CHAPTER 6

THE ECONOMIC BENEFITS OF INVESTING IN U.S. INFRASTRUCTURE

Transportation infrastructure has been a key ingredient of economic growth in this country. Ships and ports originally enabled the economic development of the U.S. colonies by fostering the export of natural resources and commodities and the import of manufactured products. Canals and systems of dams and locks on major waterways first opened up the interior of the country to global trade. Railways enabled the rapid expansion to the West, providing an efficient and reliable cross-country option for moving passengers and goods. Combined with the development of automobiles and freight trucks, roads and highways—particularly the Interstate Highway System—became the backbone of inter- and intra-state transportation, offering households and businesses easily accessible and affordable transportation. Airplanes, especially in this modern era of globalization, have fostered the expansion of international trade, the spread of new technology, and the exchange of information, accounting for about a third of the value of U.S. exports (U.S. Department of Transportation 2015a).

In each of these cases, investments in infrastructure not only contributed to increases in economic output, but also transformed the country. The geographic and modal distribution of infrastructure more broadly affects where people live and work, how we move goods from production to consumers, and how much carbon we emit. This chapter explores key aspects of our Nation's infrastructure: its current quality; the potential benefits of infrastructure investment; why now is an opportune time to increase it; the mechanisms through which transportation is typically funded; and the Federal, State, and local roles that make all this possible.

Economic Principles for Infrastructure Policy

Infrastructure is defined as fixed capital assets that are consumed jointly in various production processes that facilitate and support economic activity, with "core" infrastructure referring to roads and other transportation facilities, power generation facilities and distribution networks, and water and sewer systems. The services provided by infrastructure are an indispensable input to the productive capacity of an economy, applied in tandem with other key inputs such as labor, human capital, land, and natural resources. Firms combine the use of infrastructure with these other inputs to produce goods and services, while households employ infrastructure services in both the production of output and the consumption of leisure activities. Deficiencies in infrastructure have the potential to adversely affect economic output, employment, and overall quality of life. At various points in time, the country has recognized the need to substantially upgrade its public infrastructure to foment economic development, and has subsequently invested in new and expanded infrastructure.

The crucial role of infrastructure is well recognized in economic theory. Macroeconomics emphasizes the importance of infrastructure capital in fostering economic growth, while microeconomics notes the private and social benefits that infrastructure services can provide for consumers, businesses, and entire communities. Economic theory also highlights how, to achieve optimal levels of investment, some forms of infrastructure may require government involvement in their provision and financing because they exhibit many characteristics of what economics defines as "public goods." Pure public goods have two unique characteristics: non-excludability in supply and non-rivalry in consumption. Non-excludability in supply means that consumers cannot be prohibited from enjoying the benefits of the public good; once the public good has been provided, the entity providing it cannot exclude members of the general public from utilizing its services (usually for technological reasons), and thus cannot charge anyone for its use. Non-rivalry in consumption means that any one consumer's decision to use a good does not reduce the amount available for others. One cannot keep a ship from seeing a lighthouse once it is lit (non-excludable), and one ship seeing the lighthouse does not prevent others from seeing it (non-rival).

Since the services they provide are both non-excludable and non-rival (for example, lighthouses and street lights), many types of transportation infrastructure are classic examples of pure public goods. In other cases, infrastructure may be excludable (a bridge with limited access) or rival (overcrowded roads or bridges). Furthermore, highway and transit infrastructure often have spillovers beyond their immediate users, providing

benefits to a wide set of consumers and firms—thus making it difficult to identify who, and how much, to charge for those services. Other types of infrastructure also have positive spillovers that are difficult to monetize, such as public health benefits arising from improved clean water systems. As a result, individual entities, both public and private, may overlook projects that are not profitable for them, but nevertheless provide a net benefit for society as a whole. Moreover, some types of infrastructure may be characterized by economies of scale; as such, only one firm can profitably provide the service while competition with other firms would be inefficient. As a result, the private sector may lack the proper incentives to invest in such capital or may not provide the amount that is socially desirable, leading to market failure. These issues suggest that the government has a role to play in efficiently supplying and maintaining transportation infrastructure, especially when it spans across geographic borders.

Role of Government

The appropriate roles for different levels of government in planning and funding infrastructure investments may vary. Historically, Federal investments in infrastructure have been directed toward the formation of new capital while State and local investments have been geared toward the operation and maintenance of current infrastructure. There is a clear role for Federal funding and financing for projects that benefit the country as a whole. Still, many other arguments exist for a broader Federal role, including policy goals such as equity, safety, and enhanced access for all citizens, as well as safeguarding the environment. The Nation recently took a first step toward a sustained increase in Federal funding for infrastructure when the President signed into law the Fixing America's Surface Transportation (FAST) Act of 2015, the first law enacted in more than 10 years that provides guaranteed long-term funding for surface transportation. The FAST Act and its impact on public infrastructure spending are discussed in detail later in this chapter.

Private investment can also play an important role in the provision of infrastructure through, for example, the formation of public-private partnerships (PPPs), in which the government contracts out multiple stages in the development process for new infrastructure to single private actors. Through these partnerships, the private sector could be responsible for some, if not all, of the stages in the life cycle of an infrastructure asset: design, construction, financing, operation, and maintenance. Government involvement in PPPs and the potential benefits and drawbacks associated with these partnerships are discussed later in the chapter. In any case, the potential to attract private investment in specific circumstances does not diminish the

importance of a strong Federal role in planning and funding critical public infrastructure.

The State of U.S. Infrastructure

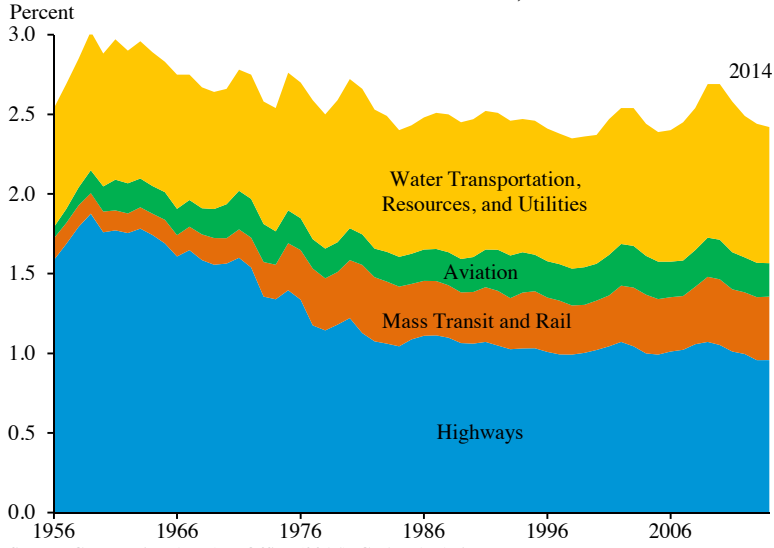
Current Investment Levels

Over the past half-century, public spending on water and transportation infrastructure as a share of gross domestic product (GDP) has trended slightly downward, as shown in Figure 6-1. Federal, State, and local government spending on water and transportation infrastructure accounted for 2.42 percent of GDP in 2014, 0.6 percentage point below its peak share of GDP in 1959 and somewhat above the smallest annual share of GDP at 2.35 percent in 1998. Most of the public spending can be attributed to State and local governments, which have accounted for, on average, about 72 percent of public spending on water and transportation infrastructure since 1956.

The composition of public spending on water and transportation infrastructure is now measurably different than it was in the late-1950s. Mass transit and rail have acquired a markedly larger share of public infrastructure funds. On average, from 1956 to 1960, streets and highways accounted for just over 62 percent of public spending on water and transportation infrastructure, while mass transit and rail accounted for only about 5 percent. By the early 1980s, the former had fallen to just under 43 percent while the latter had risen to over 15 percent. Since then, the distribution of public funds on water and transportation infrastructure has been relatively unchanged: streets and highways (42 percent); water transportation, resources, and utilities (35 percent); mass transit and rail (14 percent); and aviation (9 percent).

In the United States, public gross investment in new capital formation as a share of GDP, which includes core infrastructure as well as other types of capital such as equipment, intellectual property products, and Federal defense spending, has been declining over the past half-century. Public gross fixed investment is emphasized, as opposed to a more narrowly defined, infrastructure-specific category, because it allows for a comprehensive comparison of public investment across most of the G-7 for the past 35 years. As shown in Figure 6-2, this downward trend in new capital investment is not unique to the United States. Other members of the G-7—including Japan, France, and Germany—have experienced similar declines in their respective shares of GDP accounted for by public investment in new capital in recent decades. From 2011 through 2015, U.S. public capital investment as a share of GDP averaged 3.7 percent, its lowest trailing five-year average since 1950.

Figure 6-1
Composition of Public Spending on Water and Transportation Infrastructure as a Share of GDP, 1956–2014



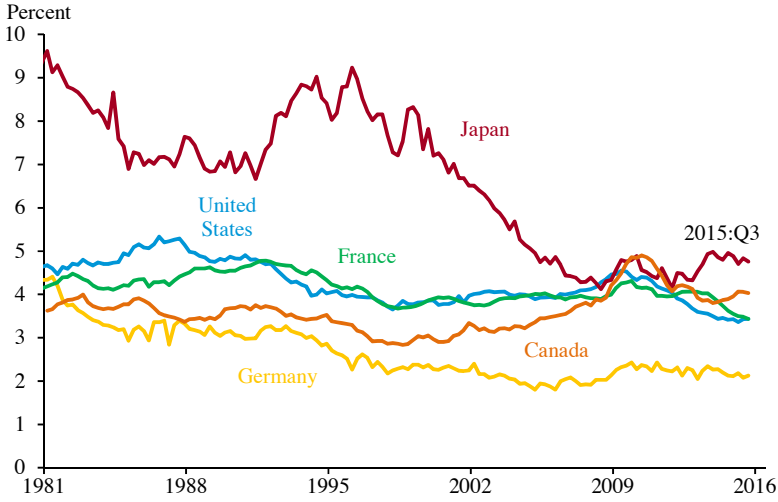
Source: Congressional Budget Office (2015); CEA calculations.

Transportation Infrastructure Quality

The aging of U.S. transportation infrastructure has been widely recognized. The Urban Land Institute (2011) noted that road systems and water-treatment plants built with Federal grants over 40 to 50 years ago are now reaching the end of their life cycles. According to the Bureau of Economic Analysis (BEA), the average age of the net stock for different public core infrastructure assets has steadily increased over the past half-century, as shown in Figure 6-3.[1] In 2014, the average age of public streets and highways, water supply facilities, sewer systems, power facilities, and transportation assets reached historic highs. Though this result is not that surprising—given that in-place capital is constantly aging—what is striking is the rapidity with which their average ages have risen of late. From 2010 to 2014, the average age of streets and highways increased 3.2 years, the greatest four-year change on record and more than the 2.9-year increase over the two decades prior. Water supply facilities aged on average 1.2 years from 2010 to 2014, above the 0.7-year increase over the 20 years prior. Public sewer systems and power facilities aged slightly less from 2010 to 2014 than they

[1] The average age is calculated as the weighted average of the ages of all depreciated investment in the stock at the end of the year, with the weight for each age based on its value in the total net stock. Consequently, an asset with a net stock consisting of a high proportion of older investment will have a high average age. Average ages are based on current, or inflation-adjusted, asset costs.

Figure 6-2
Public Gross Fixed Investment as a Share of GDP for G-7 Countries, 1981–2015



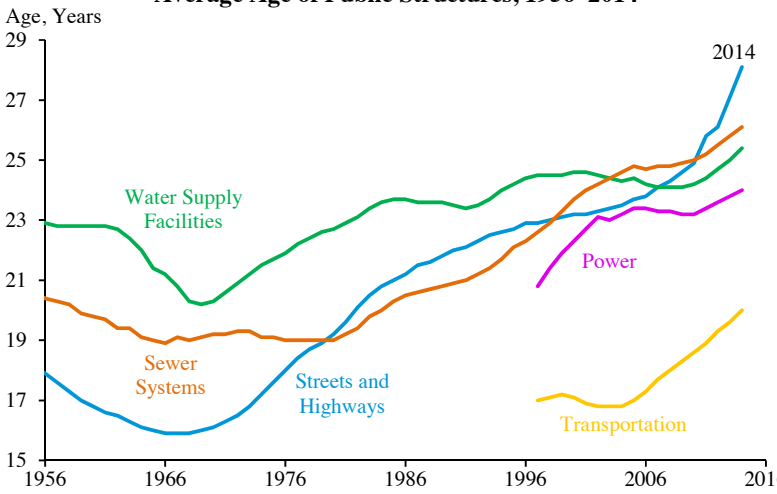
Note: Italy is excluded because comparable data are unavailable. United Kingdom is excluded because data are unavailable prior to 1997.
Source: National Sources via Haver Analytics.

did over the previous decade. And the average age of public transit assets increased nearly 20 percent over the decade ended 2014.

The declining quality of U.S. transportation infrastructure is also seen in global measures. The World Economic Forum releases annual ratings that gauge the quality of infrastructure throughout the world, and its ratings for the United States are displayed in Figure 6-4. These ratings are determined on a 1-7 scale, with a higher score indicating a better quality level. In 2015, the United States received a rating of 5.8 for its overall infrastructure, which was above the 5.4-average rating across the world's advanced economies, the 3.8-average across emerging and developing Asian nations, and the 4.1 global average. However, the overall U.S. rating for infrastructure in 2015 was noticeably below its level in the mid-2000s, falling nearly 8 percent since 2006. In comparison, the overall infrastructure rating for the world's advanced economies increased about 2 percent over the same period. Ratings for U.S. air transportation, ports, and roads are also lower today than they were in the mid-2000s. Ratings for railroads have been historically well below that of all U.S. infrastructure and of other transportation categories. Although some recent improvements have been observed, the quality of both U.S. infrastructure overall and various transportation subcategories remain either substandard or low relative to historical levels.

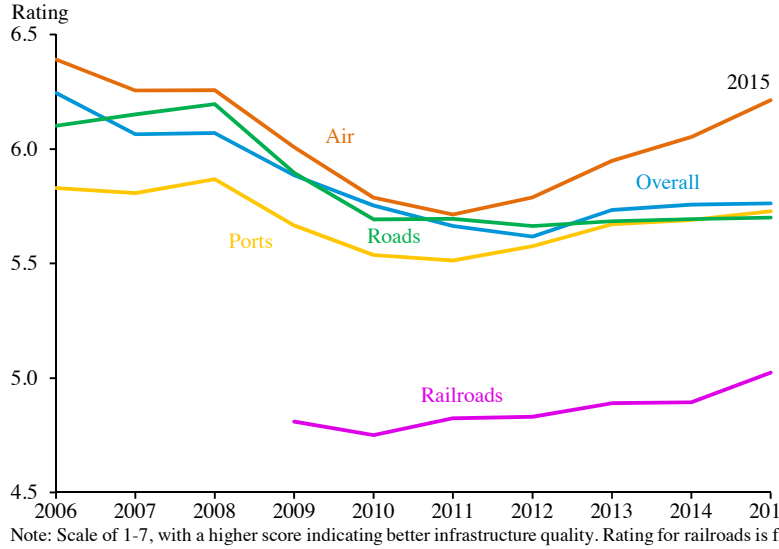
This trend of declining infrastructure quality is not uncommon among the G-7 countries, as seen in Table 6-1. The quality of overall

Figure 6-3
Average Age of Public Structures, 1956–2014



Note: Water supply facilities and sewer systems exclude Federal structures—which account for at most 6 percent of the value of their combined capital stock—because disaggregated Federal data are unavailable. Data for power and transportation fixed assets begin in 1997 because disaggregated data are unavailable for years prior to 1997.
Source: Bureau of Economic Analysis.

Figure 6-4
Quality of U.S. Infrastructure, 2006–2015



Note: Scale of 1-7, with a higher score indicating better infrastructure quality. Rating for railroads is first available in 2009.
Source: World Economic Forum, Global Competitiveness Report Survey.

infrastructure in 2015 for G-7 nations, with the exception of Japan and Italy, was lower than it was in the mid-2000s, declines comparable in magnitude to that observed in the United States. In regards to specific transportation infrastructure, the United States' performance in 2015 relative to the rest of the G-7 was mixed: The United States had the highest rating for air transportation and, along with the United Kingdom, ranked highest for ports, but ranked behind France and Japan for roads and was below the G-7 average for railroads.

Many U.S. roadways and bridges, in particular, are in poor condition. According to the International Roughness Index—a measure of the condition of road and highway surfaces—nearly 21 percent of U.S. roadways provided a substandard ride quality in 2013, the largest share from 1999 to 2013 (U.S. DOT 2015c).[2] In 2014, the number of bridges that were rated as structurally deficient was just above 61,000, while the number that were rated as functionally obsolete, or inadequate for performing the tasks for which the structures were originally designed, was slightly below 85,000 (DOT 2015d). The number of structurally deficient bridges has declined on average 2.7 percent a year since 2000, below the 4.2-percent average annual rate of decline throughout the 1990s. The number of functionally obsolete bridges has also declined steadily since 2000, falling on average about 0.5 percent a year. Combined, these two groups accounted for just below 24 percent of all bridges in 2014, the smallest annual percentage on record.

More investment is needed to resolve these deficiencies. The U.S. Federal Highway Administration estimates that noticeably improving roadway conditions and performance—rather than allowing congestion to increase further and pavement conditions to worsen—would require a capital investment in roads across all levels of government of $124 to $146 billion annually, with larger estimates corresponding to higher forecasts for the rate of growth in motor vehicle travel (DOT 2013). A growing population and economy will only serve to exacerbate these deficiencies. As the number of users who depend on transportation infrastructure increases, so too will the stress that is placed on these structures—leading to augmented congestion and necessary maintenance. Under higher expected growth rates for motor vehicle travel, roughly half (54 percent) of the aforementioned investment would be used for improving the physical conditions of current road infrastructure. The timeliness of such investment and the mechanisms through which it could occur are explored later in this chapter.

[2] A substandard quality of ride is defined as having an International Roughness Index value greater than 170. Data for 2010 and comparable data prior to 1999 are unavailable.

Table 6-1
Quality of Infrastructure in G-7 Member Countries

Type	CAN	FRA	DEU	ITA	JPN	GBR	USA	G-7 Average
2006								
Overall	6.0	6.5	6.6	3.7	6.1	5.6	6.2	5.8
2015								
Overall	5.4	5.9	5.9	4.1	6.2	5.3	5.8	5.5
Air	5.8	5.8	6.0	4.5	5.6	5.8	6.2	5.7
Ports	5.5	5.3	5.6	4.3	5.4	5.7	5.7	5.4
Roads	5.2	6.1	5.7	4.4	6.0	5.2	5.7	5.5
Railroads	4.7	5.8	5.6	4.0	6.7	4.8	5.0	5.2

Note: Scale of 1-7, with a higher score indicating better infrastructure quality.
Source: World Economic Forum, Global Competitiveness Report Survey.

Congestion

Individuals experience the costs of insufficient road and bridge infrastructure capacity partly through increased congestion, which will continue to rise as the number of cars driving on roads increases. Table 6-2 characterizes the evolution of U.S. roadway congestion over the past three decades. Commuter delays translate into economic costs through lost time that could be spent at work or consuming leisure activities, as well as through wasted fuel consumed by vehicles in congested traffic. In 1990, the average commuter was delayed a total of 26 hours over the course of the year, leading to an aggregate delay of 3 billion hours for all travelers collectively, a waste of 1.2 billion gallons of fuel, and an estimated total cost of $65 billion. Since then, a near 62-percent increase in the average commuter's annual delay, coupled with an estimated 42-percent rise in the total amount of commuters, has led to aggregate hours delayed, fuel wasted, and total cost more than doubling from their 1990 levels. Through the rest of the decade, these congestion measures are expected to continue increasing.

Higher levels of congestion also lead to increased carbon dioxide emissions: Congestion mitigation strategies that smooth traffic flows could reduce carbon dioxide emissions by about 7 to 12 percent based on typical conditions on Southern California freeways (Barth and Boriboonsomsin 2008). Clean energy transportation investments, discussed in Box 6-1, can lessen the impact congestion has on the environment. Increased congestion has also been associated with reduced employment growth: a 10-percent increase in congestion for a city with relatively high congestion levels could reduce long-run employment growth by as much as 4 percent (Hymel 2009). Investing in infrastructure will help alleviate congestion both in the short

Table 6-2

Measures of U.S. Traffic Congestion

Year	Delay per Commuter (Hours)	Total Delay (Billion Hours)	Fuel Wasted (Billion Gallons)	Total Cost (Billions of 2014 Dollars)
1982	18	1.8	0.5	42
1990	26	3.0	1.2	65
2000	37	5.2	2.1	114
2010	40	6.4	2.5	149
2014	42	6.9	3.1	160
2020[1]	47	8.3	3.8	192

[1] Forecast obtained from source assumes that pre-recession population growth and congestion trends will persist in the near-future.

Source: Schrank et al. (2015).

run, by providing increased road capacity and easing bottlenecks to allow more fluid transportation, as well as in the long run, by providing enhanced travel options that can help divert traffic away from frequently congested roadways and bridges.

More time spent commuting can also produce individual behavioral and socioeconomic costs. Transportation congestion induces more stressful commutes, which Navaco and Gonzalez (2011) note has been shown to be associated with "negative mood on arrival at work, negative mood at home in the evening, lowered frustration tolerance, cognitive performance impairments, illness, work absences, job instability, lowered residential satisfaction, and lowered overall life satisfaction." Thus, elevated stress from worsening commuting conditions may put downward pressure on workplace productivity as well as overall worker sentiment. Moreover, increased time spent commuting implies that less time can be spent on health-related activities such as sleep and exercise. As Christian (2012) notes, longer commutes are linked to "behavioral patterns which over time may contribute to obesity and other poor health outcomes."

Benefits of Investing in Infrastructure

This section discusses the role of infrastructure in the economy, highlighting the channels through which infrastructure investment can spur overall economic activity in both the short and long run. In the near term, this boost occurs through the demand-side of the economy. Because investing in infrastructure requires raw materials, manufactured goods, and extensive labor, it stimulates economic activity among firms in the supply chain and in households with members searching for employment. In the

Box 6-1: Clean Energy and Transportation Infrastructure

Infrastructure investments can have wide-ranging impacts on patterns of development in a city, the number of cars accessing certain areas, and ultimately environmental outcomes. A sound infrastructure plan takes into account environmental impacts and can help achieve both development and climate improvement goals. Such a plan can accommodate economic growth, encourage new, greener fuels in transportation networks, support public transit, encourage more thoughtful land-use planning, and reduce congestion and pollution from idling. When deciding on a new infrastructure proposal, it is important for Federal, State, and local governments to consider the overall social impact that the proposal will have. This includes not just the financial costs incurred and potential revenues raised, but also indirect benefits such as improved environmental conditions, better health from reduced air pollution, and decreased city congestion—all of which can be more difficult to monetize.

Public transit can often provide an effective way to achieve transportation goals while safeguarding the environment, and recent innovations in green transit have served to amplify these benefits. Finishing a process that began in 1995, Los Angeles County Metropolitan Transportation Authority became the first major U.S. transit agency to replace all diesel buses in its extensive Metro fleet with newer versions that operate instead on clean, alternative energy (Weikel 2011). The transition is estimated to have reduced the emission of greenhouse gases by roughly 300,000 pounds a day, and cancer-causing particulates from the city's buses by 80 percent. Also in California, an 800-mile high-speed rail system—the Nation's first—is in the process of being built and expected to begin operation in 2029 (California High-Speed Rail Authority 2015). By 2040, the new rail system is predicted to decrease the total distance vehicles travel each day by almost 10 million miles and reduce the number of daily flights by roughly 100 or more. This immense project will be funded partly by a state voter-approved $9.95 billion bond measure, and partly by funds made available through the Federal Government.

The push toward clean automobile fuel is also well underway. The American Recovery and Reinvestment Act of 2009 dedicated $17.7 billion to energy-efficient transportation: implementing tax credits for businesses that installed alternative fuel pumps, funding the development of advanced vehicle batteries, and subsidizing the reduction of diesel emissions (National Resources Defense Council 2009). These investments helped to catalyze and accelerate the development of clean energy technologies that have begun to have broad impacts on energy industries. Higher fuel efficiency standards have also pushed auto manu-

facturers toward cleaner low-emissions vehicles. In 2015, through the Biofuel Infrastructure Partnership, the Federal Government agreed to match funds provided by states and private partners for pumps that supply renewable fuels to motorists (U.S. Department of Agriculture 2015). More than 20 states have enrolled in the program, applying for over $130 million of funding—$30 million more than anticipated.

Transportation infrastructure investment can help address congestion and the subsequent pollution it produces. For example, the Congestion Mitigation and Air Quality Improvement Program provides funding to State and local governments for projects that will help meet requirements set by the Clean Air Act. Projects eligible for financing through this program include ones aimed toward expanding accessibility to public transit, reducing harmful emissions, and ameliorating traffic congestion. Included in the President's fiscal year 2017 budget is an initiative to increase Federal funding toward clean transportation infrastructure, a proposal that is discussed in detail in Box 6-4.

medium and long term, benefits materialize primarily on the supply-side. Higher-capacity and better-performing infrastructure supports faster, more reliable transport flows. As a result, households can increase their consumption through reduced travel costs and firms can exploit economies of scale in their production processes and distribution networks. Investing in new infrastructure also increases the flow of capital services that households and firms can utilize to produce valuable commodities and services. These longer-term supply improvements enable the economy to use private capital, labor, energy, and other inputs more productively, thereby augmenting the economy's future potential growth.

Short-Term, Demand-Side Benefits

Slack in the economy refers to the underutilization of resources like labor and capital. When slack exists in the economy, fiscal spending can help alleviate that slack by augmenting its contribution to public works projects. In the near term, public investment can reduce unemployment, provide workers with disposable income, and spur economic activity through the purchasing of inputs needed for implementing these projects (see Table 6-3). Government spending has a multiplier effect, which is defined as the dollar change in output caused by a $1 change in public spending. The multiplier measures the effects of government spending on overall economic activity rather than simply the impacts on businesses or households that directly receive the spending.

Table 6-3

Input-Output Effects of Infrastructure Investment

Industry	Direct Multiplier	Indirect Multiplier on Manufacturing Industries	Indirect Multiplier on Non-Manufacturing Industries	Total Multiplier
Government Investment				
Federal nondefense	1.00	0.10	0.43	1.54
State and local	1.00	0.21	0.44	1.65
Passenger transit	1.00	0.88	1.30	3.19
Electric utilities	1.00	0.12	0.69	1.81
Nonresidential Investment				
Structures (excluding commercial and farm)	1.00	0.39	0.37	1.76
Maintenance and repair	1.01	0.42	0.47	1.89
Core Infrastructure Investment				
Highways and streets	1.00	0.48	0.52	2.00
Electric power generation, transmission, and distribution	1.01	0.18	0.61	1.80
Water, sewage, and other systems	1.00	0.12	0.48	1.60

Note: Multipliers represent the dollar value of output that is generated from investing $1 of input into the industry listed.
Source: Bureau of Economic Analysis, Benchmark Input-Output Accounts 2007; CEA calculations.

The short-run public investment multiplier for economic output has been well-documented. The International Monetary Fund (2014) finds, during times of low growth, a public spending multiplier of 1.5 in the same year as the investment and a slightly higher multiplier of 3 over the next four years. When a government has clearly identified infrastructure needs, an efficient investment process for identifying and directing funding toward those needs, and economic slack, then there is a strong case for increasing public investment in infrastructure. With nominal interest rates at or close to zero percent, the effects of increased government spending can be larger than they would be during normal circumstances when interest rates are higher. When the Central Bank's policy rate is set at zero—which it was from 2009 through 2015—Christiano, Eichenbaum, and Rebelo (2011) and Eggerston (2011) find stronger effects of increased public investment, producing short-run multipliers that range between 2 and 2.5. Because of its labor-intensive nature, spending on transportation is associated with even larger boosts to economic output than other government spending, with a short-run multiplier of about 2.7 (Leduc and Wilson 2014). In addition, to the degree that

sustained losses in economic output lead discouraged workers to drop out of the labor force for prolonged periods and make them reluctant to return, alleviating these output losses in the short run can help to increase long-run output. When there is less slack in the economy, or when the Central Bank might tighten monetary policy in response to fiscal spending, fiscal multipliers are much lower (Auerbach and Gorodnichenko 2012).

As shown in Table 6-3, these short-run multipliers are in line with those calculated using the Benchmark Input-Output Accounts from 2007 released by the BEA.[3] The input-output calculations highlight the indirect effects that increased spending in a given industry can have on the rest of the economy. Each additional dollar spent toward infrastructure—whether it is through the Federal or State and local governments; used for highways and streets, electricity, or water and sewage; or devoted to the formation of new capital or the maintenance of current infrastructure—has a multiplier notably larger than 1. The largest multiplier stems from State and local government spending on passenger transit at 3.19, indicating that such an investment leads to more than triple its value in economic output. The indirect multipliers from investing in infrastructure can be especially large for the manufacturing sector (for example, 0.88 for State and local government investment in passenger transit and 0.48 for highways and streets more generally). Positive impacts on the manufacturing sector likely result because constructing, operating, and maintaining public infrastructure relies heavily on manufactured goods. There are also substantial spillovers to non-manufacturing industries, which, being the largest part of the economy, are affected by a general increase in economic activity.

Even as labor markets normalize, increased infrastructure investment would provide, at the very least, short-run boosts to output and jobs. CEA (2014) finds that 68 percent of the jobs created from infrastructure investment would stem from construction. According to the Quarterly Census of Employment and Wages, the average weekly wage for private construction employment in 2014 was $1,058, 7-percent higher than the private-sector average. Thus, most of the employment generated from investing in infrastructure would be well-paying, middle-class jobs. Although the boosts to output and employment are larger when the increase in public spending occurs during a period of greater economic slack, there is still a benefit to increasing government spending on infrastructure today. Beyond the short-term boosts to demand for labor and other resources, however,

[3] Data from 2007—as opposed to data from a more recent year—are used because 2007 is the latest year for which the BEA released a more comprehensive breakdown of the industry-by-industry input-output data, providing the cross-section between 389 industries and allowing for the analysis of more disaggregated investment categories such as those displayed in Table 6-3.

infrastructure investment is crucial for supporting long-term growth by providing the necessary supply-side inputs.

Long-Term, Supply-Side Benefits

Well-targeted infrastructure investments increase the economy's long-run growth potential. Macroeconomists have closely examined the link between infrastructure investment and economic development, finding that infrastructure boosts productivity and offers large socioeconomic gains. Public investment in infrastructure propels future productivity growth through several channels: enabling firms to take advantage of economies of scale and increase production through reduced input costs; lowering transport, storage and vehicle maintenance costs for households and firms by easing congestion and improving the quality of roads and highways; increasing the productivity of private capital through improved resource utilization; and increasing workers' access to labor market opportunities, thus facilitating more efficient hiring matches. These effects are especially relevant today as the United States continues to experience lagging productivity growth (see discussion in Chapter 2 and Figure 2-30).

Increasing public infrastructure investment supports growth in labor productivity by augmenting growth in total factor productivity and by increasing the capital intensity of production throughout the economy. Boosting the capital intensity of production occurs both directly, by increasing the accumulated stock of public capital, and indirectly because a larger stock of public infrastructure fosters increased private capital investment. By increasing private-sector output and improving the productivity of private capital, infrastructure spending can induce greater private spending by increasing the returns to investment on private capital.[4] Larger stocks of public capital, and the flow of services they generate, raise the marginal productivity of other inputs to production, including private capital and labor. Because more efficient input use leads to lower costs of production, businesses will expand their production capacity to take advantage of these cost reductions. Through this mechanism, increasing the stock of public capital investment can effectively augment the level of private investment.

Some research found that increasing aggregate public investment by $1 can increase long-term private investment by $0.64 (Pereira 2001). However, this effect was found to vary noticeably among different types of infrastructure: Pereira (2001) estimated that publicly investing $1 in electric and gas facilities, transit systems, and airfields induces a $2.38 rise in long-term private investment, whereas an additional $1 of public investment in

[4] See Nadiri and Mamuneas (1996) for an analysis of this mechanism through the highway capital stock.

highways and streets increases private capital investment by only $0.11. Although the effects are more muted for some types of infrastructure, public investment in each amplifies private investment in the long-term. By enticing greater long-run private capital investment, increased public spending spurs capital deepening and, in turn, raises future productivity and thus long-run potential economic growth.

Many studies have assessed the productivity effects of public capital investment for the United States, Organization for Economic Co-operation and Development member nations, and developing countries. The variability and potential biases associated with these estimates are discussed in Box 6-2. A literature review of economic analyses from 1983 to 2008 suggests that on average, a 1-percent increase in public capital leads to a 0.11-percent rise in output (Bom and Ligthart 2014). In 2014, the stock of physical public capital relative to GDP was about 76 percent. Given this elasticity estimate and the size of the public capital stock, the marginal product of public capital is about 14 percent. Thus, given the deficiency in infrastructure described above, a $1 increase in the total value of the public capital stock would raise annual economic output by about $0.14.

Infrastructure's Direct Boost to Productivity

Beyond the ways in which infrastructure boosts economic activity and productivity through spillovers, it also raises productivity directly by increasing capital services used by industry. For example, publically funded highways and airports provide capital services through the transportation of goods that are sold in the private sector. Real capital services from the public capital stock are a flow that is calculated as the sum of the real interest payments on and the depreciation of the capital stock. This definition roughly parallels that used in the calculation of the contribution of private capital to labor productivity growth. A business or government purchases a structure or piece of equipment when the expected present value of the future flow of services from that structure or equipment meets or exceeds the original price. As the capital stock is used and ages, it loses its value (depreciation) in rough proportion to the services that it renders. Interest payments on the funds borrowed to finance the purchase should be added to this flow.

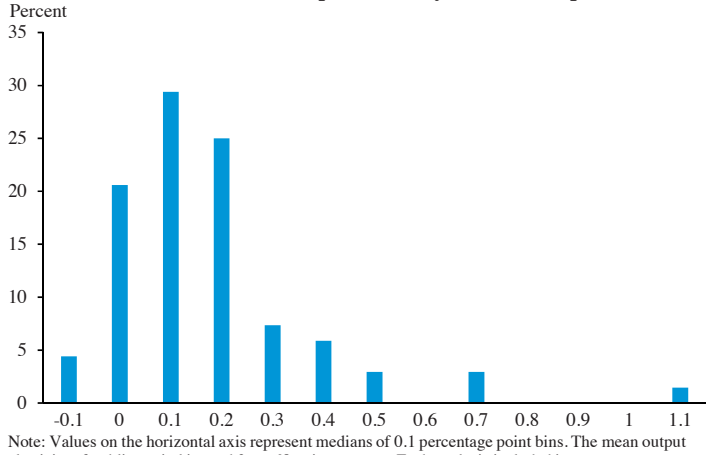
The growth rate of public capital services per private-sector employee-hour and its contribution to nonfarm productivity growth are shown in Table 6-4. Growth of capital services per hour fell from an annual rate of growth of 2.6 percent during the 1947-to-1973 period to only 0.7 percent a year during the 1973-to-1995 period. To derive the direct contribution to nonfarm productivity growth, the growth of public capital services is

Box 6-2: Elasticity of Output to Public Capital

Attempts to gauge the contribution of the public capital stock to economic output have focused on calculating the *output elasticity of public capital*, or the percent change in output that results from a 1-percent increase in public capital.[1] Aschauer (1989) was among the first to estimate the magnitude of this effect for the United States, finding an output elasticity of public capital of 0.39—implying that U.S. public capital investment has been an important factor in influencing historical growth in U.S. economic output. Since that time, an abundance of research has been devoted to gauging the elasticity of a nation's output to its public capital stock, though no consensus has surfaced, as shown in Figure 6-i. While most of the estimates summarized in the Figure cluster near 0.1, they have ranged from as low as -0.14 to as high as 1.14. The following discussion explores the reasons for the wide disparity in the estimates summarized in Figure 6-i.

One reason for the wide variation is that empirical estimates may vary depending upon the time horizon over which the output elasticity is calculated. Looking over the near term is likely to produce lower output

Figure 6-i
Distribution of the Output Elasticity of Public Capital



Note: Values on the horizontal axis represent medians of 0.1 percentage point bins. The mean output elasticity of public capital is used from 68 unique papers. Each analysis included incorporates a production function approach that results in a single output elasticity and assesses the capital stock using some measure of public output.
Source: Bom and Ligthart (2014); CEA calculations.

[1] This calculation is different than the spending multipliers mentioned earlier. These measures look at annual changes in economic activity, including the infrastructure spending itself, relative to spending in a given year. The output elasticity of public capital considers the impact from the public capital stock on other economic activity.

elasticities since short-run analyses ignore the long-term nature of public capital's effects on private investment, productivity, and economic growth. New infrastructure may not only take years to complete, but may require years before its productivity boost to society is realized. When evaluated over the long run, the output elasticity of public capital has been found to be on average nearly 0.04 percentage point higher than those calculated over the near term (Melo, Graham, and Brage-Ardao 2013; Bom and Ligthart 2014).

Second, the level of aggregation at which the analysis is conducted can heavily influence the output elasticity calculated. Given its far-reaching nature, the formation of new public capital can augment production capacity, not only in the areas in which structures are built, but in neighboring economies as well. Consequently, analyses that focus on regional data will inherently overlook spillover effects into nearby areas, whereas those that use national data will naturally internalize these effects in their empirical estimates. Not accounting for these spillover impacts can put sizable downward pressure on output elasticity estimates, resulting in values that are more than 0.15 percentage point less than their national-data counterparts (Bom and Ligthart 2014).

Third, analyses that use a production function estimated from historical data on investment and output may spuriously overstate the output elasticity of public capital. Some exercises may find relatively large output elasticities because they fail to account for common trends in the data. Given that time series for output and public capital tend to exhibit common stochastic trends, estimates produced from econometric analyses of their historical levels may produce artificially high results. Time-series analyses that fail to test for common time trends among the variables they employ often find output elasticities of public capital that are 0.1 percentage point on average higher than those that conduct such tests and employ estimation procedures that account for these trends (Bom and Ligthart 2014).

Fourth, to account for the spurious results that can arise from using historical levels of investment and output, many studies have constructed estimates that instead rely on year-over-year changes in these variables. Although this avoids the potential aforementioned bias from using the historical levels of data series, this approach is likely to understate the actual output elasticity, and can produce estimates that appear to be zero, though the true effect may be positive (Hurlin and Minea 2012). One problem with this method is that it assumes that the impact of public capital investment on output occurs instantaneously, rather than requiring a prolonged period for the effects to be felt. Because analyses that rely exclusively on year-over-year changes in investment

and output ignore potential inter-temporal long-run relationships that may exist among these variables, their results may underestimate the impact that investments in public capital have on output.

Last, studies that try to measure an output elasticity of public capital may suffer from reverse causality (or endogeneity issues), meaning that changes in economic output influence infrastructure investment and the stock of public capital, rather than the reverse. For example, higher levels of output may increase the demand for public capital or support more favorable fiscal conditions for elevating government investment. In this case, the elasticity of output to public capital may be overstated since favorable business-cycle conditions are artificially strengthening this estimated relationship. Similarly, increasing public investment may be used as a countercyclical measure to spur economic activity when output is depressed. As a result, though the size of the public capital stock may increase, economic output may remain temporarily suppressed, leading to underestimates of the relevant output elasticities. Using econometric techniques that account for potential reverse causality typically lowers the estimated elasticity of output to public capital by about 0.05 percentage point (Bom and Ligthart 2014).

When incorporating the output elasticity of public capital in an economic analysis, it is important to note the time-horizon and the geographic scope of government that is being used. Although Bom and Ligthart (2014) find an average elasticity of output to public capital of about 0.11 percentage point—notably below that reported by Aschauer (1989)—they note that the elasticity of output is heterogeneous across these dimensions. As one illustration, they find that the long-run output elasticity for State and local government spending on core infrastructure is more than twice as large as the short-run output elasticity for Federal spending on total infrastructure.

weighted by its "share" in output.[5] The slowdown in capital services per hour played a small role in causing the post-1973 slowdown in labor productivity growth, with its contribution dropping 0.08 percentage point between the two periods (from 0.18 percentage point a year to 0.10 percentage point a year). Of course, the indirect effects of lower public investment could also have played an important role.

The growth rate of public capital services per employee-hour remained low at only 1.1 percent a year during the 1995-to-2007 period. The growth rate picked up to 2.1 percent a year during the 2007-to-2014 period, a

[5] Although public capital services are not included in the official definition of nonfarm output, the definition of nonfarm output has been rescaled so as to include the implicit contribution of public capital.

Table 6-4

Direct Contribution of the Public Capital Stock to Productivity Growth

Time Period	Annual Growth Rate of Capital Services[1]	Annual Growth Rate of Employee-hours	Annual Growth Rate of Public Capital Services per Employee-hour	Average Share of Output at Implicit User Cost[2]	Contribution to Productivity Growth (percentage points)	Annual Labor Productivity Growth in Nonfarm Business Sector
1947–1973	4.0%	1.4%	2.6%	6.0%	0.18	2.8%
1973–1995	2.3%	1.6%	0.7%	7.6%	0.10	1.4%
1995–2007	2.0%	1.0%	1.1%	5.8%	0.07	2.7%
2007–2014	1.9%	–0.2%	2.1%	7.3%	0.18	1.3%

[1] Public capital services equals the sum of real depreciation plus real interest payments on the value of the net real public capital stock.

[2] Public capital services as a share of nonfarm business output, where nonfarm business output has been elevated by the inclusion of public capital services in that output.

Source: Bureau of Economic Analysis; Bureau of Labor Statistics; Haver Analytics; CEA calculations.

pickup that is fully accounted for by a dramatic slowing of employee-hours growth (from 1.0 percent a year to –0.2 percent a year) rather than a pickup in capital services growth (which was about 2.0 percent a year in both the 1995-to-2007 and the 2007-to-2014 periods). Public capital services per employee-hour (which accelerated in the 2007-to-2014 period) does not account for the recent slowdown in productivity growth as it did during the slowdown from the 1947-to-1973 period to the 1973-to-1995 period. That said, faster growth of public capital might have boosted recent productivity growth if suitable capital projects could have been found. Additional public capital investment might also have supported aggregate demand if it was appropriately timed.

Infrastructure Investment and Agglomeration

As workers and firms gather in the same location, the costs of transporting goods and hiring employees decline, leading to lower production costs for firms. An advantageous location or access to natural resources initially attracts businesses and households to a site, and as the surrounding region develops, the costs of doing business there decline and the existence of a thriving business community attracts other firms and consumers. These cost advantages stem from the spatial concentration of firms and workers, and are called agglomeration economies. Investing in high-capacity transportation facilities (such as mass transit) often fosters such agglomeration effects by enabling less-dense areas to urbanize, improving access throughout an urbanized area and reducing the costs associated with transportation.

Thus, ideas are exchanged, workers with specific skills are available, and supply systems can flourish. The benefits of reduced travel costs and more free-flowing, universal access redouble throughout the region. Workers can find jobs that take full advantage of their specialized skills, enabling firms to operate more efficiently and thus spurring other firms and workers in the economy to produce more efficiently. As a result, agglomeration effects can accentuate the impact that infrastructure investment normally has on productivity growth.

Spillover Effects

While investing in infrastructure generates direct benefits in the form of increased employment and higher productivity—benefits that may be magnified through agglomeration effects—it can also offer spillover benefits for neighboring economies. Road and highway infrastructure in particular has led to marked spillover effects (see Box 6-3, which highlights the spillover effects that stemmed from the formation of the Interstate Highway System). Output in the agricultural sector in particular has benefited through spatial spillovers from road investments. One study finds that a 1-percent increase in outlays on roads in a state is associated with a roughly 0.03-percent expansion in agricultural output in that state, and an average increase of 0.24 percent in adjacent states and their neighbors (Tong et al. 2013). The magnitude and structure of the spillover effects vary based on the location of the state and the paths available for the spillover effect. These effects are especially pronounced in the agriculturally concentrated central United States relative to less agriculturally intensive regions.

Improvements in airport infrastructure offer both direct and spillover gains, which can be geographically extensive because of the network nature of air service; that is, improving an airport in one location results in faster and more reliable connections with many other areas. Investments in air transportation can effectively reduce travel time and promote more reliable flights, enhancing worker productivity and shipping efficiency. Directly, a 10-percent increase in passenger enplanements in a metro area has been found to raise employment in service industries—which account for almost 84 percent of total private employment—by about 1 percent (Brueckner 2003). Indirectly, the expansion of airport infrastructure has been associated with cost savings in manufacturing production not only in states in which the airports are located, but in other states as well. A 1-percent increase in state airport infrastructure stock—defined as airport capital expenditures for construction, land, structure, and equipment—has been found to correspond to a decrease in manufacturing costs of about 0.1 percent within that state and between 0.1 and 0.2 percent within other states, with higher

Box 6-3: The Interstate Highway System

What has been called the "greatest public works project in history," the Interstate Highway System remains one of the largest investments in infrastructure by the U.S. Government (DOT 2015e). President Dwight D. Eisenhower recognized the social and economic importance of constructing a highway system in his 1956 State of the Union Address, highlighting that it was needed for "the personal safety, the general prosperity, the national security of the American people" (Public Broadcasting Service 1956). The 47,000-mile highway system, spanning all 48 contiguous states, was a project commissioned by the Federal Aid Highway Act of 1956.

The project pushed public spending on highways to historic highs in the late-1950s and throughout the 1960s. From 1956 to 1970, public spending on highways averaged about 1.7 percent of GDP and accounted for roughly 60 percent of public spending on water and transportation infrastructure (Congressional Budget Office 2015). Highways remain a major part of infrastructure investment. From 2000 to 2014, public spending on highways averaged just above 1 percent of GDP and represented about 41 percent of public spending on water and transportation infrastructure. From increased trade and job growth to more free-flowing and accessible transportation, the construction of the Interstate Highway System demonstrates the potential gains that large-scale infrastructure projects can offer and remains a powerful example of our past investment in infrastructure development.

When drivers switch from a traditional road to a wider, straighter interstate highway, travel costs are substantially reduced. Savings are estimated at $0.19 a mile for automobiles and $0.38 a mile for trucks, stemming from reduced travel time, accidents, and vehicle operating costs (Thompson and Chandra 1998). This effect, combined with decreased travel distance between cities, has been shown to have a positive impact on trade by, for example, allowing for the transportation of heavier goods (Duranton, Morrow, and Turner 2014). Rural counties that became connected by the Interstate Highway System experienced as much as a 10-percentage point increase in trade-related activities per capita (Michaels 2008). Moreover, a 1-percent increase in the highway capital stock per capita in a given northeast metropolitan area—measured using Federal, State, and local government expenditures on highways—was found to be associated with a 0.05-percent rise in annual economic output per capita both in that region and in its nearest neighbor (Chen and Haynes 2015). Beyond the gains from trade, investing in highways has been found to have boosted employment as well: a 10-percent increase in a metropolitan statistical area's stock of interstate highways (measured as

kilometers of road) in 1983 resulted in 1.5 percent more employment for that area 20 years later (Duranton and Turner 2012).

From decreased travel costs and increased trade to higher employment and output, the economic effects of a national highway system are clear. The Interstate Highway System provides an interconnectedness that was not there before, a means by which individuals and goods could travel more fluidly throughout the contiguous United States. The effects from the Interstate Highway System were drastic at its implementation, and continue to be substantial today.

spillover effects stemming from states without large hubs (Cohen and Morrison Paul 2003).[6]

Both investment in new public capital and improved maintenance of existing infrastructure can produce spillover effects, again presumably due to the network nature of most transportation infrastructure, where expanding a single facility can improve connections among many origins and destinations. In fact, there is some evidence that the effects from State and local government investment in public capital can be larger for neighboring states than for the ones in which the investments are made. Evaluating annual state-level output and constructing weighted spillover indexes based on the commodity flows across states and the relative magnitudes of neighboring economies, Kalyvitis and Vella (2015) find that outlays for new capital as well as those for operation and maintenance have large positive effects on neighboring economies, calculating average spillover elasticities of output from new public capital and maintenance of 0.09 and 0.34, respectively. The relatively large spillover effects from public spending on operation and maintenance may result because states and localities primarily fund operation and maintenance; as such, only the states and localities that make the investments incur the associated costs, allowing other states to enjoy the benefits without paying for the investment. Yet these authors' estimates for direct output elasticities of public capital for states in which the investments are made are noticeably smaller at near-zero values. This divergence in magnitude between direct and spillover effects from public infrastructure spending on output is one reason why Federal support and trans-state organizations such as the Port Authority of New York and New Jersey are important.

A failure to recognize these spillover effects from the construction and improvement of transportation networks by State and local government

[6] A large hub refers to an airport that accounts for at least 1 percent of the country's enplanements of passengers.

agencies responsible for funding public infrastructure may cause those agencies to undervalue the true social gains that such projects offer.

Household Effects

New investments in public transportation infrastructure, especially in expanded transit service, also support more robust and mobile labor markets by reducing geographic mismatches between the skill demands of jobs and workers who can offer specialized skills, and by providing potentially faster and less-costly transportation options to connect workers with jobs. Public infrastructure can directly influence where people choose to live and work since access to public transit can play a crucial role in this decision-making process, especially for households who cannot afford or choose not to own cars. New public transit services can improve labor market efficiency by connecting individuals with jobs to which they may not previously have had access. Kawabata (2003) found that improved access to jobs through public transit noticeably increased the probability that low-skilled workers without automobiles in San Francisco and Los Angeles would be employed, and also increased the likelihood that such employment would be full-time. Another study found that more extensive metropolitan-area public transit infrastructure increases the employment density of central cities by 19 percent, and that a 10-percent rise in bus or rail service per capita increases metropolitan-area wages by, on average, $45 million annually (Chatman and Noland 2014).

Improving public infrastructure can also foster higher city and suburban property values. Possible channels through which this effect can occur include: positive urban employment and spending spillovers from suburban inflows; the positive impact that high-quality infrastructure has on the perception of a metropolitan area; and the spillover of productivity gains from city centers to their surrounding suburbs. Haughwout (1999) found that a $1 billion increase in spending on city infrastructure would raise city property values by $590 million and related suburban property values by $540 million. This result provides a rationale for potential Federal or State involvement in the provision of urban public infrastructure, particularly where large urban regions cross state borders, and where sharing of common administrative overhead across a multi-jurisdictional project leads to more cost-efficient project delivery than undertaking multiple separate projects.

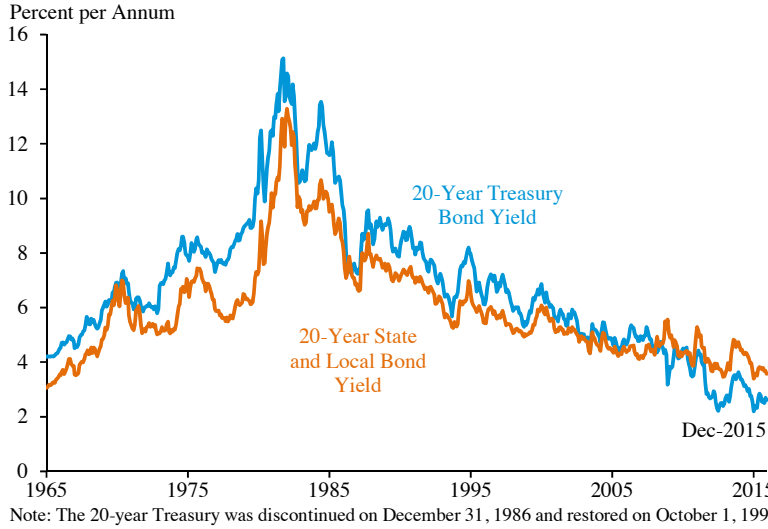
Prospects for Increased Infrastructure Investment

Low Interest Rates

Investment in America's infrastructure is arguably as important today as it has been at any point in recent history given its current state of deterioration. The financial environment faced by all levels of government provides even further justification. Yields on 20-year U.S. Treasury bonds as well as on State and local bonds are at near-historic lows, meaning that government agencies can borrow funds to finance long-term projects at costs as low as they have been over the past half-century, as shown in Figure 6-5. This is true even taking into account expected inflation rates. Long term real interest rates have moved decidedly lower in past decades (CEA 2015).

Given historically low borrowing costs and the potential upside boosts to short-run demand and long-run supply, investing in infrastructure would offer benefits that, according to Federal Reserve Vice Chairman Stanley Fischer (2015), "under current circumstances would outweigh the costs of its financing." Infrastructure investments promote current economic activity, augment the value of public capital stocks in the long run, and alleviate the burden on future generations of making needed infrastructure upgrades. During a period of low growth for an advanced economy, the large boost to

Figure 6-5
Government Bond Yields, 1965–2015



Note: The 20-year Treasury was discontinued on December 31, 1986 and restored on October 1, 1993. Data for the interim period are calculated as averages of the 10-year Treasury and 30-year Treasury constant maturity yields.
Source: Federal Reserve Board; Haver Analytics.

output in the near term from high-efficiency public investment can reduce the public-debt-to-GDP ratio (IMF 2014).

Maintenance and Repair

Infrastructure maintenance and repair can generate high returns on investment. Infrastructure depreciates over time, and does so more rapidly when it is used more intensively. Operation and maintenance expenditures allow infrastructure to function properly, deliver its promised benefits, and enable repair of structurally deficient assets. Neglecting proper maintenance and system preservation leads to deficient infrastructure conditions such as roads filled with potholes, traffic delays, power outages, and so on—which can impose sizable short-run costs on its users.

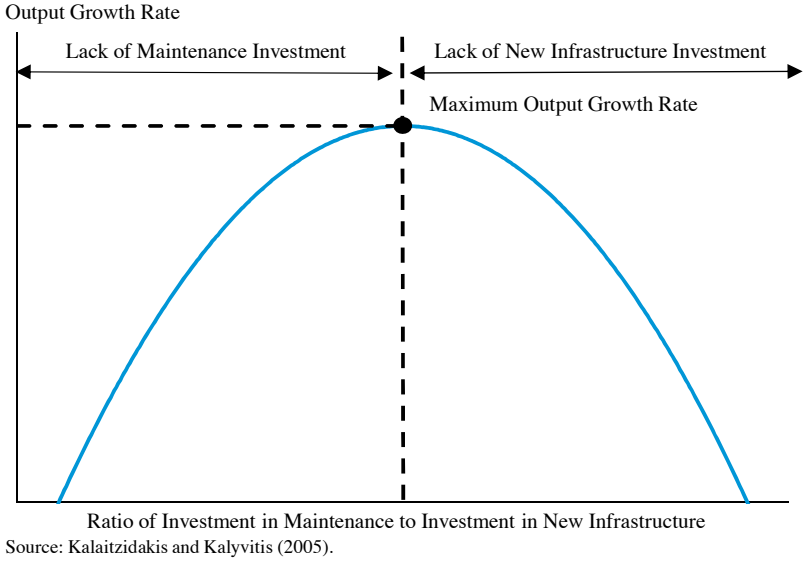
Investing in maintenance is a cost-effective technique for avoiding more expensive repairs in the future. One estimate is that every $1 spent on preventive pavement maintenance reduces future repair costs by $4 to $10 (Baladi et al. 2002). Transportation engineers have developed economic methods that determine the optimal timing for applying preventive maintenance treatments to flexible and rigid pavements by assessing the benefits and costs for each year the treatment could be applied (Peshkin, Hoerner, and Zimmerman 2004). Allowing the condition of transportation infrastructure to deteriorate exacerbates wear and tear on vehicles. Cars and trucks that drive more frequently on substandard roads will require tire changes or other repairs more often—estimated to cost each driver, on average, an additional $516 annually in vehicle maintenance (TRIP 2015). Delaying maintenance can also induce more accidents on transit systems. Not repaving a road, replacing a rail, reinforcing a bridge, or restoring a runway can result in increased vehicle crashes that can disrupt transportation flows and create substantial safety hazards.

The conceptual relationship between spending on maintenance versus new infrastructure and its impact on economic growth is depicted in Figure 6-6. The two are not perfect substitutes, as the latter adds directly to the stock of public capital while the former offsets depreciation on existing infrastructure (Kalaitzidakis and Kalyvitis 2005). Assuming that infrastructure investments are implemented efficiently, effectively, and optimally, then if spending on maintenance is too low relative to new capital investment or vice versa, economic output will grow at a rate below its potential.

To maximize economic growth from increased public investment in infrastructure, governments must properly balance the needs for new infrastructure with those for maintaining the infrastructure that is currently in place. The ratio of public spending on operation and maintenance to new capital for water and transportation infrastructure in the United States

Figure 6-6

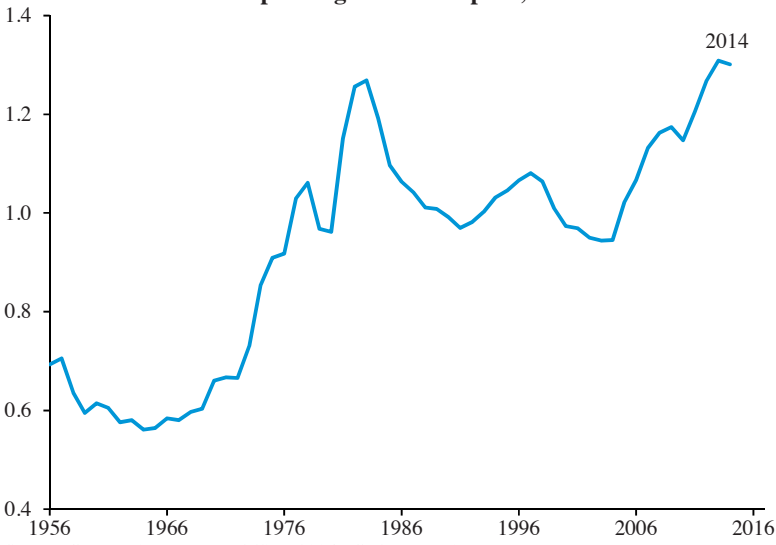
Relationship between Output Growth and the Ratio of Maintenance Investment to New Infrastructure Investment



Source: Kalaitzidakis and Kalyvitis (2005).

since 1956 is shown in Figure 6-7. From 1956 to 1970, the ratio of public spending on operation and maintenance to public spending on new capital for water and transportation infrastructure averaged 0.61—meaning that for every $1 spent toward new capital, $0.61 was spent on operation and maintenance. This relatively low public spending ratio largely reflected increased spending toward the continued construction of the Interstate Highway System. Over the 35 years that followed, the public spending ratio for operation and maintenance to new capital averaged 1.00—indicating a balanced approach between funding needs for new capital with those for operation and maintenance. Since then, public spending on water and transportation infrastructure has shifted toward supporting the operation and maintenance of current infrastructure relative to the formation of new capital more heavily than it did in the five decades prior, averaging a public spending ratio of 1.20. Although it is unclear what the optimal ratio is, what is clear is that maximizing growth requires spending on new infrastructure and maintaining in-place assets, not focusing solely on one and entirely ignoring the other.

Figure 6-7
Ratio of Public Spending on Operation and Maintenance to Public Spending on New Capital, 1956–2014



Source: Congressional Budget Office (2015); CEA calculations.

Managing and Funding Infrastructure Projects

Beyond the need for infrastructure and the economic gains that can result from a well-designed investment, a crucial decision in the infrastructure investment process is how to manage and fund such investments.

User Fees

If infrastructure is funded through conventional methods that rely on general government revenues, all taxpayers bear the costs of new projects. But through a user-fee system, only those who actually use the services that the new infrastructure provides are required to pay for it, which could present a more equitable and viable funding mechanism as long as a project does not generate extensive externalities or spillovers. If there are substantial spillovers, charging for use may dissuade users and lead to a socially inefficient outcome. One potential downfall of the user-fee approach is that revenues are dependent on demand. If the demand for a new transportation asset was over-estimated, then the revenue generated from user fees would be below expectations, causing the entity financially responsible for it to bear the shortfall—though this could lead governments and private entities to be more prudent when selecting which projects to undertake.[7] However, if

[7] One noteworthy example is the Virginia Dulles Greenway project, which defaulted on its bonds in its first few years because predicted demand for the new road system was too rosy.

there is a clear demand for an infrastructure project—which could be gauged by surveying households and firms, noting that there are heavily congested transportation structures nearby, or recognizing the need for maintenance on popular commuter routes—user fees can be an effective approach for funding its development. Although they may be cost effective, user fees are inherently exclusionary because consumers must pay to utilize the structure, which can limit access for low- and moderate-income households.

Public-Private Partnerships

Public-private partnerships (PPPs)—where governments contract with a private firm for provision of some or all aspects of an infrastructure project—have received increasing consideration and use in recent decades in the United States (Buckberg, Kearney, and Stolleman 2015), though they are relied on more heavily in other advanced economies, including Australia, Canada, and the United Kingdom. In July 2014, President Barack Obama launched the Build America Investment Initiative, a government-wide initiative to boost infrastructure investment that includes expanding the market for public-private partnerships. The adoption of PPP financing for infrastructure projects in the United States has been gradual (likely due to the availability of inexpensive financing in the U.S. municipal debt market). Through 2007, less than 15 transportation PPPs had reached financial close in the United States (Engel, Fischer, and Galetovic 2011). As of 2015, PPPs were a feature of approximately 60 infrastructure projects for new facilities in various stages of completion across the United States, with mixed degrees of private-sector involvement (DOT 2015b); more than 15 reached financial close in the three-year period ended April 2015.[8,9]

PPPs can provide a means for avoiding two of the major pitfalls that typically affect an infrastructure project designed and delivered using conventional methods of public funding. First, under the more standard approach to infrastructure provision, each of a number of firms or government entities may be called on to complete individual stand-alone elements of the project. As a result, these firms face incentives to minimize their own costs in providing their single element of the project, without regard for the quality or costliness of the project as a whole. More concretely, the segmented nature of the infrastructure provision process means that private

[8] Financial close occurs when all of the project and financing agreements have been signed and project implementation can start.

[9] These PPPs are not uniform as to the project phases that are assigned to the private sector; different project characteristics necessitate different risk sharing arrangements. Roughly 25 of the projects assigned only the responsibilities of designing and building to the private sector, while more than 20 stipulated that the private sector design, build, finance, operate, and maintain the structure.

firms that are not ultimately responsible for operating or maintaining a structure have less incentive to adopt designs or construction methods that minimize total costs over the project's complete life cycle, which includes its construction, operation, and maintenance. By contrast, and depending on how the contract is structured, PPPs can "bundle" the responsibilities of different project phases, so that, for example, a single private firm is responsible for the design, construction, financing, operation, and maintenance of the infrastructure asset. This arrangement provides strong incentives for on-time project delivery and cost minimization over the entire life cycle of the structure (Hart 2003), though PPPs can also be organized so that the private sector is responsible for just some of the phases of the project.

Second, given that the public sector would still be responsible for funding the project under conventional provision, the government would incur most or all of the risk associated with its underutilization or inadequate performance. In other words, should actual use of a project fall short of its expected level, or prove substandard in terms of its engineering or design, the responsible government agency—and ultimately, the taxpayers—would bear much or all of the resulting financial strain. On the other hand, the bundled nature of PPPs allows at least some of the demand and performance risks associated with the project to be transferred from the government agency sponsoring the project to the contracting firm (Buckberg, Kearney, and Stolleman 2015). This arrangement also serves to promote more effective project design and efficient construction. It may even ensure that more reliable and cost-effective materials are used, thus ensuring longevity and reducing the frequency of required maintenance.[10]

Nevertheless, because PPPs have potential drawbacks, it is critical to design them carefully and use them only when appropriate. PPPs in which a government compensates the private entity directly through availability payments do not reduce the demand risk borne by the government, because the private partner must be paid as long as the infrastructure service meets contracted quality standards, even if actual utilization of the service is far below expectations. This drawback, however, can be overcome. Partnerships between government agencies and private firms can be structured to mitigate the demand risks faced by the government in developing a new infrastructure asset. For example, a PPP contract could stipulate that the private firm finance the project and receive compensation through the collection of

[10] This incentive is especially relevant if the builder is also responsible for the maintenance of the structure.

user fees or shadow tolls.[11] Through this mechanism, the government could mitigate downside risks such as project cost overruns or revenue shortfalls, thereby insulating the government from budgetary risks associated with unexpected developments. However, private investors may require a higher rate of return on their investment in exchange for being exposed to these uncertainties.[12]

Another risk associated with PPPs is that by outsourcing some or all elements of a project to private businesses, the government relinquishes some of its control over planning, constructing, and potentially even operating and maintaining the structure. Although this feature is often seen as beneficial in that the private sector is perceived as being able to manage the project more efficiently, there still exists the risk that the private firm will fail to meet its obligations or that its efforts will lead to excessively high user fees. Moreover, because of their large scale of operation, infrastructure assets often have characteristics of natural monopolies: they can be unique in the role they play for given transportation markets, which in turn may eliminate the need or potential for competing options, which raises the possibility of excessively high prices or profit. Finally, many of the same principal-agent problems that arise in standard public finance, where officials may not make the best decisions on behalf of the public, can arise in PPPs. For example, if local authorities are myopic—with a horizon of the next election or next budget cycle primarily on their minds—they could strike a sub-optimal deal that casts them in a positive light in the short run, but is inefficient in the long term.

While infrastructure assets procured through PPPs are usually returned to public sector control after a contractually stipulated period, many of the perceived risks mentioned above can be mitigated through effective contract design. The government can retain a certain level of control—regulatory or otherwise—over the private entity or entities. A contract can stipulate quality levels that structures must satisfy, restrict the prices that can be charged for using assets, and require sharing of excess revenues or profit as well as shortfalls in order to achieve a balanced and mutually acceptable

[11] Shadow tolls involve periodic payments from the government to the private firm based on how many users the asset attracts per time period. Like user fees, shadow tolls provide an incentive for the private party to construct and manage the asset efficiently, thus transferring demand risk from the government to the private party. Shadow tolls differ though in that they require that the government funds the private entity.

[12] Importantly, paying a higher return to the private partner to bear the demand risk need not result in the project realizing efficiency gains. In contrast to bundled design and construction risk, for example, the transfer of demand risk to the private partner in and of itself will not induce it to take actions that lower the overall cost of the project. This is due to the fact that the private partner can do little to affect utilization, unlike the way in which its actions can substantially affect overall design and construction costs.

allocation of risks (Buckberg, Kearney, and Stollman 2015). Governments can also institute requirements for competitive bidding processes that are transparent and objective. In contracting the responsibility of financing an infrastructure project to the private sector, State and local governments can also initiate the development of new assets without having the budgetary resources necessary for financing.

The Role of the Federal Government

With the exception of freight railroads, the Federal Government plays a key role in funding and developing transportation infrastructure. A Federal presence is particularly valuable when these transportation projects offer multi-state or nationwide benefits. One reason for Federal involvement is that State and local governments may undervalue the benefits of new infrastructure projects by not accounting fully for their positive spillover effects on nearby areas. States and localities may not have financial capacity to build new infrastructure assets or to provide maintenance for structures in need of extensive repair. Without Federal assistance, such initiatives may be repeatedly postponed or bypassed entirely because of budgetary restrictions, causing their potential benefits to be delayed or foregone completely. Additionally, the private sector may lack the incentives or resources needed to adequately complete or operate new transportation infrastructure projects, which are often large and complex.

The Federal Government has an essential role in helping transportation planners and project managers collaborate on transportation infrastructure investments across jurisdictional and geographic boundaries. These efforts can enhance the economic competitiveness of metropolitan and non-metropolitan areas along major corridors that are critical for supporting current and future freight and passenger flows. Federal expertise and resources are used to promote comprehensive multimodal planning that better integrates safety into surface transportation projects. For example, Federal law requires that the State and metropolitan transportation planning processes be consistent with Strategic Highway Safety Plans.

The Federal Government has the capacity to stimulate improvements in infrastructure that maintain the resilience of the national economy, coordinate multi-state planning for emergencies, and protect and repair interconnected transportation systems. Recent extreme weather events such as hurricanes Katrina, Rita, and Sandy, the 2012 national drought, the recent California drought, and other natural disasters have demonstrated the disruptions and other costs that can result from inadequate investment in infrastructure supporting multiple transportation modes. In 2005, the damage

to transportation facilities caused by hurricanes Katrina and Rita totaled more than $1.1 billion, in addition to the costs to repair the I-10 Twin Span Bridge as well as repair and replace rail lines, pipelines, ports, waterways, and airports (Transportation Research Board 2008). In 2012, Hurricane Sandy flooded roads, subways, airport runways, marine terminals, and railroad tracks in New York and New Jersey, illustrating the widespread and cascading effects of disasters and justifying a Federal response for assistance and coordination. The costs associated with these extreme events include prolonged disruption of transportation systems, substantial capital damage, suppressed economic activity, and even loss of life.

The Federal Government contributes to infrastructure investment through direct expenditures and with incentives indirectly provided through the tax system, sometimes referred to as tax expenditures. The direct expenditures are spending on infrastructure (such as funding of dams and water resources) and grants and loan subsidies to states for transportation projects. States and localities have operational control over how the money is spent, though they must comply with certain conditions to receive Federal funding. The Federal Government subsidizes the issuance of municipal bonds by offering tax preferences that lower the cost of debt for transportation projects. State and local governments typically finance infrastructure projects with tax-preferred bonds, which are repaid with general tax receipts or from revenues collected from users of the infrastructure project. Public infrastructure investments by the private sector may also be eligible for tax-preferred financing through Private Activity Bonds if 95 percent or more of the bond proceeds are used for surface transportation or other qualified projects. State and local governments typically determine whether to provide private financing for public infrastructure investments in their jurisdictions. Federal funding and financing programs for transportation infrastructure are discussed below.

Federal Grants

One avenue through which the Federal Government has funded infrastructure investment is the Transportation Investment Generating Economic Recovery (TIGER) discretionary grant program, which was initially created as part of the 2009 American Recovery and Reinvestment Act to fund highway, transit, rail, port, and other surface transportation projects subsequently funded through annual appropriations. The TIGER program developed a merit-based competitive approach for local project sponsors to obtain Federal funds, where projects are evaluated based on the extent to which they promote the strategic goals of maintaining the Nation's economic competitiveness, ensuring environmental sustainability, improving

the livability of communities, making transportation safer, and maintaining infrastructure in a state of good repair. A Government Accountability Office (2014) review of 20 projects from 2009 to 2012 showed that about half of the total construction costs for TIGER projects were funded by non-Federal sources with sizable contributions from counties, cities, and other local agencies. Notably, every dollar invested through the TIGER program generated an estimated co-investment of 3.5 dollars, highlighting the effectiveness of the program.

The TIGER grants promote a merit-based competitive approach to directing Federal investment in transportation infrastructure. The TIGER eligibility requirements allow funding for multi-modal, multi-jurisdictional projects along with port and freight rail projects, all of which may have limited access to Federal funds. TIGER can provide capital funding directly to any public entity, including municipalities, counties, port authorities, and tribal governments, in contrast to traditional Federal transportation programs that provide funding primarily to State departments of transportation and public transit agencies. A survey of state experiences with the TIGER grant program showed that the opportunity to utilize long-standing Federal expertise in planning transportation investments allowed many states to find new and innovative ways to speed up project delivery. The TIGER program has been heavily oversubscribed with a 20:1 ratio of requests to available funding, reflecting a large demand for high-quality infrastructure projects across the country.

Federal Lending and Loan Guarantees

The Transportation Infrastructure Finance and Innovation Act (TIFIA) lending program assists State and local governments in financing infrastructure projects, such as toll roads, that are supported by user fees. Created in 1998 as part of the Transportation Equity Act for the 21st Century, the program has authorized approximately $3 billion of Federal funds to cover $22 billion of loans. The program's fundamental goal is to leverage Federal funds by attracting private and non-federal co-investment in surface transportation infrastructure projects, such as highways, bridges, intercity passenger rails, certain types of freight rail, and public transit. TIFIA requires that two-thirds of project costs come from State, local, or private sources. Borrowers benefit from improved access to capital markets and can potentially achieve earlier completion of large-scale, capital intensive projects. The program has become increasingly popular since its inception and was relied on widely during the financial crisis (Altman, Klein, and Krueger 2015). The FAST Act (discussed below) reduced TIFIA's annual authority from $1 billion to an average of $287 million a year.

Tax-Exempt Bonds

Transportation infrastructure projects provide a long-term stream of benefits and, with appropriate fee structures, can generate revenues for repayment over time from users of the projects. Construction of these projects is often financed through borrowing by State and local governments. Municipal bonds are issued by States and localities to finance a broad spectrum of public infrastructure, including roads, bridges, airports, utility systems, schools, and a limited number of private sector activities. The Federal government subsidizes the issuance of municipal bonds by offering tax exemptions and other preferences that lower the cost of issuing debt for these projects.

Tax-exempt bonds, which pay interest to bondholders that is not subject to Federal income taxes, are the dominant and most well-established type of tax-preferred debt, dating from the beginning of the Federal income tax in 1913 (CBO 2009). Purchasers of this debt are willing to accept a lower interest rate compared to rates offered on taxable debt of comparable risk and maturity. Infrastructure project development is stimulated when States and localities can readily access low-cost financing, and tax-exempt bonds reduce the borrowing costs they incur, thus encouraging infrastructure development. When State and local governments issue bonds, they retain control over capital projects, so priorities for infrastructure projects and decisions on the value and timing of tax-exempt debt issues are made by State and local governments. These entities repay all principal and interest on such debt, while the Federal government effectively contributes a smaller portion by foregoing tax revenue it would otherwise collect.

From 2004 through 2013, the amount of tax-preferred debt issued to finance new infrastructure projects initiated by the public and private sectors totaled $2.02 trillion.[13] About 73 percent, or approximately $1.5 trillion, was used by States and localities. Private capital investments to fund projects with a public purpose such as hospitals or housing accounted for the remainder (about $542 billion).

After falling substantially during the Great Recession, the amount of new tax-exempt debt issued each year has rebounded considerably. Since 2010, long-term government bond issues have grown at a rate of 15.2 percent, driven primarily by two factors. First, the demand for debt financing reflects expanded investment in public infrastructure projects. Second, the steady decline in interest rates charged to municipal borrowers has provided cheaper options for borrowers to finance capital spending by issuing debt.

[13] CEA calculations drawn from Tax-Exempt Bond Statistics data through the Internal Revenue Service. The bond issuance data cover long-term maturity debt (13 months or more), which is generally used to finance construction or other capital improvement projects.

Transportation bonds accounted for a major share—nearly 18 percent—of governmental obligations issued to finance new investment in infrastructure from 2010 to 2013. Excluding housing—which accounts for less than 1 percent of tax-exempt government bonds—transportation has been the fastest-growing use of tax-exempt government bonds, rising on average just over 28 percent a year since 2010.

Build America Bonds

Another way the Federal government has provided resources for infrastructure recently is through the Build America Bonds (BABs) program. BABs, introduced as part of the American Recovery and Reinvestment Act, were designed to encourage State and local governments to invest in economically critical infrastructure projects. State and local governments were authorized to issue special taxable bonds that received either a 35-percent direct federal subsidy to the borrower (Direct Payment BABs) or a Federal tax credit worth 35 percent of the interest owed to investors (Tax Credit BABs). BABs broadened the pool of investors and eased the supply pressure in the municipal bond market while bringing down borrowing costs.

Through the BABs program, the U.S. Department of the Treasury was able to harness the efficiencies of the taxable debt market, resulting in lower average borrowing costs for States and localities. State and local governments were able to obtain cheaper financing (averaging about 54 basis points) than through the regular municipal bond market (Ang, Bhansali, and Xing 2010). On a present value basis, BAB issuers saved an estimated $20 billion in borrowing costs compared to traditional tax-exempt municipal debt (U.S. Department of the Treasury 2011). This savings was considerably greater than the net cost to the Federal Government from the BABs program. The program lasted roughly 20 months, and 2,275 separate BABs amounting to $181 billion were issued by State and local governments across all 50 states, the District of Columbia, and two territories. Unlike other infrastructure programs, BABs were not divided equally across states but were distributed on the basis of the demand for new infrastructure by states and localities. The result was that the 100 largest metropolitan areas accounted for nearly half of all funding for BABs issuances.

The BABs program was successful in spurring investment in economically critical infrastructure projects across the country and stimulated job-intensive projects. From 2009 through the program's expiration in 2010, BABs financed a third of all new State and local government long-term debt issuances.

Recent Legislation

In December 2015, President Barack Obama signed into law the Fixing America's Surface Transportation (FAST) Act, which authorized roughly $306 billion in spending for highways, transit, rail, and safety over the next five years. While the FAST Act offered important benefits by increasing transportation funding and providing greater certainty on funding over the coming years, it fell short of the level of investment needed to fully modernize U.S. infrastructure and the $478 billion that the Administration proposed as part of its GROW AMERICA proposal. Of that approved spending, approximately $226 billion has been designated for highways and approximately $61 billion for transit projects. Based on CEA assumptions about the future rates of inflation, these dollar amounts translate to increases in investment of about 4 percent for highways and 7 percent for transit in real terms. The law also reauthorized the collection of Federal taxes on gasoline and other fuels, which are frequently used to fund transportation projects and raise approximately $35 billion in revenues annually—with most of the tax revenue stemming from gasoline (18.4 cents per gallon) and diesel fuels (24.4 cents per gallon).

The FAST Act established new Federal grant programs, expanded current programs, and furthered initiatives to improve safety and innovation. The Act established the Nationally Significant Freight and Highway Projects competitive grant program aimed to support economically beneficial projects that will facilitate improved freight movement. This $4.5 billion discretionary grant program will be complemented by $6.3 billion in Federal-aid formula funding for states to invest directly into projects that contribute to the efficient movement of goods. The FAST Act also established the Federal-State Partnership for State of Good Repair grant program to improve critical passenger rail assets for which maintenance had been deferred as well as the Consolidated Rail Infrastructure and Safety Improvements program to support rail projects more generally.

The Act expanded State eligibility for Federal lending through TIFIA and the Railroad Rehabilitation Improvement and Financing programs. The application processes for these programs will be consolidated into the Surface Transportation Innovative Finance Bureau within the Office of the Secretary of Transportation, another FAST Act creation, which will strengthen the programs through streamlined review and transparent approval processes. The Innovative Finance Bureau will also help to promote public-private partnership procurements of large-scale infrastructure projects through expanded technical assistance. The Act established a formula freight program, to be administered by the Federal Highway Administration, which will fund critical transportation projects that would

Box 6-4: 21st Century Clean Transportation Plan

The President's fiscal year 2017 budget proposes a 21st Century Clean Transportation Plan that expands investments in clean transportation infrastructure by 50 percent above current levels in nominal terms. The 21st Century Clean Transportation Plan consists of four components designed to put America on a long-term course to reduce reliance on oil, cut carbon pollution, and strengthen resilience to the adverse impacts of climate change. The initiative aims to transform our transportation system using targeted Federal investments, to stimulate State and local innovations in smarter, cleaner, and regional transportation systems, to accelerate the adoption of low-carbon technologies, autonomous vehicles, and intelligent transportation systems, and to provide funding to maintain and increase the safety of our transportation systems as they evolve.

Innovative methods to reduce congestion, manage sprawl, and improve air quality while providing affordable access to jobs are essential as the United States experiences continued population growth in mid-sized and large urban areas. The program will distribute capital funds to expand transit systems in cities, suburbs, and rural areas, and make high-speed rail a viable alternative to flying in major regional corridors. Other targeted investments include funding to invest in new rail technologies, modernize the Nation's freight system, and expand support for the TIGER competitive grant program for innovative local road, rail, transit, and port projects.

A second component of the initiative will assist State and local governments to develop smarter and cleaner regional transportation systems. The plan provides incentives for State and local governments to maximize the returns on public investments and deliver more efficient results by reforming existing transportation formula funding. The initiative creates a Climate Smart Fund to reward states that leverage Federal funding to cut carbon pollution and improve efficiency in the transportation sector.

The plan advances specific proposals to promote the adoption of low-carbon, cost-competitive intelligent transportation systems. Working with State and local governments and leveraging public-private partnerships, the initiative sets the goal that all Americans have access to at least one alternative transportation fuel by 2020, including electric vehicle charging, advanced biofuel fuel pumps, and others low-carbon options.

benefit freight movements. The Act also provided funds to improve transportation safety by supporting projects that will alleviate highway congestion, reduce accidents, and improve rail safety.

Included in the President's fiscal year 2017 budget is a proposal, discussed in Box 6-4, to expand the development of clean transportation infrastructure.

Conclusion

As discussed throughout this chapter, infrastructure investment is important for the economy. At its core, strengthening our Nation's transportation infrastructure improves economic opportunities for both households and businesses, and supports the interconnectivity of individuals, firms, and regions. In the long run, investing in infrastructure boosts the economy's productivity and thus spurs output growth. Reliable infrastructure facilitates the efficient exchange of goods, labor, and innovative ideas. From the Erie Canal in the early 1800s to the Transcontinental Railroad in the 1860s, to the Interstate Highway System in the 1950s and 1960s, previous generations of Americans have made these investments, and they were instrumental in putting the country on a path for sustained economic growth.

By 2040, our population is expected to increase by more than 60 million people, and continued investment in infrastructure is essential to increasing productivity and spurring continued economic growth. Improvements in infrastructure provide more capital to the economy, thereby increasing labor productivity, reducing congestion and time lost in traffic, and enhancing market efficiency. Workers benefit from reduced commuting times, making it easier for them to move between jobs and expanding labor force opportunities. Businesses are able to manage their inventories more efficiently and transport goods faster and more cheaply, helping them to access new suppliers and markets. Concentrated investment in infrastructure may even draw market participants together and build new cooperative efficiencies, magnifying the resulting productivity gains. By making these investments in a smart way, we can make our transportation system both more efficient and more climate friendly.

Investing in U.S. infrastructure boosts both short-run demand and long-run supply. The former generates new economic activity by increasing employment and workers' earnings. The longer-run effect stems from increased productivity in the use of labor, private capital, and other resources, thus allowing opportunities for both consumers and businesses to flourish. Sufficient infrastructure, especially that supporting transportation, is a fundamental underpinning of continued economic prosperity. Whether

it is flying across the country, shipping goods across state borders, or simply commuting to work each day, households and firms alike depend on adequate infrastructure. As our economy strives to increase investment and productivity, public spending on infrastructure can play an important role.