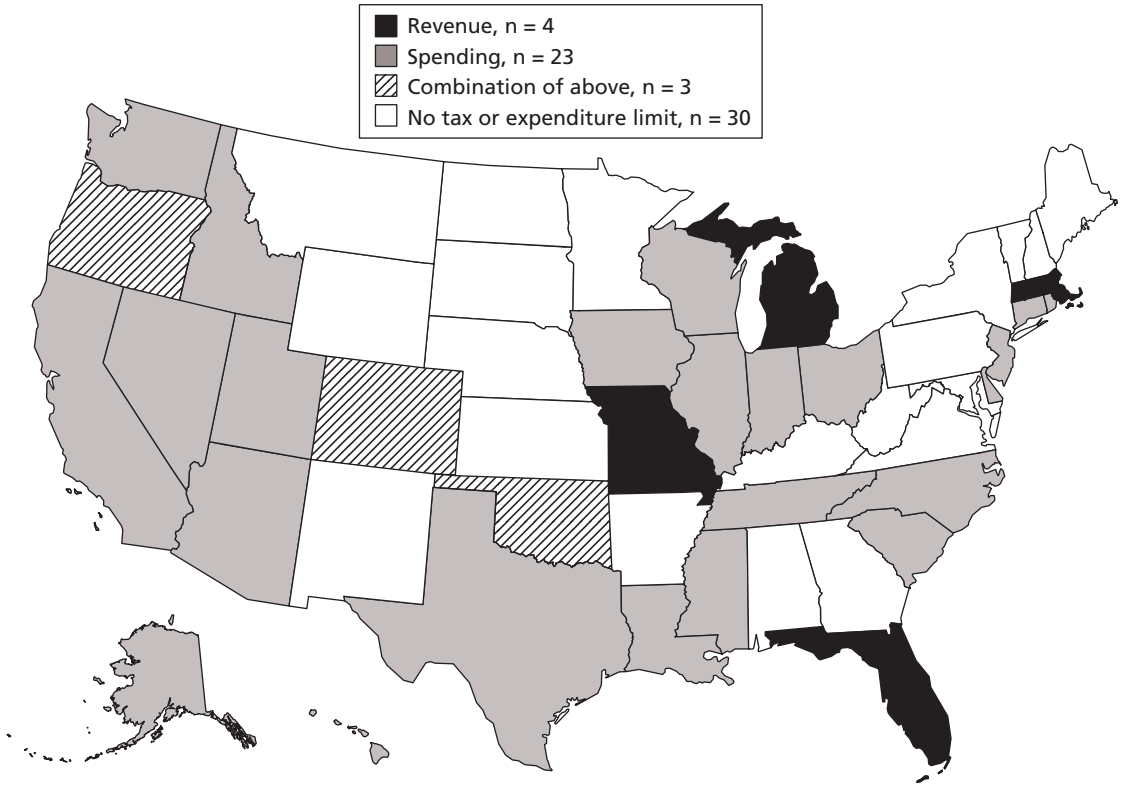
[17] This is a plan and a hope, and by no means a certainty (California High Speed Rail Authority, 2016, Section 6: "Funding and Financing").

[18] Not included, for example, is California's Proposition 13, a well-known revenue limitation that has hamstrung local governments in California for decades (California Tax Data, no date).

Figure 3.3
Tax and Expenditure Limitations, 2010



SOURCE: Waisanen, 2017. Used with permission.
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is taking place, tax-exempt financing provides public borrowers with the advantage of lower borrowing costs over private investors. However, if local bidding procedures allowed investors to receive a revenue stream that reflected full- and life-cycle cost recovery, the private sector could potentially overcome its disadvantage in borrowing costs through more-attractive revenue streams, and PPPs could be more competitive with a public-only finance model.[19]

Finally, there is simply the risk of building something ambitious and long-lasting in a rapidly changing economy and technological environment. The amount of revenue that will flow from a project that will last for decades is difficult to predict. Estimates of usage or demand and estimates of capital and operating costs are prone to large errors. Some technologies could make the useful lives of assets shorter or require major reinvestment to extend their use, but other technologies could enhance the efficiency of maintenance procedures (e.g., embedded sensors) and lengthen the lives of assets. Roads also may need to be modified to provide wireless dynamic charging of electric vehicles, which could prove to be a potential revenue stream, or adapted for use by autonomous vehicles. We know that some public projects will never generate sufficient revenue to cover costs, but we rarely can predict which projects they are. The demand for many services is difficult to predict, and projects have failed because forecasted urban development and traffic have failed to materialize when expected, although growth in demand may eventually come to pass after a long period of operating in a deficit. This is in

[19] G. T. Mehan, private communication, 2017.

addition to barriers presented by the patchwork of procurement practices and is simply a fact of life in public infrastructure investment.

Findings

The flow of capital and O&M funding into public infrastructure is shaped by the economics of the projects themselves and tax and investment policies at all levels of government. Infrastructure projects that generate revenues greater than their costs of construction and maintenance generally get built, although some of these projects may falter for reasons other than inadequate capital or cash flows for maintenance. Compared with other developed countries, the U.S. infrastructure market still attracts relatively little private capital into public infrastructure at the state and local levels, potentially because low-interest public financing crowds out private investment. Nonetheless, there are some promising developments through the TIFIA and WIFIA programs and changes in state-level policies intended to encourage PPPs. The biggest challenge for the public sector in crafting PPPs is to incentivize private investment while also managing risks to taxpayers through terms that ensure accountability and transparency over the life of the project. This has proved to be easier said than done.

Some public works projects have diffuse and long-term benefits that cannot be easily monetized through user fees or customer charges. These tend to be the projects least attractive to private investors seeking a predictable return competitive with other investment options. Mass transit projects fall into this category. While it is easy to monetize the direct use of a mass transit system through fares, affordability and equity concerns tend to put a ceiling on how high those fares can be set. Further, it is more difficult to convert side benefits, such as reduced congestion and emissions, into a revenue stream. Thus far in the U.S. experience, paying for the more diffuse and longer-term benefits of public infrastructure still requires tax revenues generated from a broader base of the population—for example, through income, property, sales, or excise taxes—to make up for the shortfall in revenue from user fees.

CHAPTER FOUR

Federal Transportation Policy and Its Impact on Infrastructure Investment

In this chapter, we examine the particular features of transportation infrastructure that complicate its construction, maintenance, and repair. What we refer to as transportation infrastructure consists of facilities that are, for the most part, owned and operated by public agencies. Roads, ports, airports, and public transit lines are generally planned, managed, and operated by governmental or quasi-governmental agencies, but, with the exception of mass transit systems, those facilities and networks are heavily used by privately owned companies and their vehicles. Private companies operate the ships calling at U.S. ports, the airlines in American skies, and the trucks on U.S. roads. And, of course, ubiquitous automobiles are operated by individuals, households, and businesses that own or lease them. One notable exception to this ownership pattern is provided by freight railroads, which typically own their tracks, yards, and rolling stock. In some cases, they also lease capacity to public passenger rail operators, such as Amtrak, in addition to operating their own trains. Our focus in this chapter is on highways, roads, and bridges.

Challenges of Building and Maintaining Transportation Infrastructure

Those who operate or travel on transportation infrastructure differ from those who own, plan, maintain, and operate the infrastructure. Owners, operators, and users of that infrastructure often have conflicting interests.

Conflicting Interests

The largely private users of transportation facilities seek to maximize returns by shifting as much of the burden as possible to infrastructure providers while paying as little as possible to use it. Truckers, for example, demand better roads of public system providers and try to lower costs by taking actions, such as overloading trucks, that shift costs to the public sector (DOT, Federal Highway Administration, Office of Policy and Governmental Affairs, 1997, pp. 1–13). Truckers have every reason to overload trucks to the point that they damage roads because doing so increases their returns in the short run (National Research Council, Transportation Research Board, 1997, pp. 24–25). While charging trucks directly for the costs they impose on the system is possible—for example, by charging weight-distance fees, as is done in Oregon, Germany, and elsewhere—this is often the exception. Partial or even full cost recovery is achievable through user fees, which in many places is politically unpalatable. Governments instead opt to raise funds indirectly—through bond issues, sales taxes, or gasoline taxes paid

largely by owners of autos that do less damage to the roads but are far more numerous than trucks (Balducci and Stowers, 2008; Day et al., 2014; Martin, Bell, and Walton, 2014; Montufar and Clayton, 1998).

Variability in Demand over Space and Time

Transportation system users demand high-quality system performance and adequate capacity at peak hours. Efforts to space out use by raising prices for peak-period travel have been adopted throughout the world, including in the United States, most commonly by introducing time-of-day tolling or high-occupancy tolling (HOT) lanes. But peak pricing remains underutilized, mainly because of the public's aversion to new or higher fees (Downs, 2004; Small, 2001).

Similarly, travel demand is highly concentrated in busy places: high-capacity and high-volume facilities that constitute a small portion of the transportation system. The rural roads, urban neighborhood streets, and local rail branch lines that constitute most of the transportation network carry a small fraction of traffic but are essential to providing access and connectivity (King, Manville, and Shoup, 2007; Wachs, 2005). Citizens must accept, and policymakers must manage, the financial burdens associated with simultaneously providing and maintaining crowded superhighways, major regional hub airports, crowded international ports, and a rich network of lightly traveled feeder routes and supportive facilities serving every travel mode.

Features of Federal Policy and Programs

There has never been an explicit federal transportation infrastructure policy. A carefully articulated current statement of federal transportation priorities, *Beyond Traffic, 2045: Trends and Choices*, outlines principles upon which there is widespread agreement, though it is too abstract to constitute policy guidance to state and local governments (DOT, 2015).[1]

Federal Government's Limited Role in Transportation Infrastructure

Federal involvement in infrastructure for transport has long reflected a history of partnerships with and incentives to the private sector and, more recently, state and local governments (Wells, 2012). The federal government does not operate, manage, or control most transportation infrastructure. It is one actor in a transportation infrastructure network that has national consequences but, by design, is highly decentralized. Most rural roads and urban streets are under the control of local governments. Major arterial roads and highways between cities are controlled by state departments of transportation and, in some cases, by special-purpose toll road authorities. Most ports and airports are operated by branches of local government or special authorities. Railways, airlines, and trucking are mostly controlled by the private sector (Weiner, 2013). These patterns are reflected in the expenditures by transportation infrastructure type, summarized in Table 2.1.

The federal government does directly own and operate some important elements of the national system—such as roads on federal lands, the air traffic control system, and the Transpor-

[1] See especially the chapter entitled "How We Align Decisions and Dollars," pp. 148–185.

tation Security Administration. However, transportation infrastructure policy is most usefully viewed as a decentralized network of programs with many public and private constituencies.

The U.S. Department of Transportation (DOT) was created in 1967 to streamline and integrate the wide variety of transportation infrastructure programs, but it consists to this day of separate agencies that address separate modes of transportation. Each reflects its unique history and particular mix of public and private participants (Weingroff, 2016). Despite calls for integration, five decades later, policies and legislation continue to treat the modes separately. Aviation, maritime, railroad, transit, and highway transportation modes differ to such a great extent that they require specialized knowledge. For example, safety regulations for railroad cars and for pipelines have nothing in common. And each mode of transportation has a unique history of funding and finance. Over time, the programs and cross-modal institutions have demonstrated their capacity to collaborate—and conflict—with one another. For example, since 1962, states and metropolitan areas have been required under federal law to designate and fund "metropolitan planning organizations" (MPOs). MPOs develop and implement long-range multimodal transportation plans mobilizing and integrating elements of federal programs and funding streams that operate separately by mode (Sciara and Wachs, 2007). To spend federal funds on transportation infrastructure, states and metropolitan areas are required to certify that projects are compliant with plans developed by MPOs, which are updated periodically and approved by the Federal Highway Administration and Federal Transit Administration. These plans, by definition, are financially constrained, in that they must include realistic plans for funding the implementation of the projects that comprise the regional plans (DOT, Federal Highway Administration, 2017d).

Dominance of Local and State Governments in Transportation Infrastructure

As citizens demanded better roads during the early 20th century, states began to provide intercity highways, and the dramatic growth of automobile travel strained state budgets. By 1920, roads and bond payments for roads were the largest items in many state budgets. States introduced motor fuel taxes to help expand and maintain their growing road networks. Fuel taxes cost far less than toll roads because they did not require the building and staffing of toll booths. And fuel taxes charged those who used roads: In an era when a small proportion of the population used roads for intercity travel, it seemed fair to charge users rather than taxpayers.

By World War II, all the states had adopted motor fuel taxation, and most limited the use of these taxes to roadbuilding and maintenance by creating "trust funds" and prohibiting user fees to be used for purposes other than transportation. Gradually, some states added toll roads or turnpikes in high-volume corridors, such as the Pennsylvania Turnpike and the New York Thruway, which were financed by tolls, and especially where roads were used by long-distance travelers, including large numbers of residents and trucks from other states.

The federal government responded at first modestly. Before 1900, it created an "Office of Road Inquiry" to improve the science and engineering of roadbuilding. Later, it gave states money to improve "post roads" that were used to carry mail between communities. Gradually, the federal role in the provision of transportation infrastructure grew to recognize the importance of roads to interstate commerce. Between the world wars, the federal government provided aid to the states for what were known as "Federal Aid Primary" road networks connecting major centers, and "Federal Aid Secondary" networks that provided access to the primary network. The federal role was to support state and local responsibilities for transportation infrastructure, although advocates sought special treatment for particular long-distance

roads, such as the Lincoln Highway, dedicated in 1913, that ran from New York City to San Francisco.[2]

Expansion of the Federal Role in the Second Half of the 20th Century

After more than 40 years of advocacy and debate, the National System of Interstate and Defense Highways (commonly known as the Interstate Highway System) took shape in the 1950s, and the federal Highway Trust Fund, modeled after earlier state trust funds, was created to finance it.[3] Congress clearly articulated that states were the decisionmakers and provided them with 90 percent of the construction costs of interstate highways. In return, states agreed to build roads in compliance with a set of national standards, match federal funding with 10 percent of state funding, and maintain the highways they owned (Seely, 1998).

Auto travel caused major disruption to the businesses that had been running mass transit. Many went bankrupt and were acquired by the public sector. That is why, today, mass transit is almost entirely in the hands of local governments or special units of government created as joint powers authorities. Rail transit could, in theory, be financially self-sustaining if methods such as land value capture were used to supplement fares. However, rail transit carries massive fixed costs that are difficult to recover through affordable fares (Jones, 2008).

Congress enabled federal participation in grants and loans for local transit operations by allowing highway user fees to be spent in limited ways on public transit as well. City leaders and transit advocates see this as a necessary and appropriate expenditure to achieve environmental goals and to increase urban accessibility; they portray transit as a complement to highway systems. Other interests consider the use of funds derived from highway users for mass transit to be an inappropriate "diversion" of user fees for new purposes (Poole, 2015).

Evolution and Influence of Federal Regulatory Requirements

The federal role in transportation is subtle and complex, reflecting its evolution. While the federal government does not directly choose *where* and *what* highways and bridges are built, unless they are located on federal land, it exerts a strong influence on *how* projects are built through extensive environmental and safety regulations and by requiring states to meet certain obligations to be eligible for federal funding. Many of the regulations and obligations are implemented by DOT, but others are overseen by different federal agencies, such as the EPA and the USACE.

Federal transportation funds, including fuel tax revenues, are available to states on the basis of allocation formulas, while other funds are available to states that compete for them by submitting proposals to federal agencies' discretionary programs. Federal priorities change from time to time; these are explicitly enunciated in federal transportation authorization bills that are enacted by Congress—typically every five or six years. These priorities influence agency decisions when applications for funding are reviewed.

Requirements for federal funding include provisions of the Civil Rights Act, the Executive Order on Environmental Justice (DOT, Federal Highway Administration, 2017e), rigorous review and public comment under the terms of the National Environmental Protection Act,

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[2] The Lincoln Highway was conceived in 1912 and dedicated in 1913 (Lincoln Highway Association, no date).

[3] The federal Highway Trust Fund was created through the Interstate Highway Act of 1956. A 1947 map of the then-proposed National System of Interstate and Defense Highways is available at http://ajfroggie.com/roads/yellowbook/conus-1947.jpg.

current requirements under the Clean Air Act Amendments, permit approval by the USACE under Section 404 of the Clean Water Act if projects impinge upon navigable waterways or threaten to harm the quality of drinking water, and permit approval by the U.S. Fish and Wildlife Service for "incidental taking" of endangered species (Lederman and Wachs, 2016). When transportation infrastructure projects are planned and built in coastal zones, they are also subject to limitations and permitting requirements under federal coastal zone protection legislation (DOT, Federal Highway Administration, no date).

Issues in Funding

The Highway Trust Fund was to be fed by a uniform national tax on gasoline and diesel fuel paid by consumers, truckers, and others at the gas pump. The principle behind this fuel excise tax was that roads should be paid for by those who use them. Motor fuel taxes, set in 1993 at 18.4 cents per gallon for gasoline and 24 cents per gallon for diesel fuels, are the Highway Trust Fund's main dedicated revenue source. Taxes on the sale of heavy vehicles and truck tires also bring in smaller amounts of revenue. These taxes contributed to a growing Highway Trust Fund for many decades as auto ownership grew, and increasing miles driven per driver compounded that growth.

Congress has not raised the per-gallon federal gasoline excise tax since 1993, and because the tax is not tied to inflation, it has declined in real value over time. The principal objection to raising the fuel tax has been that the price of fuel has risen and legislators do not wish to burden taxpayers more by charging them even more (U.S. Energy Information Administration, 2017). Further, technological innovations have enabled cars to drive more miles on the same amount of fuel, meaning that, over time, drivers pay increasingly less for each mile they drive. Congress encouraged this shift by enacting increasingly stringent fuel economy standards and incentives for buying electric and hydrogen-powered vehicles; whether this trend will continue in the Trump Administration remains to be seen. However, the result is that Americans are driving more but paying less fuel tax, creating a crisis in transportation financing. Since 2008, Congress has had to repeatedly "top up" the Highway Trust Fund with general funds, totaling $143.6 billion as of 2016 (Kirk and Mallett, 2016).

Many alternatives have been proposed for financing transportation infrastructure, including revenues from the sale of strategic oil reserves, from repatriated corporate profits on foreign operations, or from a revamped fuel tax. One idea is a tax linked to both inflation and average fuel efficiency. This would create a stable flow of revenue per average mile driven (Crane, Burger, and Wachs, 2012). Owners of cars with lower fuel efficiency would pay a higher tax rate per mile driven than owners of higher-efficiency vehicles. This would move the United States closer to pay-per-use infrastructure than funding transportation purely through general tax revenue, though taxpayers would still need to supplement the user fees. Others propose to treat the fuel tax as a carbon tax and exempt electric vehicles from taxation even though they still use the roads. In the end, a fee-collection approach based on vehicle miles traveled is the form closest to matching users to payers and hence connect the costs of highways to those who benefit the most (Sorenson, Ecola, and Wachs, 2012).

State and Local Alternatives to Motor Fuel Taxes

Because revenues from motor fuel taxes are declining and the widespread application of new and more direct forms of user fees are not likely to become widespread for decades, there are two national trends toward new forms of financing transportation infrastructure. Many cities and counties are increasingly enacting voter-approved sales taxes to support road and transit projects. In California alone, more than 20 counties have adopted local sales taxes that are earmarked specifically for transportation projects (Crabbe et al., 2005), and the Center for Transit Excellence reports on local ballot measures in literally hundreds of jurisdictions across the country over many years (Center for Transportation Excellence, no date-b). For example, in 2015 there were 34 transportation tax measures on ballots across the nation, and 24 were approved (Center for Transportation Excellence, no date-b). As a reflection of voters' growing perception of need, there were 77 transportation-funding propositions on ballots in 26 states on the November 8, 2016, ballot, of which 55 passed (Center for Transportation Excellence, no date-b).

In addition, states are increasingly adopting more-direct user-financed facilities in the form of toll roads, including roads that incorporate some form of congestion pricing, in which road charges are higher during periods of high demand. In many instances, such facilities are being financed by private investors who are able to monetize the expected revenue streams from projected traffic growth. State initiatives in transportation finance are discussed further in Chapter Three.

Conditions and Needs Assessments

Federal transportation laws for many decades have required that DOT publish systematic assessments of the "conditions and performance" of the surface transportation system. These biannual reports incorporate estimates of resources that would be required to meet anticipated needs. States are required to participate by carefully monitoring the condition of infrastructure assets and by forecasting future population, economic growth, and travel volumes. The process of assessing the condition of pavement, bridges, and transit structures has become more precise during recent decades, as agencies have replaced traditional periodic visual inspections with technological approaches that include test vehicles that traverse pavements and record ride smoothness, the use of sensors embedded in facilities, and radars that penetrate structures to assess internal components. Assessing current conditions is the first critical step in the assessment of needs.

The 2013 federal *Conditions and Performance Report* states that all levels of government in 2010 spent a combined $205.3 billion for highway-related purposes and a combined $54.3 billion for transit-related purposes (DOT, Federal Highway Administration, Office of Policy and Governmental Affairs, 2014). The report goes on to estimate that the average annual capital investment level needed to maintain the conditions and performance of highways and bridges at 2010 levels through the year 2030 ranges from $65.3 billion to $86.3 billion per year, depending on the future rate of growth in vehicle miles traveled. Improving the conditions and performance of highways and bridges by implementing all cost-beneficial investments would cost an estimated $123.7 billion to $145.9 billion per year. These investments would be in addition to annual expenditures on O&M. In its 2015 update on conditions, the Federal Highway Administration estimated that increasing spending on highways and bridges by around

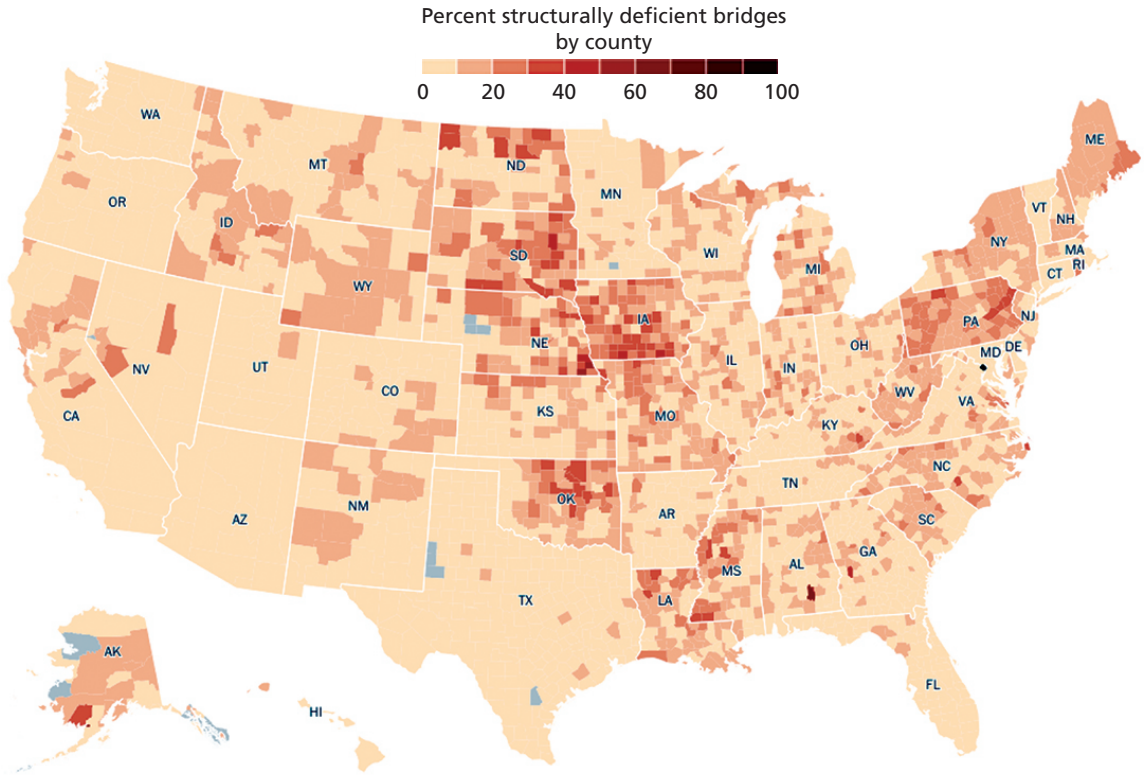
2.8 percent annually above inflation through 2032 would eliminate its projected maintenance backlog nationwide (DOT, Federal Highway Administration and Federal Transit Administration, 2016).

Aggregate national statistics on infrastructure condition and their consequent cost, however, mask salient regional or local differences. The data in DOT's *Conditions and Performance* report for 2015 show that the physical condition of the most heavily traveled roads improved a bit, and the condition of lesser-traveled roads worsened a bit in terms of pavement condition. If performance is measured in terms of congestion, that generally worsened over the past few years (DOT, Federal Highway Administration and Federal Transit Administration, 2016). In absolute terms, about 50 percent of U.S. roads are in poor or mediocre condition, but these are mostly local and not eligible for federal funding. The physical condition of bridges improved slightly over the past few years, but, as with all classes of assets, location matters. Figure 4.1 displays a snapshot of the percentage of structurally deficient bridges, by county, for the entire United States in 2016. The darker areas on the map show counties that, for whatever reason, are not keeping up with maintenance of their existing bridges. Among the 56,007 structurally deficient bridges nationwide (out of a total of 614,387), 1,900 are on the Interstate Highway System; more than 30,000 are in ten states, with almost 5,000 in Iowa alone, suggesting that the problem may not be systemic (DOT, Federal Highway Administration, 2017a). In the context of any proposed new federal spending on infrastructure, expectations of return on such investments need to be tempered by realistic prospects of sustained maintenance at the local level, hence the importance of life-cycle cost analysis.

Because what is "needed" is inherently subjective, a variety of approaches have been used to ensure that published estimates are widely accepted as realistic and perceived to be objective. A myriad of "needs" studies for transportation infrastructure are widely available in a variety of formats. Many states have commissioned panels of experts who have considered state-provided data to produce analytical reports that attempt to establish financial need for maintenance, upgrading, operations, and expansion of transportation facilities. An example of this is the widely cited Texas 2030 Transportation Needs Study, which was carried out by a panel of 12 highly respected independent experts appointed for the purpose by the Texas Transportation Commission at the request of the governor (Texas 2030 Committee, 2009). New York State commissioned an "outside research organization" to assess its needs, and the report has been widely cited. The study, conducted by TRIP (The Road Information Program), established that, despite ongoing spending, there was a growing unmet need for maintenance, upgrading, and system expansion (TRIP, 2016). While TRIP describes itself as "a non-profit organization that researches, evaluates and distributes economic and technical data on surface transportation issues," the group chosen was financially supported by "insurance companies, equipment manufacturers, distributors and suppliers; businesses involved in highway and transit engineering and construction; labor unions; and organizations concerned with efficient and safe surface transportation" (TRIP, 2016).

A dilemma inherent in all needs studies is that needs cannot be established objectively. Experts familiar with transportation infrastructure are most qualified to assess needs, yet experts also are likely to be advocates for improved infrastructure. The Texas panel of experts, the nonprofit group that produced New York's needs assessment, and the ASCE, which publishes the periodic *Infrastructure Report Card*, all represent deep knowledge of infrastructure needs yet all are also ultimately advocates for improved infrastructure.

Figure 4.1
Disparities in Structurally Deficient Bridges Among Counties



SOURCE: Lu and Keating, 2017; based on data drawn from the National Bridge Inventory Database (Nationalbridges.com, 2017). Used with permission.

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Notwithstanding the inherent impossibility of defining needs objectively, federal transportation infrastructure policy has evolved rather rapidly over the past decade from overt self-serving "pork barrel politics" to a somewhat subjective but far more transparent and data-driven assessment of needs based on the concept of "performance management" (BPC, 2011). To comply with federal requirements and thus to maintain eligibility for federal funding, states must report on their performance using objective indicators of performance, and they must estimate future needs that employ those indicators and estimates of improvements that can be expected in transportation system performance if new resources are expended to address their "needs," which reflect shortfalls in state performance measures. Federal requirements dictate that states develop measures, collect data, and report performance in seven areas (DOT, Federal Highway Administration, 2017c):

- Safety: To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.
- Infrastructure condition: To maintain the highway infrastructure asset system in a state of good repair.
- Congestion reduction: To achieve a significant reduction in congestion on the National Highway System.
- System reliability: To improve the efficiency of the surface transportation system.

- Freight movement and economic vitality: To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.
- Environmental sustainability: To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- Reduced project delivery delays: To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.

Gradually, in response to federal requirements, states and MPOs are transitioning toward needs assessments that explicitly measure current performance and state goals and objectives, and quantify financing needs according to these federally specified criteria. There is an evolving federal "toolbox" of methods that facilitates the transition. While there is recognition that needs cannot be defined using entirely objective data and methods, systematic analysis complemented by public participation processes can lead to productive debates, the setting of priorities by duly empowered bodies, and consensus on future actions.

Project Selection

The selection of projects at state, metropolitan, and local levels is, like the analysis of needs, an inherently subjective action that, in a democracy, can be informed and influenced by technical and analytical processes. Most states empower representative bodies, such as transportation commissions, and most metropolitan areas empower their MPOs, to select and prepare lists of approved projects for implementation as funds become available. Serving on these commissions and boards are local elected officials and citizens appointed by the governor or other senior public officials. The approved projects are enumerated in "transportation improvement plans" (TIPs) that typically list approved projects for the coming five years, and the lists are updated periodically. MPOs enact TIPs after debates, public testimony considering technical analyses, and recommendations developed by career staff and technical consultants. Typically, the deliberations ensure that a program of improvements emerges that is attentive to geographic distributions of benefits and costs to classes of beneficiaries (highway, transit, freight). The deliberations reflect interactions between technical and political considerations.

Most transportation projects selected through such deliberative processes have been assessed by staff or consultants using cost-benefit analysis (CBA) or an alternative assessment process like CBA. Many states have adopted standardized software that is widely used for the conduct of CBA.[4] Typically, transportation projects are assessed by comparing a list of specified categories of benefits to estimated costs. The benefits usually include improvements in safety, as measured by reductions in deaths, injuries and property damage; travelers' time savings, enumerated in minutes and valued according to a specified value of time; travelers' sav-

[4] For example, California and Minnesota's transportation CBA software are available online, including training manuals, case studies, and guidebooks, and are widely employed in those states and also are employed by agencies that do not have their own software packages (California Department of Transportation, no date; Minnesota Department of Transportation, no date).

ings due to changes in travel costs; and, often, environmental impacts, such as changes in air pollutant emissions.

CBA requires that benefits be "monetized" by estimating dollar values of benefits that are not usually measured in dollar terms. A large literature addresses such questions as the appropriate discount rates to employ in assessments of streams of transportation benefits and costs over time, and how to assign monetary values to estimate nonmonetary benefits. While some applications of CBA can be controversial,[5] the tool nonetheless provides a common language for debate and a means by which deliberative processes can move toward consensus.

After adopting projects and including them in regional or state TIPs, they move from planning into preliminary engineering. Projects are subject to a wide variety of further evaluations under federal and state law before they can be implemented. Among the further evaluation requirements are environmental reviews under the National Environmental Protection Act, certification that projects meet the requirements of the Americans with Disabilities Act, and compliance with other appropriate environmental reviews, such as the Clean Water Act for projects that impinge upon streams and rivers, and requirements of the Endangered Species Act for projects that will affect habitats of listed or threatened species. Compliance with these requirements can sometimes lead to reconsideration of previously approved projects.

Findings

Three critical path issues emerged from this review of surface transportation policy:

- failure to pivot from gas taxes to more sustainable funding sources
- barriers to priority setting
- a plethora of regulatory requirements at all levels of government.

As a nation, the United States continues to struggle with how to deal with its existing transportation assets and how to set priorities for both new investment and reinvestment (via the market, public choice, or hybrid approaches). At the same time, the nation's expectations of the features and benefits that highways, roads, bridges, transit, airports, and ports should provide have changed dramatically over the past half century (e.g., resilience to disaster, greenhouse gas emissions, equity). U.S. transportation networks are mature, but opportunities remain for advances in passenger rail and major innovations that take advantage of and respond to the rapid changes in transportation technologies and business models that are under way. The United States lacks processes to act on these changes. While some changes in the past decade on the edges of federal policy have affected project selection and evaluation, the United States still lacks systematic means of identifying projects of regional and national significance and bringing to bear the considerable financial capacity of the federal government to advance these projects.

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[5] Some oppose CBA on grounds that include the ultimate subjectivity of the choices of economic values, and because of the propensity to "double count" benefits when, for example, air quality improvements result in increased property values. Some controversial projects can be deliberated for years or even decades, and assumptions and data employed in CBA can be the subject of ongoing debates and litigation.

CHAPTER FIVE

Federal Water Policy and Its Impact on Infrastructure Investment

In this chapter, we describe the federal policy landscape for development and operation of water-related infrastructure, particularly the boundaries that have developed over time among the federal government, regional and local governments, and private utilities. Water supply is drawn from streams and rivers and pumped from aquifers, and can be stored in reservoirs and lakes or underground. Replenishment from rain and snowmelt is vital. Water is used for many purposes: drinking, agriculture, industrial processes, energy generation, and transportation. To this list of "human" water uses must be added water for the environment and sustainment of ecosystems. Ownership and operational responsibilities vary widely among different types of facilities, such as ports and harbors; inland waterways; facilities built to provide surface and groundwater, supplies such as diversions, pumps, pipelines, aqueducts, and reservoirs; hydropower turbines; water filtration, treatment, conveyance, and distribution to households, businesses, and industry; storm water storage and conveyance; and wastewater storage, conveyance, and treatment.

Challenges of Building and Maintaining Water Infrastructure

River and groundwater basins typically span state boundaries. Consequently, actions related to development and use of water by anyone can create spillover effects, or externalities on communities and states downstream. The determinant of such interstate effects is not the size of the infrastructure but rather the consequences for neighboring jurisdictions. For this reason, water management requires a high level of cooperation across jurisdictions as a matter of practical necessity. This is the primary reason why the federal government has historically played a prominent role in water resource development, flood control, and navigation. The situation is reversed for the actual provision of drinking water and wastewater services, in which local government dominates and federal and state governments play the role of regulator and provider of occasional financial assistance.

Aging Federal Water Resource Development Projects

Federal investment in water resource development has varied widely across regions, driven by a political consensus around economic development needs. The questions now are how much of this investment is past its prime and either should not be replaced or should be financed differently going forward.

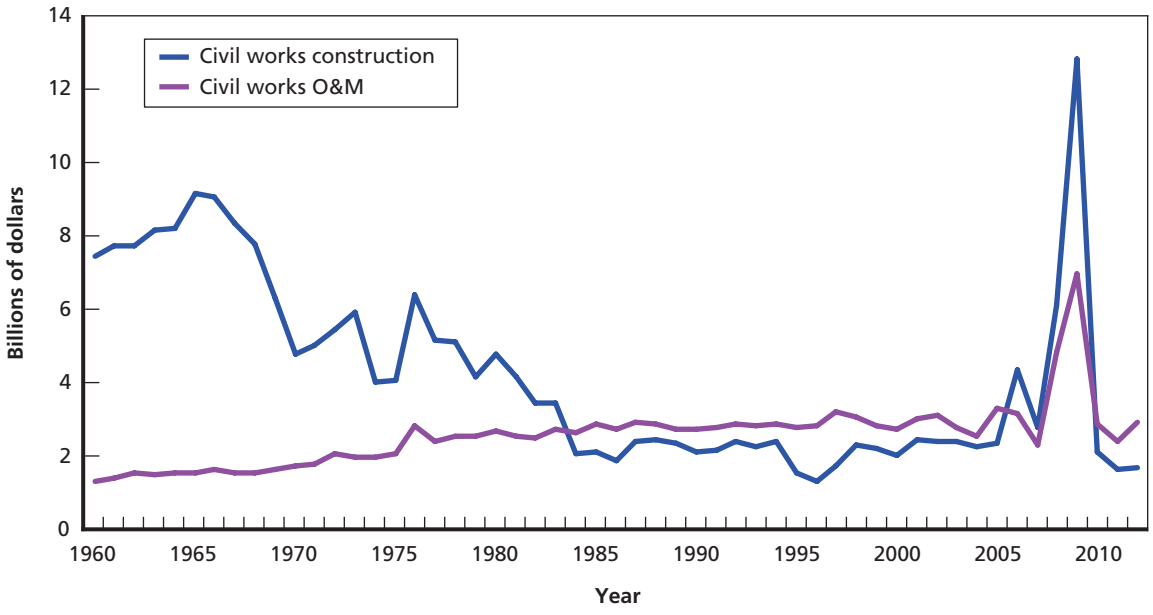
Improvement of navigable waters came first when Congress in 1824 authorized the USACE, formally established in 1802, to improve navigation on the Ohio and Mississippi

rivers to advance economic development (USACE, no date).[1] The USACE construction of dams, ports, and flood works continued through the remainder of the 19th century and peaked in the 1950s and 1960s. As shown in Figure 5.1, the USACE's appropriations for construction trended downward between 1960 and 2012, with a sharp spike from the ARRA stimulus. Spending on O&M rose gradually over this period, again with a spike from the ARRA stimulus. With so many of the USACE's assets constructed by the mid-20th century, it is not surprising that the value of the USACE's capital stock has been declining since around 1983, as shown in Figure 5.2.

With the great western expansion of the nation's boundaries, Congress established the BOR in 1902 to bring irrigated agriculture and, with it, settlers to what was then called the Great American Desert, west of the Mississippi River along the 100th meridian (National Park Service, no date). Over time, as cities such as Denver, Phoenix, and Salt Lake City grew, BOR irrigation projects began including more-substantial investments in municipal and industrial water supply for those cities. In contrast, Congress never gave the USACE authority to assist in constructing major infrastructure components of water supply systems in Boston, New York City, Philadelphia, Chicago, or other major population centers on the eastern seaboard or cities on the Great Lakes. These systems were considered strictly a local responsibility.

Both the USACE and the BOR are obliged to maintain aging assets while modifying operating rules and structures to lessen the environmental damage that many of their facilities have caused over the years. The decades-long process of changing the operations of the Glen

Figure 5.1
Trends in U.S. Army Corps of Engineers Appropriations, 1960–2012



SOURCE: National Research Council, 2013, Chapter 2: U.S. Federal Water Project Planning, Authorization, and Appropriations.

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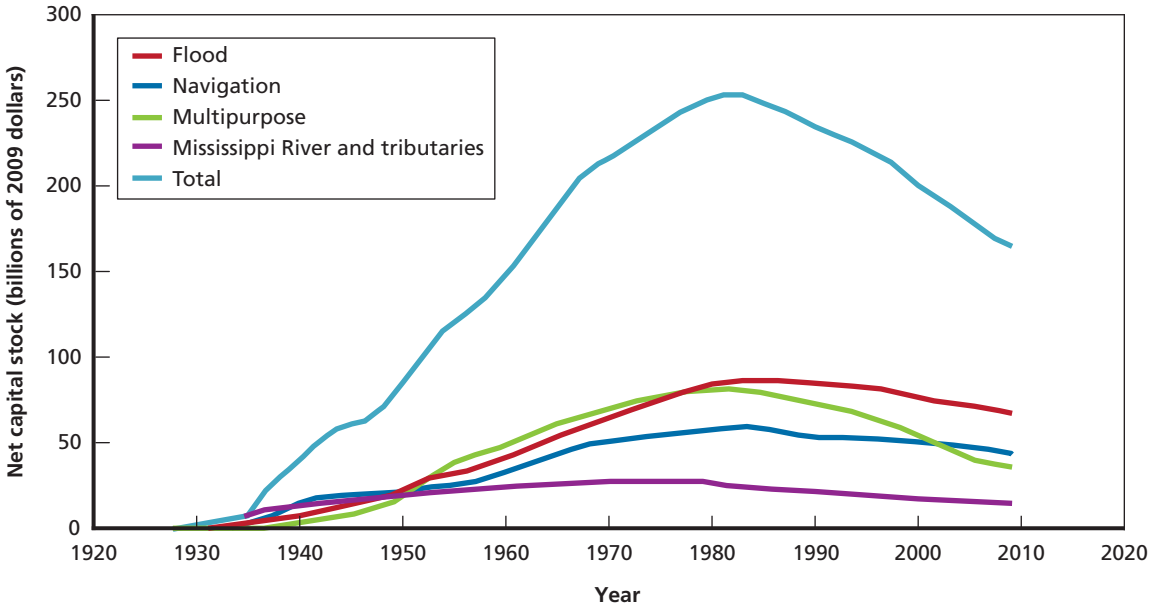
[1] In 1824, the Supreme Court ruled in *Gibbons v. Ogden* that the Commerce Clause of the Constitution gave the federal government authority over interstate commerce, including riverine navigation.

Figure 5.2
Trends in U.S. Army Corps of Engineers Capital Stock, 1928–2009



SOURCE: National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, 2011.

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Canyon Dam on the Colorado River to restore aquatic habitat along the lower reaches of the river is one of many examples. Some nonfederal dams in Oregon and elsewhere have even been removed because they have outlived their useful lifetimes and otherwise disrupt natural systems (Wegner, 1990). To some extent, the water resource agencies' missions in the 21st century can be characterized as one of "reverse engineering" many of their major capital investments of the 20th century.

With westward expansion no longer a national goal and the end of the era of major dam building, the federal role in water resources has largely evolved from one of development to environmental management. States generally have primacy in nearly all aspects of regulation. However, given the interstate nature of our major river basins, such as the Colorado and Mississippi rivers, and aquifer systems, such as the Ogallala and Edwards, federal involvement in some form remains relevant.

The United States has a rich and storied past when it comes to interstate and more-localized disputes over water use (Reisner, 1986). Allocation of water from the Alabama-Coosa-Tallapoosa and the Apalachicola-Chattahoochee-Flint river basins has led to a major conflict among Alabama, Florida, and Georgia (Southern Environmental Law Center, 2015). In northern California, conflicts among farmers, urban water users, and water needs to support endangered species have persisted for several decades (Baker, Sampson, and Harwood, 2013). These examples reinforce the point that repairing or building new water-related infrastructure is rarely as easy as "cutting red tape" or authorizing large sums of money. Legitimate differences in priorities often exist within regions and between states that inhibit new investment or rehabilitation of existing facilities.

Chronic Issues in Procurement and Pricing of Water Services

Local governments pay for over 95 percent of drinking water, sewer, and storm water infrastructure, with the states making up most of the difference. Local governments also invest in "source protection," by acquiring lands and easements in the areas upstream of reservoirs or above groundwater sources (Soll, 2013). Funding is typically secured through municipal bonds, and households and businesses are charged fees for actual water usage in the case of water supply facilities. Sewerage fees are also charged on the basis of usage. Storm water management is typically funded through property assessments and other taxes related to property value and extent.

For the same reasons that user fees or their equivalent are essential for maintenance of transportation facilities, proper pricing of water services is critical to the sustainability of water utilities. Yet, full-cost pricing, in which life-cycle costs are reflected in the prices charged to customers, is not practiced in many places throughout the United States, causing them to fall behind in maintenance (Kane, 2016; also see Ellis, 2017). While utilities should make provisions for households who cannot afford basic water services, the system as a whole cannot afford to run in the red and defer maintenance and repairs. As an example of how more-appropriate pricing can make a difference, Chicago doubled its water rates between 2010 and 2015 to enable it to speed up replacement of aging pipes; water in Chicago as of June 2017 costs $3.88 per 1,000 gallons, less than a half a penny per gallon (City of Chicago, 2017; Circle of Blue, 2015). For comparison, a gallon of bottled water cost about $2.10 in 2017—more than 500 times the cost of water at the tap. The average monthly water bill for a family of four in major U.S. cities ranges between $25 and $150.

Many older water systems experience water losses because of persistent leaks; they also lose revenue in the process. Leaks and pipe breaks in combined storm and wastewater systems can lead to higher inflows and infiltration and thus more water requiring treatment before its discharge to rivers. Poor controls on flows, whether of treated water or untreated wastewater, can lead to higher volumes flowing into treatment plants, and consequently higher operating costs (Fischbach et al., 2017).

The federal government felt an obligation at the time of passage of the Clean Water Act of 1972, and many years after the passage of the Safe Drinking Water Act of 1974, to provide support to communities as they sought to comply with the federal regulations. The federal government's most prominent role is in regulating the quality of streams, rivers, and other water bodies receiving treated and untreated wastewater and storm water and in regulating drinking water quality for the purposes of protecting human health and aquatic ecosystems. The goal of the Clean Water Act is often expressed in the vernacular as intended to make all waters of the United States "fishable and swimmable."

The question of the appropriate role of the federal government in helping disadvantaged communities modernize their drinking water infrastructure came to the fore with the unfortunate case of Flint, Michigan. The pathway to excessive levels of lead in Flint's drinking water is complicated. The city of Flint, whose population declined from 144,500 in 1990 to 102,000 in 2016 (Suburban Stats, 2017), had been drawing water from Lake Huron through Detroit's debt-ridden public water utility, the Water and Sewerage Department. Since the early 1990s, Detroit has generally maintained its lead levels in compliance with federal standards. In 2013, Detroit canceled its arrangement with Flint after Flint's city council voted to switch to a new pipeline from Lake Huron. In April 2014, Flint began drawing its water instead from the Flint River as an interim measure until the new pipeline was constructed. Michigan's Department

of Environmental Quality chose not to require Flint to adopt procedures for corrosion control, as recommended by the EPA. Many old service lines (those leading from the city's system into homes) in Flint contain lead. Corrosive water in contact with lead pipes substantially increased the concentration of lead in drinking water—orders of magnitude greater than the acceptable federal guideline.[2]

Residents of Flint, as in many lower-income and rural communities, face prohibitive costs of replacing aging service lines running into their homes and the pipes within homes. Flint's particular difficulties are compounded by its shrinking population and high water rates relative to peer communities, a consequence of poor management decisions made in the past (State of Michigan, Department of Treasury, 2016). The Service Line Removal Collaborative, founded by the Environmental Defense Fund, Clean Water Action, the American Water Works Association, and many other water associations and nongovernmental organizations, has been taking actions to increase the rate of voluntary action at the community level (Lead Service Line Removal Collaborative, no date). Other options, such as corrosion control or other infrastructure investments, also need to be considered. Water utilities have limited authority and resources to take on this issue themselves, as recently demonstrated in Pittsburgh (May, Fischbach, and Abbott, 2017).

Water Infrastructure as an Integrated System

The field of water resource management has undergone a major transformation since the time most federal water-related programs were put in place. Separate, stovepiped local and state departments for water supply, wastewater, water quality, flood control, ecosystem restoration, and resilience to natural disasters make little sense when planning, investing, and operating water infrastructure. These issues are clearly intertwined, and separate investment strategies are costly and potentially counterproductive. With the addition of stakeholder engagement and attention to governance issues, the preferred approach is called *integrated water resource management* (Lenton and Muller, 2009). For example, a barrier to protect densely populated areas from coastal storm surge has the potential to degrade water quality and ecosystem resources if not designed and operated with these concerns in mind. This development parallels the similar movement toward intermodal transportation planning identified in Chapter Three.

Even though integrated water resource management is widely accepted among water professionals in the United States and throughout the world, actual implementation has been slow. Federal programs for water resources remain fragmented. At the local and state levels, management of water supply, wastewater, and storm water infrastructure generally remain under separate governance structures.

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[2] One narrative places the blame on lax regulation by Michigan's governor and his Department of Environmental Quality for knowingly turning a blind eye toward the corrosion problem, abetted by the federal EPA. Another narrative points to the old lead pipes in Flint as another of many signs of America's neglect of aging urban infrastructure. A third narrative points to incompetence of city leaders in managing what was intended to be a transition strategy to a different means of supplying water from their same old source of Lake Huron water—and avoiding further dealings with the struggling Detroit system. Still another narrative casts Flint's tragedy as a sign of a larger trend of differential treatment toward the most vulnerable of residents in urban areas. Finally, another narrative places Flint's water problem in a broader frame of residual environmental risk decades after the United States passed its landmark environmental protection laws that were intended to protect the public, particularly infants and children, from all sorts of harms, including lead in drinking water or paint chips in homes. All of these narratives have some validity with respect to Flint.

Relevant Features of Federal Policies and Programs

Although direct federal involvement in water infrastructure has been shrinking relative to local and state expenditures, federal involvement in spending, regulation, and tax policy exerts an outsized influence on local public- and private-sector investment patterns. In FY 2016, federal funding for water infrastructure was provided largely by six U.S. departments/agencies:[3]

- Department of Agriculture (Natural Resources Conservation Service and Rural Utility Service)
- Department of Commerce (Economic Development Agency)
- Department of Defense (USACE, Civil Works Directorate)
- Department of Housing and Urban Development (Community Development Block Grants)
- Department of the Interior (BOR)
- EPA.

Coordination of budget and policy among these programs is the responsibility of OMB. Given the dispersion of these programs and the complexity of congressional oversight over them, the reality is that water infrastructure policy and investment are not often well aligned across the federal government.

Water Resource Development and Navigable Waters

Distinct from wastewater and drinking water systems, water resource infrastructure includes dams, levees, harbors, canals, and the locks and dredged channels of navigable waterways. Capital spending for federal water resource programs has been in decline for decades. Most of the nation's desirable sites for hydropower have been developed or otherwise been foreclosed from development and the need for "reclaiming" arid lands in the West has diminished. In the South, Northeast, and Pacific Northwest, the USACE was the primary builder of dams and levees, but the USACE now spends most of its budget on dredging and ecosystem maintenance/restoration (National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, National Academies Press, 2011). The share of the USACE's budget dedicated to O&M has been increasing every year and now exceeds spending on capital improvements. One of the most concerning issues on the USACE's agenda is dam safety, with so many of the dams built in the mid-20th century nearing or surpassing their planned lifetimes.

Federal support for navigation, coastal protection, flood control, and ecosystem restoration is highly variable in terms of cost-sharing arrangements with state and local governments (Rubin, 1983). The variability in cost-sharing across the different business lines reflects changing perspectives in Congress about the national and regional priorities over the 20th century. Table 5.1 summarizes these cost-sharing arrangements as of 2016. In FY 2010, about 32 percent of the USACE's budget was allocated to navigation improvements, 34 percent to flood risk management, nearly 17 percent to environmental restoration, and the remaining 17 percent to

[3] Article 1, Section 8, Clause 3 of the Constitution, known as the Commerce Clause, is the primary rationale for federal involvement in navigable waters of the United States, leading to national investment in navigation improvements, harbor dredging, flood control, water supply (in some regions), and eventually regulation of discharges of wastewater and chemical pollutants.

Table 5.1
Federal Cost-Sharing for Capital and O&M by Type of Water Infrastructure

Project Purpose	Maximum Federal Share of Construction (%)	Maximum Federal Share of O&M (%)
Navigation		
Coastal ports		
<20 ft. harbor	80[a]	100[b]
20–50 ft. harbor	65[a]	100
>50 ft. harbor	40[a]	50
Inland waterways	100[c]	100
Flood and hurricane damage reduction		
Inland flood control	65	0
Coastal hurricane and storm damage reduction	65	0
Except periodic beach renourishment	50	0
Aquatic ecosystem restoration	65	0
Multipurpose project components		
Hydroelectric power	0[d]	0
Municipal and industrial water supply storage	0	0
Agricultural water supply storage	65[e]	0
Recreation at corps facilities	50	0
Aquatic plant control	Not applicable	50

SOURCE: Carter and Stern, 2017, Table 2, p. 14, drawing on 33 U.S.C. 2211–2215.

[a] Percentages reflect that nonfederal sponsors pay 10, 25, or 50 percent during construction and 10 percent over a period not to exceed 30 years.

[b] Appropriations from the Harbor Maintenance Trust Fund, which is funded by collections on commercial cargo imports at federally maintained ports, are used for 100 percent of these costs.

[c] Appropriations from the Inland Waterway Trust Fund, which is funded by a fuel tax on vessels engaged in commercial transport on designated waterways, are used for 50 percent of these costs.

[d] Capital costs initially are federally funded and are repaid by fees collected from power customers.

[e] For the 17 western states where reclamation law applies, irrigation costs initially are federally funded, then repaid by nonfederal water users.

hydropower, recreation, water supply, emergency management, and administration (National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, National Academies Press, 2011).

Even with state or local cost-sharing, the USACE and BOR programs have a long history of subsidizing municipal and agricultural water users, particularly in the western United States. Environmentalists and fiscal conservatives have criticized these programs for not requiring full-cost pricing of water and, along with various crop subsidy programs through the U.S. Department of Agriculture, encouraging overconsumption of water supplies (Lustgarten and Sadasivam, 2015; Reisner, 1986).

Capital investment through the USACE process is remarkably inefficient, due to the unique role of Congress in involving itself in project-level funding decisions. It takes at least four acts of Congress before a single USACE capital project can be constructed. Congress must first authorize a study, then fund the study through appropriations, authorize construction following completion of the feasibility study and a recommendation to construct from the Chief of Engineers, and, finally, authorize appropriations to fund construction. This dysfunctional approval process can take decades, and it has created a vast backlog of projects that will never—and likely, should never—be built.

In recent years, the USACE has made improvements in how it plans, prioritizes, and budgets its work. It also plays an active role in ecosystem restoration as part of resilience strategies led primarily by local and state governments, such as in New York City following Hurricane Sandy (Sanderson et al., 2016) and the Louisiana coast following Hurricane Katrina (Coastal Protection and Restoration Authority of Louisiana, no date).

Economists and others have suggested that water markets and trading, now in limited use in the western United States, could lead to more efficient pricing and hence allocation of water from federal water projects, but, thus far, the idea has not taken hold because of significant technical, institutional, and political impediments (Howitt and Hansen, 2005; Raffensberger and Milke, 2017, Chapter 13).

Wastewater Infrastructure

For the past 45 years, the largest federal expenditures on water overall have been through the EPA. The 1972 Clean Water Act authorized substantially more federal financial assistance for municipal wastewater treatment plant construction than had been the case in the 1950s and 60s, and the law significantly expanded and tightened regulations to reduce pollution in navigable waters. To compensate for the underspending by state and local governments, Congress in 1972 raised the share of federal spending from 55 to 75 percent of the costs of secondary treatment of wastewater in response to widespread pollution of the nation's streams and rivers, with state and local governments picking up the other 25 percent (Copeland, 2012). Funding was allocated to the states according to a formula based on population and need, as determined by an EPA survey, and states set their own priorities. Historically, wastewater treatment has not been a particularly attractive investment opportunity for the private sector, in part because of the availability of extensive federal funding beginning in the 1950s and extending into the 1980s (National Research Council, 2002). The federal share was later reduced to 55 percent in 1981.

The most recent major amendment to the Clean Water Act was the Water Quality Act of 1987 (Pub L. 100-4), which authorized a wide variety of appropriations related to water and pollution, including the phase-out of grants and an initial infusion of $8.4 billion for CWSRFs for sewage treatment infrastructure, discussed in Chapter Three (Weinraub, 1987). Both grants and loans were set to expire by the early 1990s. However, even in the face of major budget deficits and a growing federal debt, Congress has found it difficult to wean states and local agencies off of federal support and has consequently continued to appropriate funds for the SRFs to this day (Copeland, 2014b). At the same time, some SRFs have built up large balances of unobligated funds, leading to questions about the extent of need for federal funding (GAO, 2015). The need for federal subsidies is further called into question in the absence of a requirement that utilities employ full-cost pricing to account for life-cycle costs and pay for upgrades and repairs.

Drinking Water Infrastructure

Ninety percent of investment in drinking water infrastructure is made at the local level through the use of municipal revenue bonds. The federal Safe Drinking Water Act regulates the quality of drinking water at the tap for more than 152,000 public water systems in the United States. Ninety-seven percent of these public water systems serve communities of 10,000 or fewer people, but, in total, they serve about 21 percent of the U.S. population (EPA, Office of Research and Development, 2016). About 12 percent of the U.S. population is served by privately owned water systems (Kopaskie, 2016).

The EPA has set standards for more than 90 contaminants, including lead; states are free to set more-stringent standards. Meeting these standards can be costly and technically difficult, particularly for the smaller rural systems serving fewer than 10,000 people. Populations in these small communities are typically dispersed, requiring more pipe "miles per customer" than larger systems and making consolidation of these smaller systems into more financially viable utilities difficult in places (American Water Works Association, 2012, p. 12). Congress authorized a state revolving loan program in 1996 to assist water utilities in their compliance with federal drinking water regulations (EPA, no date-a). Before that time, the federal government largely stayed out of funding or financing drinking water facilities, in contrast to its involvement in wastewater treatment.

Conditions and Needs Assessments

A needs assessment is the first part of estimating the gap between the spending that is thought to be needed and actual spending. The arithmetic is simple—GAP = NEEDS – SPENDING—but is often complicated by a number of methodological issues (Copeland and Tiemann, 2010).

The bottom line of the ASCE report card on U.S. infrastructure and other infrastructure assessments is the large gap between the infrastructure America has today and the infrastructure America "should" have. In 2013, ASCE estimated a need for $1 trillion in capital spending for drinking water infrastructure over the next 25 years and $298 billion spending for wastewater infrastructure over the next 20 years (ASCE, 2013a). On an annual basis, these needs estimates translate to about $55 billion in capital spending for drinking water and wastewater infrastructure. Other recent needs assessments range from $11.25 billion to $40 billion per year (in 2011 dollars) for drinking water infrastructure (EPA, 2013a; American Water Works Association, 2012). Estimates of wastewater capital costs come in at around $12.7 billion per year (2011 dollars) (Copeland, 2012). For comparison, in 2014, CBO estimated public capital spending on drinking water and wastewater infrastructure to be $34 billion and O&M spending to be $72 billion.

The size of the gap depends on assumptions about replacement rates of pipes and facilities. Some costs in needs assessments are based on varying standards of repair frequency, including factors such as population growth and age of the system. Assumptions about construction costs, including the price of energy, also influence the numbers. Assessments also differ by the method used to generate the estimates. For example, the EPA's Drinking Water Infrastructure Needs Survey and Assessment uses survey data to collect information on self-reported costs of planned future projects (EPA, 2011). Systems that do not appropriately price their services—and are consequently undermaintained—are implicitly given greater weight in these assessments than systems that employ full-cost pricing to cover their routine maintenance and

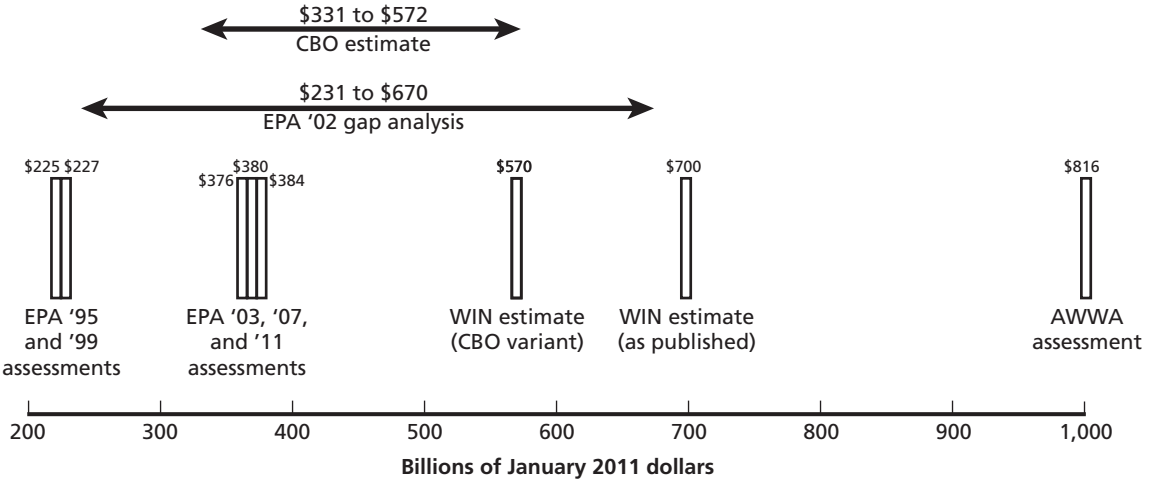
system upgrades. Further, needs assessments do not account for whether users are willing to pay for higher levels of maintenance or investment.

Because of these and other issues, national-level needs assessments can provide some indication of order of magnitude needs, but they cannot reliably guide levels of investment or individual investment decisions. A 2002 CBO study found the average annual gap between current spending (1999 at the time of the study) and projected needs between 2000 and 2019 for its low-cost (and preferred) scenario to be $0 for water supply and $3.2 billion for wastewater systems, an increase of 14 percent above 1999 spending levels; its high estimates came in at 90 percent above 1999 spending (CBO, 2002; Copeland and Tiemann, 2010). CBO was more confident about the validity of its low-cost scenario. As CBO noted at the time, the "result contradicts conventional wisdom that the nation's water systems will soon be straining to fund a large increase in investment." A 2010 Congressional Research Service study reviewed the 2002 CBO study, noting that a future investment gap was not inevitable as long as water and wastewater utilities ramped up their revenues to cover maintenance and replacement costs.

Example: Drinking Water Infrastructure

To drive home the limited use of needs assessments, we examined the varying estimates of drinking water infrastructure needs. Figure 5.3 compares multiple needs assessments covering roughly the same time period, illustrating the problem of using these widely varying assessments as a guide for setting policy and priorities. In its latest report to Congress in 2013, the EPA found that the "nation's drinking water utilities need $384.2 billion in infrastructure investments over the next 20 years" (EPA, 2013, p. i). The EPA only surveys projects eligible for DWSRF funding. The report also compared this estimate to prior EPA estimates and estimates from other organizations and found widely varying results.[4] The EPA's own estimates jumped from $227 billion over 20 years in 1999 to $376 billion over 20 years in 2003 by "better captur-

Figure 5.3
Comparison of Needs Assessments for Water Utility Infrastructure



SOURCES: EPA, 2013; American Water Works Association, 2012.
NOTE: WIN = Water Infrastructure Network; AWWA = American Water Works Association.
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[4] All EPA estimates are in 2011 dollars for comparison purposes.

ing previously underreported longer term needs for infrastructure rehabilitation and replacement" (EPA, 2013, p. 3).

There is considerable uncertainty behind these point estimates. A 2002 CBO study estimated $331.2 to $571.7 billion in investment needed for drinking water systems over the same 20-year period as the 2003 EPA assessment, not including significantly larger O&M costs (CBO, 2002). In its own 2002 study, EPA reported a wider range, estimating the cost of capital investments in drinking water systems for 2000–2019 would range from $231 billion to $670 billion (EPA, 2002). CBO found that critical assumptions drove differences in estimates of water infrastructure costs over time: replacement rate for drinking water pipes, the cost savings associated with improved efficiency, the costs of controlling overflow caused by heavy rainfall events for systems that combine storm water with household and industrial water, and the repayment period of any borrowed funds. In contrast, under different assumptions about replacement rates and expansion needs driven by growth, the American Water Works Association estimated $1.02 trillion would be needed to cover investments in water mains over the 25 years from 2011 to 2035 (American Water Works Association, 2012), which for comparability to other estimates is an average of $816 billion over 20 years.[5] Similarly, a report by the Water Infrastructure Network (WIN) (WIN, 2002) estimated the cost of drinking water infrastructure built in 2000–2019 at $700 billion.

One reason for the discrepancy between government and interest group estimates is that WIN's $700 billion estimate includes principal and interest costs paid on debt after 2019 but does not include principal and interest paid during 2000–2019 on pre-2000 capital investments. The CBO estimates follow the opposite approach, including borrowing costs on earlier projects paid during 2000–2019, but not considering principal and interest paid after 2019. This makes comparison difficult. CBO estimated that if WIN had used the CBO approach to counting principal and interest payments, the WIN estimate would be $570 billion. Further, the estimates in Figure 5.3 do not include O&M costs. Adding in O&M costs, WIN estimates "the cost of building, operating, and maintaining needed drinking water and wastewater facilities over [2000–2019] approaches $2 trillion" in 1999 real dollars.

In sum, the wide range of estimates produced from inconsistent assessment methods yields little information or guidance to decisionmakers on how they should decide how much to spend on capital versus O&M for drinking water infrastructure, and where to spend it. The assessments do, however, suggest the order of magnitude of potential funding needed over some future time period. Needs assessments directed toward policymakers also tend to miss the potential for market responses to real needs. For example, water industry analysts projected in 2016 that spending in the water and wastewater utility sector alone will exceed $532 billion over the next ten years, a 28 percent increase over the previous decade (Nabers, 2016).

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[5] According to the American Water Works Association (2012, p. 9):

> Many utilities will have pipes that last much longer than these values suggest while others will have pipes that begin to fail sooner. However, these values have been validated as national "averages" by comparing them to actual field experience in a number of utilities throughout the country. The model also includes estimates of the indicative costs to replace each size category of pipe, as well as the cost to repair the projected number of pipe breaks over time according to pipe size.

Project Selection

Public officials make decisions about capital and O&M spending on infrastructure, typically within the structure of an annual budget process in which long-term perspectives on investment are difficult to communicate. Within a single level of government and among different levels of government, coordination of project development, design, and implementation is difficult, particularly for projects that cut across jurisdictional and sectoral lines. This is a problem of governance.

Federal Processes

Clear national criteria for priority setting are lacking but exist implicitly for the various infrastructure types. Since the passage of the Clean Water Act and Safe Drinking Water Act, water quality regulations have indirectly set investment priorities for states, local governments, and private system operators. For USACE and BOR projects, the strength of congressional delegations from individual states has often driven funding priorities; in the case of smaller-scale water projects with the USACE, the availability of a willing and able local partner has sometimes driven funding priorities.

Dating back to the 1930s, the federal government has used some form of CBA to evaluate individual water resource, navigation, coastal protection, flood control, and ecosystem restoration projects. *Principles, Requirements and Guidelines for Water and Land Related Resources Implementation Studies* (PR&G), a document maintained by the Council on Environmental Quality, establishes principles and evaluation criteria to guide federal water investments (Council on Environmental Quality, 2014). Finalized in December 2014, this represented a substantial update to the previous Principles and Guidelines established in 1983. However, there remains room for improvement, particularly when it comes to life-cycle cost analysis, pricing of services delivered by the project, and factoring in future performance under a wide range of uncertain future conditions (e.g., climate change, technological innovation, demographic shifts).

For the very few capital projects still being developed by the USACE and the BOR, project selection continues to be done by Congress, with analysis carried out by the agencies and oversight conducted by OMB. However, congressional approval and funding processes for the USACE are sclerotic, as evidenced by the large backlog of authorized projects awaiting appropriation and the growing maintenance backlog (National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, National Academies Press, 2011, pp. 2–3). A 25-year wait for funding a congressionally authorized project is not uncommon. O&M priorities are largely set by the agencies themselves, with occasional interventions by Congress.

The USACE has vital river-basin scale and other interstate navigation, hydropower, and flood control infrastructure to maintain and protect, and its budget should be commensurate with those responsibilities. However, as a 2011 National Research Council study committee noted, "The modern context for water resources management involves smaller budgets, cost sharing, an expanded range of objectives, and inclusion of more public and private stakeholders in management decisions" (National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, National Academies Press, 2011, pp. 2–3). The National Research Council committee went on to note two implications of these changing conditions: "more flexible, innovative, and lower cost solutions to achieving

water-related objectives" and the necessity of the USACE working "in settings with more collaboration and public and private partnerships than in the past" (National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning, National Academies Press, 2011, pp. 2–3).

With the exception of investments to support national parks, military installations, and other federal facilities, the federal government does not involve itself in direct selection of water or wastewater infrastructure projects, but the federal government influences project selection indirectly through regulatory actions (e.g., court orders to force local or state action on a storm water or wastewater facility as a consequence of violations of the Clean Water Act), its capitalization and rules governing SRFs, and its provision of tax-exempt financing, discussed in Chapter Three.

State and Local Processes

State and local governments face two large questions: how much money to spend on water infrastructure relative to other public needs, and which specific capital and O&M projects should get priority. The availability of financing and cost-sharing programs through the USACE, EPA, and, to a lesser extent, the BOR can complicate—and distort—state and local governments' decisionmaking, particularly when capital funding, but not O&M funding, may be available. If not operating under regulatory constraints by the EPA, local governments generally set priorities that are responsive to demands from their residents and businesses and can be sustained through fees and taxes.

State and local governments also need a way to assess whether individual projects are consistent with long-term goals and complementary to related projects. Evaluating individual projects is the easier problem. Public and private water utilities generally follow standard procedures of engineering economics to evaluate projects. Integrated, regional-scale projects are more difficult. The calculus requires sophisticated analysis, not always available or affordable to most local governments. In reality, this kind of system-level thinking is the exception rather than the rule at the state and local levels (Neuman and Whittington, 2000).

Findings

Federal water resource programs have been on the decline for decades, as national needs have been met, in the case of major hydropower development, or shifted, in the case of reclamation of arid western lands. Now, the focus is on flood risk reduction, navigation improvements, safety of aging dams, and the restoration of aquatic ecosystems that deteriorated as a consequence of the earlier water resource development projects that dammed major rivers throughout the country. With the exception of port and harbor improvements, there is no market mechanism for financing these types of public works. Federal funding of water resources remains fragmented through multiple agency programs, none of which adequately reflect the underused wisdom of integrated water resource management. Congress and federal agencies have yet to systematically confront decisions about which of the aging water resource infrastructure to continue to maintain, which to overhaul to adapt to a changing climate and concerns about resilience to natural and manmade disasters, and which to dismantle.

The situation is wholly different for water utilities, for which 90 percent of investment happens at the local level, largely through the use of municipal revenue bonds and property assessments. Federal water quality and drinking water laws and regulations drove much of

this investment in past decades, with the EPA as the dominant funder. An unintended consequence of the regulatory regimes in place has been the differential financial burden placed on communities of different sizes and economic trajectories. Once-thriving industrial cities with extensive water infrastructure are now faced with the consequences of deferred maintenance of aging systems. With declining populations and tax bases and a reluctance to raise water rates, these cities lack the financial means to fix their systems. The more prosperous cities and regions, by and large, are doing better at maintaining water utilities, as evidenced by their willingness to rely on full-cost pricing, and their consequent high bond issuance rates, bond ratings, and well-functioning systems.

CHAPTER SIX

Policy Options

The previous chapters show that the calculus of infrastructure investment and its maintenance is complicated and set within a diverse and multilayered system of government and taxation. In a rapidly changing, innovation-driven economy, the public benefits of providing infrastructure services vary from place to place and from one type of infrastructure to another. Communities have vastly different needs: Urban needs differ from rural; older cities' needs differ from newer cities'; coastal regions' needs differ from those in inland river basins and the intermountain west.

There is not a single switch to flip that will make the diverse collection of issues that contribute to the nation's infrastructure needs disappear. Whether through grants or tax credits, massive infusions of federal spending to repair or build anew without a focus on long-term priorities and differential needs may do some good by virtue of stimulating demand for construction services, but money alone will not fix what is broken in our approach to public works—and not everything is broken.

In this chapter, we first propose criteria with which to compare and contrast policy options. We then review recent federal and state initiatives intended to advance these criteria and increase investment. Finally, we consider other ideas proposed by the Trump Administration, members of Congress, and other organizations and commentators. Our focus is on national-level policy, but we note areas where changes in state policies could point the way to larger-scale reforms or have beneficial effects.

Desirable Characteristics of Infrastructure Policy

Neither Congress nor the Executive Branch has articulated a national infrastructure policy or the desirable attributes of such a policy. This is not impossible to do. A report published in 2006, known as the Eddington Report, is an example of such a long-term vision and policy statement (Eddington, 2006). While originating in the UK, the report is directed to a wider global audience. Its focus is on transportation, but the report is applicable to other public infrastructure policy. Among other purposes, the report identifies a series of principles that should "guide the development of transport policies to support sustainable development of the UK economy over the next 15 to 30 years" (Eddington, 2006, p. 41). The four key principles in the Eddington report are worth noting verbatim (Eddington, 2006, p. 43):

- Start with a clear articulation of the policy objectives and the transport outcomes required to deliver these objectives, focusing where relevant on the 'whole journey' rather than particular stages or modes in a journey;

- Consider the full range of policy options for meeting the policy objectives, including different modal options, and policies for making more efficient use of existing capacity as well as small and larger scale capacity enhancements and packages of policy measures;
- Prioritise limited public resources on those policies which most cost-effectively deliver Government's objectives, taking account of the full social, environmental and economic costs and benefits of policy options; and
- Ensure the evidence base can support this process, providing information on the needs of users, current and anticipated use and performance of the network, supporting option generation through modelling and appraisal of options, and evaluating impacts to inform future decision making.

Drawing on the Eddington Report principles, we suggest similar principles in a U.S. context, drawing on the fragments of existing policy and practice applicable to transportation and water infrastructure. Principles of a national policy for the United States could look something like the following:

1. Articulate national priorities and target funding to those investments that reflect priorities, such as increasing economic efficiency and productivity in specific sectors or regions; reduce risks by mitigating vulnerabilities and building resilience to natural disasters and effects of a changing climate; reduce or eliminate traffic fatalities; and eliminate waterborne contamination and illness.
2. Support states, local governments, and regional bodies in continuing to lead in the planning, selection, and provision of intrastate infrastructure by whatever funding and financing mechanisms they choose but encouraging standardization of policies to enable institutional investors and private equity to more actively participate in these markets.
3. Promote the federal role of inducing and encouraging investment in multijurisdictional programs, such as those that serve intercity travel and freight transport and those that address river basins and large watersheds that cross state lines.
4. Coordinate, leverage, and consolidate federal investments coming through different agencies and programs, by using federal incentives to move state and local government partners beyond looking at local project impacts in isolation.
5. Incentivize innovation and energy and water efficiency in the conceptualization, design, construction, operation, and maintenance of new infrastructure and upgrades to existing infrastructure.
6. Support and coordinate consistent and transparent evaluation criteria related to net benefits, life-cycle cost analysis, performance metrics, and return on investment.
7. Support R&D and dissemination and guidance as to how to execute the above principles.

The first principle speaks not only to direct investment but also to the implicit responsibility at the federal level to promote and enforce regulations aimed at protecting public health, safety, and the environment. Taken as a whole, these principles could guide the fixing of current policies and practices that are inhibiting long-term planning and productive investment, particularly with regard to maintenance; increase national benefits of infrastructure investment through more-targeted spending; and make the federal government a better partner to state and local governments—and the private sector—as they seek to improve public assets.

Recent Initiatives by the Federal Government

Over the past 30 years or so, Congress and the Executive Branch have made vital changes in federal transportation and water policy that point in the direction of the above principles, but only a few have received public attention. Here, we highlight notable changes that were made by the end of December 2016.

Targeting National Priorities

The last several transportation and water bills that Congress passed included a partial list of national goals related to traffic safety and movement of freight with respect to transportation policy,[1] and disaster resilience, drought, and coastal protection with respect to water policy.[2] These represented incremental steps toward a more comprehensive view of national goals and priorities for infrastructure investment (DOT, no date). In addition to these laws, former President Barack Obama made use of executive orders to further goals related to adaptation to climate change, energy efficiency, and resilience.[3] In early 2017, President Trump rescinded Executive Order 13690, which required federally funded projects to meet more stringent flood risk reduction standards, as well as others related directly to regulatory processes.[4]

National priorities can also be expressed through federal grant programs. Project-based grants have the ability to more effectively target federal resources to the most critical needs from a national perspective. They can demand certain conditions of project submissions, such as requiring cost-share or leveraging with nonfederal resources. One of the more popular competitive infrastructure grant programs has been DOT's Transportation Investment Generating Economic Recovery (TIGER) program. An outgrowth of the 2009 ARRA, TIGER is a supplemental discretionary grant program that allows DOT to use a merit-based process to select projects with exceptional benefits. Funding provided through ARRA in 2009 was $1.5 billion. Congress has continued funding the program each year since, though at reduced levels (between $474 and $600 million during FYs 2010 through 2016).

With Congress having dedicated nearly $5.1 billion over eight rounds of funding, DOT reports that TIGER projects have historically achieved, on average, co-investment of 3.5 dollars (including other federal, state, local, private and philanthropic funds) for every TIGER dollar invested (DOT, 2017c). The popularity of the program with grantees, either because of its genuine appeal or because of the absence of alternatives, is evidenced by extraordinary

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1 Public Law 114-94, Fixing America's Surface Transportation (FAST) Act, December 4, 2015; Public Law 102-240, Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), December 18, 1991; Public Law 112-141, Moving Ahead for Progress in the 21st Century Act (MAP-21), July 6, 2012; Public Law 109-59, Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), August 10, 2005.

2 Public Law 113-121, Water Resources Reform and Development Act of 2014, June 20, 2014.

3 The White House, Executive Order 13604 (*Improving Performance of Federal Permitting and Review of Infrastructure Projects*), Executive Order 13653 (*Preparing the United States for the Impacts of Climate Change*), Executive Order 13677 (*Climate-Resilient International Development*), Executive Order 13690 (*Establishing a Federal Flood Risk Standard and a Process for Further Soliciting and Considering Stakeholder Input*), Executive Order 13693 (*Planning for Federal Sustainability in the Next Decade*), Executive Order 13717 (*Establishing a Federal Earthquake Risk Management Standard*), Executive Order 13728 (*Wildland-Urban Interface Federal Risk Mitigation*), Executive Order 13754 (*Northern Bering Sea Climate Resilience*).

4 The White House, Executive Order 13777 (*Enforcing the Regulatory Reform Agenda*), Executive Order 13783 (*Promoting Energy Independence and Economic Growth*). In the wake of Hurricane Harvey, the Trump Administration is reported to be reconsidering its rescission of Executive Order 13653 (*Preparing the United States for the Impacts of Climate Change*).

demand that far exceeds available resources. For the FY 2016 round ($500 million available), DOT received 585 eligible applications collectively requesting more than $9.3 billion in funding. Despite strong demand and the ability to attract significant leveraged funds, Congress did not permanently authorize the TIGER program in the recent long-term reauthorization of the transportation bill in 2015 (Pub L. 114-94). As a result, the program's fate each year remains uncertain and subject to the vagaries of the annual appropriations process.

The TIGER program has not been without its challenges. Evaluation of earlier rounds of funding found that award decisions were not adequately documented (GAO, 2011), which left open the opportunity for awards to be made on political grounds by program officers interpreting CBAs differently depending on the project applicant (Feigenbaum, 2012). Some of these legitimate criticisms of earlier TIGER grant review cycles have been addressed by refining program guidelines and review procedures, but further improvements should be considered, such as tightening the focus on regional projects that cross state lines and yield the highest national economic development and environmental benefits (GAO, 2014).

That being said, TIGER has gone through multiple rounds of solicitations over the past seven years, building up a wealth of experience and expertise. This program could be expanded and better targeted to projects with broader regional benefits for which revenues cannot be easily collected directly from beneficiaries, and thus not likely to be attractive to private investors. Appropriate cost-sharing would be required to ensure full buy-in among those jurisdictions in the affected region. There is no equivalent TIGER program for water-related infrastructure, but there could be, housed within either the BOR or the USACE, as an alternative to their existing funding mechanisms through congressional authorization.

Prior to taking office, then-President-elect Trump's transition team staff circulated a "working draft" list of "sample" priority projects to the National Governors Association (Wagner, 2017). Since taking office, the Trump Administration has avoided naming specific projects. It formed an infrastructure task force to oversee its interagency effort to build a comprehensive infrastructure proposal, summarized in a fact sheet (OMB, no date) but with few other details thus far. In its FY 2018 budget, the Trump Administration proposed to eliminate the TIGER program entirely, although the idea of nationally significant projects remains.

Providing Flexibility to State and Local Governments

State and local governments have long had the discretion to plan for and implement federally assisted transportation and water projects according to their needs and priorities. DOT's Surface Transportation Program, through which states pass a substantial portion of funds to regions, has historically been the most flexible. While no significant structural changes were made to the program in the FAST Act, Congress renamed the program the Surface Transportation Block Grant Program to stress this flexibility.[5] Funds within this program can be used for nearly any type of transportation project, whether highway, bridge, transit, pedestrian, or bicycle. This type of program serves as a sort of modified block grant program, whereby a collection of specific but related categorical grant programs is effectively consolidated into a broader categorical program.

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[5] Despite its name, the program does not operate with the same degree of flexibility as traditional block grant programs of other federal agencies, such as the U.S. Department of Housing and Urban Development's Community Development Block Grant (CDBG) Program.

Another model for coordination across federal agencies is EPA's Performance Partnership Grants (PPG) program, which allow grantees to combine funding from 17 separate environmental categorical grant programs into a single grant with a single budget and grant-specific performance metrics. Authorized by Congress as part of the National Environmental Performance Partnership System in 1996, the PPG model has been used by 43 states in reducing administrative burden and maximizing overall outcomes among numerous stovepiped categorical grants (EPA, 2014).

In 2014, Congress built on this model to establish cross-agency Performance Partnership Pilots (Pub L. 113-76; 31 U.S.C. 1502). This pilot program was developed around the consolidation of grants from multiple federal agencies for the purpose of addressing the challenges facing disconnected youth.[6] In order to blend funds from across departments and agencies, participating departments and agencies were granted broad waiver authority to align eligible activities and to reconcile or remove regulatory barriers. While it is too early to determine the success of this model, it is a test of a conceptual approach that could perhaps be broadened to include blending funds from multiple federal departments toward coordinated infrastructure investments at the state and local levels. Early evaluation of the pilot has noted that it takes time to institutionalize the necessary level of shared knowledge and collaboration among agency staff to align performance priorities, maximize waiver flexibility, and streamline reporting requirements (Lester, 2016). However, given the scale of federal investment in transportation and water infrastructure by numerous departments and agencies, further exploration of ways to simplify administration of currently stovepiped grant programs while increasing flexibility and outcomes is likely to be worth the effort.

The Trump Administration's budget document for FY 2018 highlights its priority to remove, reduce, or better coordinate federal regulatory requirements that state and local governments, as well as developers and other businesses, perceive as inhibiting timely investment in infrastructure.

Encouraging Public-Private Partnerships Through Credit Subsidies

In addition to authorizing the capitalization of state revolving loan funds for storm water and wastewater systems (1987) and drinking water systems (1996), Congress authorized the TIFIA credit assistance program for transportation projects in 1998 and WIFIA program for water projects in 2014, as discussed in Chapter Three. Neither of these policy tools is new, as loan fund capitalization has been around for 30 years and credit subsidies for nearly 20 years. While both tools have undergone tweaks over the years, they remain limited in their ability to transform the landscape of infrastructure finance.

The Obama Administration made several efforts to ease the path toward greater private-sector investment in local infrastructure. It established new offices in DOT and EPA dedicated to infrastructure finance and provided support for these centers.[7] These centers serve as single points of contact for all financing-related issues, provide guidance to state and local government to help build capacity, and work with the private sector in an attempt to standardize and

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[6] Congress has authorized five departments and two agencies to participate: the Departments of Education, Labor, Health and Human Services, Housing and Urban Development, and Justice, and the Corporation for National and Community Service and the Institute of Museum and Library Services.

[7] The Build America Bureau at DOT and the Water Infrastructure Resiliency and Finance Center at the EPA.

streamline the often-complicated process of establishing PPPs. Another key focus of these centers is the coordination and administration of the TIFIA and WIFIA programs.

President Trump's FY 2018 budget calls for the expansion of TIFIA, WIFIA, and PABs (OMB, no date). The Trump Administration also signaled its interest in lowering barriers for private capital to public infrastructure and incentivizing the sale and privatization of existing public infrastructure as a means of generating substantial cash for state and local governments that would then invest in new projects, a process the Australians call "recycling assets" (Eicher, 2017).

Implementing New Forms of User Fees

Beginning around 2006, Congress and many states have been considering new forms of direct highway user fees ("Road User Fee Pilot Program Results Summary," no date). These are increasingly feasible because of developing technology, such as vehicle telematics, global positioning satellites, cell towers, and on-board diagnostics, that can report vehicle movements. The FAST Act allocated $95 million under Section 6020, requiring the U.S. Secretary of Transportation to "provide grants to states to demonstrate user-based alternative revenue mechanisms that utilize a user fee structure to maintain the long-term solvency of the Highway Trust Fund." The states of Oregon and California are engaged in field trials of systems that would charge travelers electronically per mile of driving, and which could eventually charge different rates for travel at different times of day, on different classes of roads, and for different groups of vehicles. Six other states and consortia of states are planning trials as well (DOT, Office of Public Affairs, 2016).[8] While this program is too recent to have yielded substantial results, and many remain skeptical that direct user fees will be adopted on a wide scale, this approach to transportation funding is emerging rapidly and will be closely watched.[9]

Coordinating and Leveraging Investment Strategies

Relatively early in the Obama Administration, OMB issued a memo to the heads of all executive departments and agencies that outlined a new approach for how federal resources should be budgeted and deployed. Recognizing the continuing growth trend of the nation's cities and surrounding metropolitan areas (which contain more than 80 percent of the nation's population and generate nearly 90 percent of its GDP), the memo established a "place-based" policy to direct federal investments (OMB, 2009). This policy attempts to draw on the compounding effect of well-coordinated action to increase the impact of government dollars in specific geographic areas by leveraging those investments with other public, nonprofit, and private-sector investment occurring in the area.

This policy, which was further outlined in a subsequent OMB budget memo (OMB, 2010b), was reflected in executive agency actions until the end of the Obama Administration.[10]

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8 For background, see also Sorensen, Ecola, and Wachs (2012).

9 For periodic updates on the status of direct user charges, see Mileage-Based User Fee Alliance (no date).

10 Place-based principles were initially put to work through the implementation of the American Recovery and Reinvestment Act of 2009, but would also be reflected in various multi-agency program initiatives, such as the Partnership for Sustainable Communities, Strong Cities/Strong Communities Initiative, Empowerment Zones, Regional Innovation Clusters Initiative, Neighborhood Revitalization Initiative, Promise Zone Initiative, Choice Neighborhoods Program, Partnerships for Opportunity and Workforce and Economic Revitalization, and the Investing in Manufacturing Communities Partnership.

The policy sought to maximize economic growth and increase the cost-effectiveness of federal financial investments. It also directed agency staff and technical assistance to break down siloes, align regulatory requirements, and build capacity at the local level. The place-based policy took a regional approach to coordinating investments, often at a multijurisdictional scale. Given that local capacity has long been a challenge for many communities, this policy has resulted in the federal government being more proactive in creating the local/state/federal partnerships often needed to affect transformative change on the ground.

This and similar policies have relatively low costs but can result in high returns by getting the most out of what is already being invested, while building capacity and advancing program reform in the process (U.S. Department of Housing and Urban Development, 2017). The policy was formalized through the establishment of a Community Solutions Council by Executive Order in November 2016, just prior to the end of the Obama Administration (The White House, Executive Order 13748, *Establishing a Community Solutions Council*). It remains to be seen whether such a policy will be retained by the Trump Administration.

Incentivizing Innovation

Competition has been used as an approach to achieve excellence and innovation since the earliest days of the U.S. government. The designs for both the U.S. Capitol building and the White House were the winners of competitions in 1792. In recent times, competitions and challenges often receive bipartisan support to drive innovation, solve complex problems, and maximize taxpayer return on investment. The America COMPETES Act (Pub L. 110-69), signed into law in 2007 by President George W. Bush and reauthorized in 2011 by President Obama (Pub L. 114-322), encourages federal departments and agencies to use competitions and challenges as a key tool in achieving their mission.

In March 2010, OMB issued a memo to further stimulate federal departments and agencies to use prizes and challenges (OMB, 2010a). It established a web-based hub for federal prizes and challenges to advance open government and share lessons learned and best practices. Challenge.gov, maintained by the U.S. General Services Administration, has since received Harvard University's Innovations in American Government Award and contains information on more than 740 federal prize and challenge competitions.

One of the primary goals of competitions is to generate solutions that are highly replicable and/or scalable beyond their initial application. While competitions are often seen used in the fields of science, technology, and health, they are also being used to increase the performance and decrease the cost of infrastructure investments. Recent examples can be seen is the Desal Prize, sponsored by the U.S. Agency for International Development and the BOR, and the Smart City Challenge, sponsored by DOT.

The Desal Prize was an engineering competition to develop technologies that could desalinate salt water to a drinkable quality. The top five teams produced technologies that were able to be deployed as pilot projects, with a team from the Massachusetts Institute of Technology being named the winner in 2015. Competitions such as this are able to generate infrastructure solutions that benefit cities not only in the United States, but around the world.

Competitions, in addition to generating innovative solutions that increase performance and/or decrease costs, can also successfully leverage nonfederal investment from philanthropy and the private sector. The Smart City Challenge solicited cities seeking to integrate innovative technologies into their transportation networks. The winner, Columbus, Ohio, was awarded a $40 million grant from DOT to help implement its strategy. The $40 million DOT award was

joined by a $10 million pledge from private-sector partners, and the seven finalist cities in the Smart City Challenge raised more than $500 million in other funding from a wide variety of partners to help implement their strategies (DOT, 2016c). Because they are new programs, it is still too early to assess their effectiveness.

Maintaining Consistent Procedures and Criteria for Project Evaluation

"Cutting red tape" has been a rallying call among those who would like to see fewer regulations imposed on public investments. The Obama Administration sought to simplify and streamline uniform administrative requirements (combining multiple OMB circulars) and permitting processes and procedures (under the National Environmental Protection Act) to lighten the administrative burden on investors and reduce external risk to project partners (Council on Environmental Quality, 2014; DOT, Build America Burea, 2017). When multiple public agencies are involved in reviewing a major infrastructure proposal, there is ample room for front-end coordination to consolidate public meetings, share data and models, run review processes concurrently, and work on a single timeline to ensure timeliness and consistency. An early example of this model was implemented in the landmark December 1994 Bay Delta accord when four federal agencies, the State of California, municipal water suppliers, environmental organizations, and agricultural interests came together on a single regulatory review process (Rieke, 1996). In the last two years of the Obama Administration, an interagency team moved to increase certainty in the federal permitting process through development of two presidential memoranda, an executive order, and a detailed implementation plan (U.S. Department of Treasury and U.S Department of Transportation, Build America Investment Initiative Interagency Working Group, 2015).

In his first days in office, President Trump announced his intention to freeze all new federal regulations and reduce existing regulations by "75 percent," although the precise meaning of that target is unclear (Restuccia and Juliano, 2017; Devaney and Wheeler, 2017). Regulatory relief was a keystone of the Trump Administration's first months in office (e.g., Executive Orders 13777 and 13783) and is expected to be part of his infrastructure initiative, which had not been released at the time of this writing.

Aside from the question of how much regulation is appropriate, there are questions about the extent to which federal agencies use the same procedures and criteria when evaluating the efficacy of similar types of federally funded projects, and whether those criteria are consistent with current policy. As one particularly apt example in the area of infrastructure policy, comprehensive life-cycle analyses have not been established with consistency across the federal agencies in the same way that CBAs have. Life-cycle analysis should be a critical determinant for investment when the provider of capital is not the same as the entity responsible for O&M over the lifetime of the investment, as is typically the case for most federal infrastructure investment. State and local governments, anxious to take advantage of available federal funding, often saddle themselves with assets that they may not be capable of maintaining, particularly if their regional or local economies are stagnant or in decline.

As an example of improving consistency, a 2015 OMB memorandum clarified guidance to agencies in their consideration of benefits of ecosystem services (OMB, 2015). Other recently revised agency guidance documents incorporate the valuation of environmental benefits (e.g., USACE, 2016; National Oceanic and Atmospheric Administration, Science Advisory Board, 2016).

Spending and Policy Changes Recently Proposed

Proposed changes in spending or policy related to infrastructure should be viewed through the lenses of current conditions and future economic and fiscal projections. At the time of this writing, the U.S. economy is growing slowly but is not in recession. The national unemployment rate was 4.2 percent in September 2017, although the rate was higher and lower in specific areas and among some demographic groups (Bureau of Labor Statistics, 2017). Job creation is a stated priority for Congress and the administration, but infrastructure spending may not necessarily be the vehicle by which that priority will be pursued. At the same time, CBO has estimated that the federal budget deficit will grow by 2027 to $1.4 trillion, or 5 percent of GDP, under current program assumptions (CBO, 2017). This projection will change depending on tax cuts and spending increases enacted in the coming years.

Direct Federal Spending

The challenge for sponsors of bills authorizing direct spending on infrastructure is to find offsets in the budget— that is, other spending items to cut as a means of remaining "revenue-neutral" according to congressional budget rules in place. In light of CBO's recent deficit estimates, this hurdle has likely become even higher for major infrastructure spending, particularly new programs authorized in the previous Congress.

In the closing week of the 116th Congress, President Obama signed the Water Resources Development Act (WRDA; Pub L. 114-322, Title I) to fund new water infrastructure (Smith and Barrigan-Parrilla, 2016). WRDA authorized new spending on deepening "nationally significant" ports, authorized 30 new projects, and modified eight others. It also included funds to support the replacement of lead service lines in Flint, Michigan (Section 7101). With the 2015 passage of the FAST Act, Congress may not see a need to authorize further transportation spending in the near term (Zanona, 2017). FAST authorized $305 billion for total transportation spending between 2016 and 2020 (DOT, Federal Highway Administration, 2017b; DOT, Federal Highway Administration, 2016; DOT, 2016a).

Passing these periodic transportation and water infrastructure authorization bills is a necessary but insufficient condition for federal spending. Lawmakers need to also ensure that funds are appropriated or, in the case of the FAST Act, allocated from the Highway Trust Fund, for authorized programs. Individual appropriations bills have been largely superseded in recent years by Continuing Resolutions that maintain the prior year's spending levels. Congressional disagreements about spending priorities may dampen prospects of significant new spending. At the time of this writing, President Trump's FY 2018 budget proposes to eliminate dozens of existing federal infrastructure programs in DOT, the USACE, the U.S. Department of Housing and Urban Development, and the U.S. Department of Agriculture in favor of initiatives aimed at attracting private investment in public infrastructure (OMB, 2017; OMB, no date).

Members of the Senate and House have already introduced dozens of bills in the 117th Congress to authorize higher levels of infrastructure spending. On January 24, 2017, a group of Senate Democrats announced plans to introduce a bill to authorize $1 trillion spending that they say would "create 15 million jobs over 10 years" (O'Keefe and Mufson, 2017). Their plan would provide authority to spend not only on transportation and water infrastructure, but also on the electricity grid, broadband, hospitals within the Veterans Health Administration, and schools. In addition, they would set aside $200 million of the $1 trillion for projects of national

significance or what they call "vital infrastructure projects" and funding of $10 billion to seed an infrastructure "bank" to offer loans and loan guarantees to private investors. To avoid adding to the deficit, the senators say that they will close tax loopholes. Finally, some members of Congress and Secretary of the Interior Ryan Zinke support increasing direct federal spending on the large backlog of maintenance and repair needs within the National Park System, estimated to be in the range of $12.5 billion (Fears, 2017).

Changes in Tax and Other Policies and Regulations

In September 2017, the Trump Administration released a fact sheet on its proposed infrastructure initiative (OMB, 2017). The $200 billion initiative promotes four principles: make targeted federal investments, encourage self-help, align infrastructure investments with entities best suited to provide sustained and efficient investment, and leverage the private sector. The initiative also spells out numerous proposed policy changes, including reform of the Inland Waterways Trust Fund, a mechanism originally established in 1986 to collect tolls from commercial users of federally maintained waterways to cover half of the capital costs of the system. Other proposals include a Federal Capital Revolving Fund to aid in financing nonmilitary federal capital assets, and Partnership Grants for Federal Assets, a means to draw private partners into the improvement of federal infrastructure. Most of these proposals have not yet been explained in detail or translated into legislative language.

Prior to announcing its current initiative, the Trump Administration had signaled its intent to leverage tax credits to investors in infrastructure projects to generate a total of $1 trillion of investment in infrastructure (*The Economist*, 2017). In subsequent communications, the administration suggested $800 million of private investment and $200 million in direct spending. Tax credits are classified in budget terms as expenditures. For each $1 invested in infrastructure, the tax credit would reduce the investor's tax liability by $0.82. The credit would only apply to equity investment; funds borrowed for investment would not be eligible for the credit. In practice, enforcement could be problematic: It is not clear how equity investments can be distinguished from investments first borrowed from elsewhere.

In explanatory material accompanying the January 2017 plan, a claim was made that the plan is revenue-neutral, but this claim relied on a number of significant assumptions:

- $1 of every $6 invested will be equity investment and hence eligible for the credit.
- 44 percent of the total $1 trillion investment will become new wages, and 10 percent will become new corporate profits.
- Wages and corporate profits will be taxed at an average rate of 28 percent (personal income) and 15 percent (the capital gains tax rate), respectively.[11]
- The investment arising from the tax credits would come from sources not previously subject to any federal taxation, such as repatriating funds previously held abroad; otherwise, any tax revenue raised through infrastructure wages and profits is simply displacing wages and profits that would have been taxed regardless.

[11] The 28 percent *marginal* income tax rate starts at $91,000 for single filers, $130,000 for head of household, and $152,000 for married filing jointly. The average construction worker is not in this tax bracket. The Trump campaign plan appeared to suggest that a quarter of the wage-based tax revenue would come from some tax which is diverted to a trust, such as a payroll tax.

These assumptions would be difficult to meet. Another challenging assumption was that there would be sufficient opportunities for investors to gain profitable returns on these investments.

For a simple example, suppose that a developer invests $1 million in an infrastructure project that pays back in one year with a 3 percent annual return. Following the Trump plan's assumptions, this developer borrows an additional $5 million to invest, presumably at a rate less than 3 percent (otherwise, the developer would not borrow the $5 million); we arbitrarily presume 2 percent for this example. The developer receives $0.82 million through the tax credit, and then is paid another $6.18 million from user fees or taxpayers at the end of the year. The developer then repays $5.10 million to the lender from which it borrowed $5 million, and keeps $1.08 million. In short, the developer provided $1 million in exchange for $1.90 million ($0.82 million + $1.08 million). Under the assumptions of the Trump Administration's earlier infrastructure plan, $0.82 million appears as tax revenue, not as an expenditure, meaning taxpayers and users effectively spent $6.18 million paying back the $6 million infrastructure loan—a good deal. But if we instead assume the money invested in this infrastructure simply displaces otherwise taxed investments, then $7 million in user fees and tax credits were used to build infrastructure that cost $6 million—not a good deal. And if other assumptions related to the tax credit proposal were not met, the deal would be even more costly for taxpayers and users.[12]

Expanding Capital Pools: Public Pension Funds as Investors in Infrastructure

Although lack of capital is not always the problem, there have been calls from public officials for public pension funds to increase their investment in domestic infrastructure. Public pensions have several appealing properties as potential investors, but they currently invest relatively little in domestic infrastructure. This is because their long-run investment interests tend to match the long lifespans of infrastructure projects better than the investment funds currently available to them, which demand profit over shorter time horizons (Eicher, 2013). First and foremost, however, pension funds have fiduciary responsibilities to pensioners, present and future, and must strive for the best returns on investment while carefully managing their risks. Because public pension funds do not pay taxes on investment income, municipal bonds, with their lower interest rates, are less attractive than higher-yielding investments. Public pensions have largely responded by investing in other countries' infrastructure, where higher rates of return on investment can be achieved and risks can be better managed (Eicher, 2013).

Encouraging Public-Private Partnerships

As a means of injecting more private capital into a system perceived as short of public capital, proposals have been advanced over the years to make it easier for private parties to invest in local and regional transportation and other projects. To this end, the Bipartisan Policy Center (BPC) released a report in 2016 calling for states to both loosen and standardize their treat-

[12] The logic is as follows: $0.82 million was spent as a tax credit, and $6 million was borrowed. The $6.18 million is the full repayment for the money borrowed at a 3 percent interest rate ($6.18 million + $0.82 million = $7.00 million). How much money appears as new tax revenue to offset this $7 million bill depends on assumptions. The cost could easily be higher than $7 million. If firms do not borrow money to invest in infrastructure—if all $6 million is instead an equity investment—then the total cost to taxpayers and users could instead be as high as $11.10 million ($4.92 million paid in tax credits, in addition to the $6.18 million in loan repayment). The U.S. economy would effectively be borrowing from private investors at higher than market interest rates.

ment of PPPs as a way to reduce risks and consequently lower the barriers of entry for private investors into public infrastructure markets (BPC, 2016). The BPC report noted three major barriers to private investment: lack of a project pipeline, political risk that may delay or stop a project that already had received approval, and permitting risk associated with complex and sequential regulatory reviews that typically accompany major infrastructure projects.

The BPC report identified a long, yet focused, list of actions that states could take to lower barriers to private funding of public infrastructure (BPC, 2016). The report recommended that states consider opening the door to more-effective means for alternative investors to assess and choose attractive long-term investment opportunities. In parallel with such thinking, states could also share their experiences with past PPPs to do a better job of fulfilling their fiduciary responsibilities to taxpayers and managing risks on the public side. Changes in regulators' practices would need to go hand-in-hand with efforts to increase the attractiveness of some of these investments, but loosening environmental, health, and safety standards in the name of streamlining or cutting red tape was not among the BPC's recommendations. However, even if all these measures were taken, it is unclear whether the number of project proposed for private-sector financing is, in the words of Eicher (2013), "adequate to establish a worthwhile market opportunity for private-sector investors."

In March 2017, the EPA released a report documenting nine "alternative water project delivery" methods, a term meant to encompass a wide range of alternatives to the traditional design, bid, and build model, in which a local government entity retains ownership (Hughes, 2017). The report demonstrates the richness in experimentation now under way but, by design, does not address whether these alternative forms are better than the traditional financing model. In May 2017, the Trump Administration released its proposed FY 2018 budget, calling for major initiatives to increase private investment in infrastructure across many sectors but without providing further details.

International Examples of Public-Private Partnership Models

In 2012, the UK began offering government guaranteed loans to private-sector investors in infrastructure, funded by fees paid by the developers who stand to gain from the investment opportunity. The government bears the risk and as yet has not had to bail anyone out. With low default rates, lenders were able to offer lower interest rates (Government of the United Kingdom, 2012). As another example of government subsidizing of risk, the Netherlands offers inflation-proof payments on loans backed by the government. Lenders thus reduce inflation risk in their portfolio and offer lower interest rates (Bennon, Monk, and Nowacki, 2015).

In Europe, Australia, and Canada, policymakers encouraged their pension funds to pool assets to diversify risk and to achieve economies of scale in deploying capital into infrastructure. Perhaps the best example of this approach is in Australia, where pooled-asset structures, according to Eicher (personal communication, 2016), enable "institutional investors to make direct investments in infrastructure assets and projects. This capacity enables investors to draw on in-house expertise to make investment decisions and to acquire equity ownership interests in assets. This lowers costs and increases control over their investments."

Australia has been experimenting with an "asset recycling" program, essentially a means of privatizing many public infrastructure systems while generating cash for local government

to invest in new infrastructure. Its success has stimulated interest among U.S. policymakers (Eicher, 2017).

Synthesis of Findings

Promising policy initiatives are under way. Many additional options have been proposed within Congress and among nongovernmental organizations to "fix" some aspect of the infrastructure problem. Programs and initiatives in other countries further expand the pool of options for consideration within a U.S. context.

Proposals intended to address infrastructure needs in the United States divide along several lines: direct public spending, use of the tax code, and policy and process changes. In the past several years, Congress and the Obama Administration took a series of incremental steps toward targeting federal transportation spending on projects of national significance, streamlining water resource development planning processes, and improving the coordination of regulatory actions among agencies. However, many of these initiatives are still relatively immature and limited in scope. We do not as yet have the research base to know whether they could be effectively scaled up, nor do we yet know which of these will be continued under the Trump Administration.

CHAPTER SEVEN

Summary of Findings and Recommendations

Our intent in this report is to present a more nuanced view of the infrastructure challenge than has been portrayed by public officials and in the media. Not all transportation and water infrastructure in the United States is falling apart. The extent of underinvestment differs markedly by type of infrastructure, its ownership and maintenance arrangements, and the economic fortunes of the region. For this reason, a rapid and substantial ramp-up of federal spending—whether through direct funding, tax credits to private developers, or a combination—will not solve the real infrastructure problems that need fixing *unless* accompanied by thoughtful consideration of priorities, policy constraints, and regional variations. Further, a one-off spike in federal spending could divert local and state governments' attention away from their longer-term imperative to adopt new technologies and secure sustainable financing.

In this chapter, we synthesize our findings from the preceding chapters and offer several ideas for policymakers to consider going forward. Each of these ideas merits more extensive analysis and field-testing.

Findings

The Spending Picture Is Not Dire

Overall, the data do not support a picture of precipitous national decline in total spending, per capita spending, or spending as a share of GDP. Total public spending on transportation and water infrastructure in constant dollars as a share of U.S. GDP has been remarkably stable since 1956. Private funding in these areas of infrastructure is less than 3 percent of the total, nearly all of which is for rail. When federal spending has declined, state and local governments often have picked up the slack. By the end of 2016, municipal bond issues were at their highest levels ever, more than double levels in 1996, although bond issues fluctuate from year to year. Apart from these broad trends, federal capital spending on highways has been in a period of a gradual decline since around 2002. Capital spending by water and wastewater utilities declined after the 2008 financial crisis but has been rising since.

State and local O&M spending for water infrastructure has been on a relatively steady rise since at least 1956. The system of financing new and major rehabilitation projects through public borrowing and, to a much lesser extent, some version of PPPs is generally working for projects whose benefits fall within single states and local jurisdictions and whose revenues are sufficient to cover debt service and ongoing O&M costs.

Serious Problems Exist

Where the local and regional economies are thriving, good governance is the rule, and revenue streams for sustainable O&M are in place, infrastructure tends to be well maintained and modernized. Elsewhere, problems persist that defy easy solutions:

- The federal Highway Trust Fund and many of the state funds for drinking water and wastewater treatment plants have not been operating on a sustainable basis for some time now.
- Congestion on some interstate highways and freight transportation systems hurts regional economies.
- Without operating subsidies, mass transit systems have a hard time paying their way.
- Critical infrastructure problems that cross jurisdictional lines, such as the proposed Gateway rail tunnel under the Hudson River between New Jersey and New York, are proving difficult to resolve through existing governance arrangements.
- Communities with declining tax bases struggle to maintain their roads, bridges, and water systems and repay their debts to bond holders.
- Some communities are at risk of flooding from structurally compromised dams and levees, coastal communities are at risk from rising seas and changing patterns of precipitation, and many communities are vulnerable to flooding from undersized and aging storm water systems.

Not all of these problems fall squarely within the bounds of federal funding or control, but they each should figure prominently in the debate about national infrastructure priorities.

Federal Efforts Are Unfocused and Fragmented

Under current practice, state and local governments are responsible for 88 percent of O&M for transportation and water infrastructure and 62 percent of capital investment (CBO, 2015). The evidence suggests that the division of responsibility among the levels of government is generally appropriate and does not warrant wholesale change. In addition, the federal government could do a better job intervening in the gaps where state and local actions are less effective or beyond their capacities. This includes not only targeted spending on capital improvement projects with regional or national implications, but also creating appropriate incentives for regional, state, and local authorities to innovate in their provision of infrastructure. Finally, the federal government has a unique role in investing in R&D, including support for pilot studies to test innovations in construction, O&M, financing, and revenue generation.

State and local governments, by and large, identify their own infrastructure funding priorities, though the availability of federal funding can skew those priorities. States generate priority lists for transportation projects. Local governments and water authorities generate and routinely update capital and O&M plans. Missing from the picture is priority setting or even vision setting at the federal level. At present, the federal government does not have an explicit set of priorities for direct investment in infrastructure projects of national significance.

Underpricing of Infrastructure Persists

State and local governments do not always choose to price transportation and water services commensurate with maintenance, replacement, and capacity costs. If supplemental revenue sources are not secured, the persistence of pricing below life-cycle costs can lead to deferred

maintenance and higher demand than the user base can (or should) support—a bad combination. For surface transportation, states are experimenting with new forms of revenue-raising to replace the declining base of federal and state excise taxes on motor fuels. The logistics of capturing payment for transportation and water services is easier now than ever before because of technological advances in monitoring actual usage, although the politics remain fraught.

There nonetheless remains a class of projects for which user fees are impractical, difficult to monetize, or impolitic. These are the opportunities best suited for cross subsidies and support from general funds generated through income taxes, sales taxes, and other forms of broad-based taxation. However, in many states, there is a tension between statehouses and local governments about how to distribute these general funds among the competing public purposes for which they are intended: public education, public safety, health and welfare, as well as transportation, water supply and water quality, green space, and other broad-based needs. This is not a technical problem, but rather one assigning relative value to different types of public assets and services. Under our system of federalism, states are empowered to make their own choices on these matters.

Some projects may generate national economic benefits, but not commensurate revenues, in part because positive externalities in which project benefits extend beyond the place where the infrastructure is located and further revenue capture is impractical. These projects could include regional highway and rail lines in densely populated urban corridors, major port-rail-highway junctions, major dam repair or dismantlement, and infrastructure in national parks and other publicly managed recreational areas.

The Role of Private Capital for Transportation and Water Infrastructure Is Still at the Margins

Much has been written about the availability of private capital to "come off the sidelines" to support the rebuilding of public infrastructure through PPPs. The 2016 BPC report on this topic makes a compelling, fact-based case for policy changes, predominantly at the state level, to eliminate barriers to these funding flows. Eicher's and others' work on the prospect of public pension funds to get into the U.S. infrastructure investment market is equally compelling. Further, the federal government in recent years has taken a number of steps to lower transaction costs imposed by federal rules and serial review processes, and to actively promote PPPs on projects receiving some share of federal funding.

Estimates of both private capital and public pension fund assets potentially available for investment suggest that they could "solve" the funding shortfall, at least for those projects that have low-risk profiles, defined as a reliable and durable revenue stream—but there should be no illusions about the need for these investments to be profitable and their risks manageable for the investor. Large projects tend to carry higher risks. Striking the appropriate balance between drawing in the private sector and shielding taxpayers from the burden of financial risk has proven difficult in practice. This remains an area of policy in need of further refinement in the U.S. context.

Historical Justification for Some Federal Programs No Longer Holds

The challenge for federal infrastructure programs has always been managing the tension between meeting national needs and satisfying congressional demands for equity: among the states, between urban and rural communities, and between older and newer communities. Problems and needs differ from place to place, and federal capital programs painted with a

broad brush are bound to miss the mark for some. National and regional infrastructure needs differ markedly from the decades past, when Congress first enacted many of the programs that still dominate the policy landscape. The justification for the BOR in 1902 to reclaim the Great American Desert is no longer valid. At the beginning of the 20th century, the U.S. population was 60 percent rural and 40 percent urban (U.S. Census Bureau, 1995). Now, 80 percent of the population resides and 90 percent of GDP originates in urban areas. A fuel tax made sense when all vehicles on the road used liquid fuels, but hybrid and electric vehicles are making significant gains, and the revenue basis for the federal Highway Trust Fund needs to be changed accordingly.

Recommendations

To maintain stable financing for infrastructure, **Congress should preserve the federal tax exemption on interest earned from municipal bonds for at least the next decade**. During this period, lawmakers should **reinstate taxable Build America Bonds** (BABs) and **experiment with other financing alternatives**. The aim is to draw as much capital into infrastructure as the market demands without the distortion of tax policies that favor one class of investors over another.

Tax-exempt municipal bonds are an inefficient means of subsidizing local government borrowing for infrastructure projects. Still, the $3.7 trillion market for these bonds provides stable financing to local governments. In the interest of continuity, tax-exempt municipal bonds should be kept while alternative funding mechanisms are given a chance to develop. Congress successfully experimented with BABs in 2009 and 2010. They offer one potential alternative. BABs can be structured to be revenue neutral. Public pension funds and other investor classes receive no benefit from municipal bonds' tax exemption because they have either no or low tax liabilities. But BABs would allow their "patient" capital to be put to work funding low-risk infrastructure projects with long payback periods and competitive returns.

Therefore, BABs should be reinstated for a ten-year period with the assurance that the subsidy, at whatever level set by Congress, will be honored over the life of the bonds. At the end of the ten-year period, Congress should assess the impacts on state and local infrastructure spending and the federal budget and determine whether to maintain the status quo, make BABs permanent, or cap or eliminate the municipal bond exemption.

The revenue model for the Highway Trust Fund, based on a federal motor fuel excise tax, is unsustainable. **The FAST Act authorized the Federal Highway Administration to make grants to states for the purpose of exploring alternative user-based revenue collection. Congress should ramp up funding for these efforts at the state level and be prepared to fund expansion of effective designs for broader testing in more states.** Americans are driving more but paying less into the Highway Trust Fund by using more fuel-efficient vehicles and benefiting from lower oil prices. Over time, as more hybrid and electric vehicles come into wider use, the decline in revenues from the sale of motor fuels will continue. To restore stability and sustainability to the Highway Trust Fund, Congress should support a robust program of pilot testing and experimenting with mileage-based fee collection at the state level and direct the Federal Highway Administration to begin a long-term planning process for an orderly transition to a new federal system.

"Shovel-ready" projects are not necessarily priority projects. Rather than using "shovel-ready" as the criteria for federal capital investment in nonfederal assets, as was done in the 2009 stimulus package, Congress should instead target longer-term projects likely to produce significant national benefits. Congress should work with the Executive Branch, states, and local governments to generate a list of regional infrastructure investments that would increase productivity and bring demonstrable improvements in transportation and water services. Each proposed project should undergo rigorous, transparent CBA and life-cycle analysis to enable ranking of projects based on consistent estimates of multistate or national-level net benefits. For example, passenger connections among rail, transit, and airports, and freight connections among trucks, rail, and ports, are critical nodes in the U.S. transportation infrastructure. Improvements could offer real economic gains in the form of higher economic productivity. Priority should be given to projects with compelling multijurisdictional health, safety, and environmental benefits and to those state and local governments that work together to identify their top priorities for federal capital spending. Federal funding would be conditional on regional sponsors securing matching funds from any combination of public and private sources, including user fees and taxes when appropriate.

The federal government should focus its capital investment on major investments in renewal of aging infrastructure and new infrastructure for the coming decades. To this end, Congress should make life-cycle cost analysis and sustainability of investments a condition of future federal transportation and water funding. Not everything that has ever been built warrants perpetual maintenance. Some infrastructure may need to be dismantled in response to changing demographics, economics, and public priorities. Under our system of federalism, state and local governments are empowered to make their own choices on these matters. However, federal infrastructure spending should be conditional on state and local government demonstrating their ability to maintain new or renovated assets. Assuming existing infrastructure is worth maintaining, more capital spending enabled by the federal government in the absence of sustainable O&M funding for existing assets will make matters worse for local governments struggling to make payments on existing debts.

Congress should place its highest maintenance priorities on vital federal assets. The federal government has a responsibility to properly maintain its own vast infrastructure managed by the U.S. Department of Defense, the USACE, the BOR, the National Park Service, and other agencies with resource management and national security responsibilities. Priorities for direct federal spending should be set based on public safety, national security, and national economic and environmental benefits. Examples include mission-critical military bases and such federally owned assets as dams, levees, locks, and national parks and recreation areas around national forests, wildlife refuges, and historic sites.

Congress should require each agency to report on their estimate of funding needs over the next 25 years to sustain the infrastructure under its jurisdiction. Agencies should be required to describe the analytical process by which they have chosen whether to maintain, recapitalize, perform only minimal maintenance, or divest their holdings. This would be the foundation of a federal capital budget to be updated on an as-needed basis.

Congress should condition capital funding on state and local governments' efforts to incorporate resilience to natural disasters and adaptation to rising seas and other climate trends. The dollar value of damage from extreme weather events has quadrupled in real terms over the past four decades. New spending creates an opportunity to make design changes in old infrastructure or rethink infrastructure concepts entirely to meet new condi-

tions. Following the lead of many states and cities, Congress should embed resilience guidelines in federal infrastructure investment through statutory means. Well-executed resilience measures have the potential to constrain or reduce spending on the growing federal cost of disaster assistance, which GAO estimated to have been at least $277 billion between FYs 2005 and 2014 (GAO, 2016) and is likely to rise in the future.

Congress should support state and local governments in their development of common standards for structuring public-private partnerships. The U.S. experience with PPPs in the realm of transportation and water infrastructure has been mixed, with success largely hinging on the skill of state and local negotiators in balancing the benefits and financial risks to the public. From the perspective of private investors, the market for such investments is fragmented and fraught with political risks and uncertainties in project timing. Navigating different rules across the states is a burden on investors and adds to political uncertainties. The federal government could provide technical assistance and help with tax issues and permitting processes.

The federal government should streamline regulatory approval processes involving multiple federal agencies while honoring applicable environmental, health, and safety standards. Consensus-building around major infrastructure investment is a challenging business in a democratic society when multiple public objectives are in play—and often in conflict with one another. As part of the U.S. system of checks and balances on government power, administrative processes are designed to enable stakeholders to engage, review, and intervene in regulatory decisions on grounds of protecting health, safety, and the environment. Trying to circumvent public participation and undermine widely supported protections and standards in the name of speeding up infrastructure projects can result in delay or gridlock. But sometimes multiple agencies regulate sequentially and without coordination. Experience has shown that efficiencies can be gained by consolidating information gathering and organizing collaborative, concurrent public outreach and review processes among agencies, as recommended in 2015 by the Build America Investment Initiative Interagency Working Group.

Congress should end the historical division of the USACE and the BOR and consolidate them into a single federal water resource agency. Consolidation would impose consistency in exercising the federal role in water infrastructure and its maintenance; enable a more integrated and fair approach to water resource management in partnership with states, local governments, and other stakeholders; and bring the water infrastructure programs of the two agencies under the same congressional oversight. Consolidating the transportation modal administrations into a more unified and integrated DOT also might be more efficient, but would likely be more difficult to implement because of the multiplicity of private and public interests and regulatory responsibilities served across the various modal administrations. Government reorganizations come with large costs. These costs need to be carefully weighed against the potential benefits of consolidating technical expertise and encouraging integrated water resource and transportation management.

Congress should place some big bets on research, development, and deployment of new technologies to support infrastructure construction and maintenance. We propose an infrastructure research agenda that would build on the competitive peer-reviewed grant mechanisms already in place with the Transportation Research Board. This should be expanded into an integrated infrastructure research program that crosses sectoral lines and coordinates the needs and resources of individual agencies across the federal government. The agenda would stimulate the development of new concepts of provisioning of infrastructure and

improve building methods and materials, engineering designs, cost-effectiveness and efficiency, and all aspects of system operations.

Widespread adoption of newer construction methods, more durable and sustainable materials, and sensor technologies could have a profound effect on the calculus of infrastructure maintenance. Advances have been made in new materials that could extend the lives of roads, bridges, and pipes. New road coverings have been developed and are in use elsewhere in the world. Sensors could help pinpoint maintenance needs and operational concerns. Road technologies must adapt to the age of driverless vehicles. Smart roads, long a dream of transportation experts, are not far away: We already have ground-penetrating radars and embedded sensors that can report on the condition of infrastructure in real time. Current policies and funding mechanisms will require changes to encourage more transitional experiments and pilot projects.

Improving the capacity to govern and make analytically supportable decisions across jurisdictional lines ought to be a research priority as least as high as those topics above relating to new technologies. Research in the social and behavioral sciences could help to inform changes in how local, state, and regional governmental bodies tackle the difficult cross-jurisdictional decisions on infrastructure operations and investment.

Abbreviations

ARRA	American Recovery and Reinvestment Act
ASCE	American Society of Civil Engineers
BAB	Build American Bond
BOR	U.S. Bureau of Reclamation
BPC	Bipartisan Policy Center
CBA	cost-benefit analysis
CBO	Congressional Budget Office
CWSRF	Clean Water State Revolving Fund
DOT	U.S. Department of Transportation
DWSRF	Drinking Water State Revolving Fund
EPA	U.S. Environmental Protection Agency
FAST	Fixing America's Surface Transportation Act
FY	fiscal year
GAO	U.S. Governmental Accountability Office
GDP	gross domestic product
MPO	Metropolitan Planning Organization
NHTSA	National Highway and Transportation Safety Administration
O&M	operations and maintenance
OMB	White House Office of Management and Budget
PAB	Private Activity Bond
PPP	public-private partnership
R&D	research and development
SDWA	Safe Drinking Water Act
SIB	State Infrastructure Bank
SRF	state revolving fund
TEL	tax and expenditure limitation
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIGER	Transportation Investment Generating Economic Recovery
TIP	transportation improvement plan
USACE	U.S. Army Corps of Engineers

WIFIA	Water Infrastructure Finance and Innovation Act
WIN	Water Infrastructure Network
WRDA	Water Resources Development Act

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