CATCHING UP

GREATER FOCUS NEEDED TO ACHIEVE A MORE COMPETITIVE INFRASTRUCTURE

INFORUM REPORT TO THE NATIONAL ASSOCIATION OF MANUFACTURERS / SEPTEMBER 2014

NATIONAL ASSOCIATION OF Manufacturers

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Glossary[1]

Capital Investment: The acquisition of goods that are used to produce other goods and services. They are used repeatedly in the production process. Also called capital goods and physical capital.

Capital Stock: The supply of goods (structures and equipment) that have been produced and are used repeatedly to produce other goods and services. Capital stocks are the accumulation of past investment activities, minus depreciation of capital due to wear and obsolescence.

Disposable Income: The total income received by households that can be used for consumption and saving. The income remaining after taxes is removed, and government benefits, such as social security and unemployment compensation, are added.

Gross Domestic Product (GDP): Nominal GDP is a measure of the dollar market value of all final goods and services produced in an economy in a given year; real GDP is a measure of the quantity of all final goods and services produced. Real GDP is calculated as nominal GDP divided by an index of the GDP price level to remove the effect of inflation. Potential GDP is the maximum sustainable amount of goods and services that the economy can produce, measured in nominal or real terms.

Gross Output: The amount of goods and services produced by an industry. Nominal gross output is a measure of the dollar value of goods and services produced by an industry; real gross output is a measure of the quantity of goods and services produced. Real gross output is calculated as nominal output divided by the average prices of the goods and services produced.

Inflation: A rise in the general or average price level of goods and services produced in an economy. GDP price inflation refers to general price growth for all goods and services in the economy. Inflation also may describe the growth of average prices for particular goods and services.

Infrastructure: The basic capital foundation needed by an economy, composed of buildings and facilities, such as roads, bridges and waste disposal systems that support activities such as transportation, communication and energy delivery.

Input-Output (I-O): An accounting framework that shows the relationships between the industries in the economy and all of the commodities that these industries produce and use.

Investment: The acquisition of physical capital goods and infrastructure (e.g., buildings, tools and equipment) used to produce other goods and services. Nominal investment is the dollar value of expenditures for physical capital goods and infrastructure; real investment is a measure of the quantities of acquired physical capital goods. Real investment is calculated as nominal investment divided by the average price for the investment type.

Operation and Maintenance: The performance of routine, preventive, scheduled and unscheduled actions intended to prevent failure or decline with the goal of increasing efficiency, reliability and safety.

Potential GDP: The maximum sustainable amount of goods and services that the economy can produce. Potential GDP may be measured in nominal (dollar) terms or in real (quantity) terms.

[1] Definitions were adapted from the following glossary sources: Federal Reserve Bank of St. Louis (**www.stlouisfed.org/education_resources/glossary**), U.S. Department of Commerce, Bureau of Economic Analysis (**www.bea.gov/glossary/glossary.cfm**), Economic Glossary (**glossary.econguru.com**), *The Economist* (**www.economist.com/economics-a-to-z**), econedlink (**www.econedlink.org/economic-resources/glossary.php**) and the U.S. Environmental Protection Agency (**www.epa.gov/oaintrnt/glossary.htm**).

Catching Up:

Greater Focus Needed to Achieve a More Competitive Infrastructure

September 2014

Executive Summary

Modern economic growth and development depends on high-quality infrastructure. There is no getting around it. However, what, exactly, does that involve? Infrastructure spans a wide range of public and private assets, including highways and bridges, airports, ports and inland waterways, electricity plants and transmission lines, information and telecommunication networks and water and sewage facilities. Such assets are indispensable for facilitating production across various industries — not least of which include agriculture, energy, mining and, in particular, manufacturing. The ability to safely and efficiently move goods from a manufacturing facility to a customer located far away is crucial to the industry's long-term health and global competitiveness. In other capital-intensive industries, such as telecommunications and electricity distribution, infrastructure plays an equally important role. Beyond the manufacturing industry, basic infrastructure also underlies the daily occupational and recreational activities of U.S. households. Our energy, mobility, information and travel capabilities all depend on safe, accessible and reliable infrastructure.

Unfortunately, recent data concerning U.S. public- and private-sector spending indicates a decline in real investment spending for many types of infrastructure. Real or "constant-price" investment is the purchase of structures and equipment by government entities and private companies, where dollar amounts have been adjusted for inflation. It, therefore, is an indication of the physical volume of infrastructure installed in each year. The decline goes beyond the recent recession and includes a period that stretches over the past decade. Consumers are cognizant of delays and congestion problems along urban corridors and airport runways. Others experience breakdowns in water supply and sewage because much of the nation's drinking water and wastewater infrastructure is rapidly aging. Even private infrastructure is not immune from underinvestment. However, most notably and noticeably deficient is the state of the nation's streets and highways. Costs in time, wasted fuel and vehicle maintenance continue to grow annually. According to the Texas A&M Transportation Institute's *2012 Annual Urban Mobility Report*, the cost of congestion has escalated to $121 billion, or $818 per commuter. Trucks moving freight along the nation's roads and highways bear a significant cost of that congestion — $27 billion is derived from wasted time and diesel fuel.[2]

Quantifiable evidence exists to support public concern over the current state of U.S. infrastructure. Every four years, the American Society of Civil Engineers (ASCE) conducts a national assessment of conditions and investment needs for major types of infrastructure, including roads, bridges, water systems, ports, mass transit and the electricity grid. According to the ASCE, the nation's infrastructure is failing. Few of the systems garner even a "C" grade, and the overall grade in 2013 was a "D+," up from a "D" in 2009.[3]

This report provides a historical accounting of infrastructure investment and offers a "whole picture" assessment that is important to the well-being and growth of the manufacturing economy. The report provides new evidence on the state of private-sector infrastructure and offers additional data concerning the deteriorating state of U.S. public infrastructure. Findings include the following:

- Recent trends in private sector infrastructure investment reflect a mixed performance. Freight rail and electric utilities have experienced steady and strong investment over the past decade. On the other end, capital investment in the communications and private water supply and wastewater industries would have been more robust if it were not for a protracted recession, a slow recovery and uncertainties in the regulatory environment. The burgeoning pipeline industry requires new investments and the regulatory certainty that would come from successful approval and construction of the Keystone XL pipeline.

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[2] Texas A&M Transportation Institute (2013). *2012 Annual Urban Mobility Report.* Retrieved from **http://mobility.tamu.edu/ums**.

[3] American Society of Civil Engineers (2013). *Report Card for America's Infrastructure*. Retrieved from **www.infrastructurereportcard.org**.

- The average annual growth of real GDP and real public infrastructure spending over two intervals—1956-2003 and 2004-2012—is shown in Figure E-1. In the almost 50 years through 2003, infrastructure investment rose, albeit at an average rate of about 1 percent lower than GDP growth. Over the past nine years, GDP has grown more slowly on average. Perhaps not coincidently, real infrastructure spending has contracted sharply by more than 1 percent per year during this period, and this investment expenditure has lagged GDP growth by a whopping three percentage points on average.

- Early in the decade, a sharp escalation of construction prices eroded effective investment because each dollar of federal and state funding purchased relatively less infrastructure capital. Then, as the recession took hold in December 2007, public spending contracted in nominal terms, especially at the state and local level. Although construction inflation fell from previous highs and the federal government provided an infrastructure stimulus through the American Recovery and Reinvestment Act, the volume of investment spending continued to decrease. In total, the volume of public infrastructure investment was 10.5 percent lower in 2012 compared to 2003, and available data indicate it has fallen further since then.

- Expenditure details for the major categories of public infrastructure are shown in Table E-1, reflecting real spending levels from 2003–2012. Five types of expenditures concern transportation: highways and roads, mass transit, rail, aviation and ports and inland waterways. The remaining two types concern water infrastructure: water resources and water supply and waste disposal. In contrast to most of the preceding 45 years, the volume of investment in almost all of the public infrastructure categories contracted significantly from 2003 through 2012—disturbingly so for highways and roads. The level of real investment in highways and roads was almost 20 percent lower in 2012 compared to 2003.

- A resulting effect is the inability to gain ground in improving the nation's infrastructure base. Therefore, it is not just a matter of restoring growth to infrastructure budgets to reverse the decade-long decline. Current approaches to funding, financing, building and maintaining infrastructure do not create the opportunity to catch up on a backlog of deferred projects that states and localities have been unable to complete. Patterns noted in this report provide further economic evidence consistent with the engineering analysis of the ASCE as well as the competitiveness analysis of the World Economic Forum,[4] the global manufacturing competitiveness analysis of Deloitte and the U.S. Council on Competitiveness[5] and a survey of U.S. manufacturing executives released in 2013.[6]

- To make up for the almost decade-long decline in infrastructure capital spending, a more focused and results-driven effort that expands and sustains higher levels of investment from all public and private infrastructure sources would have positive short- and long-term economic returns. In the short run, investment in infrastructure stimulates aggregate demand that increases economic activity and creates jobs through direct, indirect and induced demand impacts.[7] However, the long-term benefits of infrastructure spending are even more significant and durable. Improvement of roads, highways and bridges, for instance, would boost industrial competitiveness in proportion to the industry's use of trucking services and other ground transport infrastructure. Manufacturers that depend heavily on trucking for receiving supplies and delivering products would benefit the most from this boost to competitiveness. In turn, cost savings would be passed on to customers, both at home and abroad.

- This study leverages available historical data and previous work concerning the economic costs of degraded infrastructure as it considers how an increase in public infrastructure investments would affect economic performance. The Inforum analysis uses the LIFT model of the U.S. economy to show how infrastructure investments above current funding levels will help to recover nearly a decade of underinvestment in infrastructure, enable higher growth, improve trade performance, expand employment opportunities and enhance the real value of household incomes.[8]

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[4] Schwab, K., and X. Sala-i-Martín (2012). *The Global Competitiveness Report 2012–2013.* Geneva: World Economic Forum. Retrieved from **www.weforum.org/gcr**.

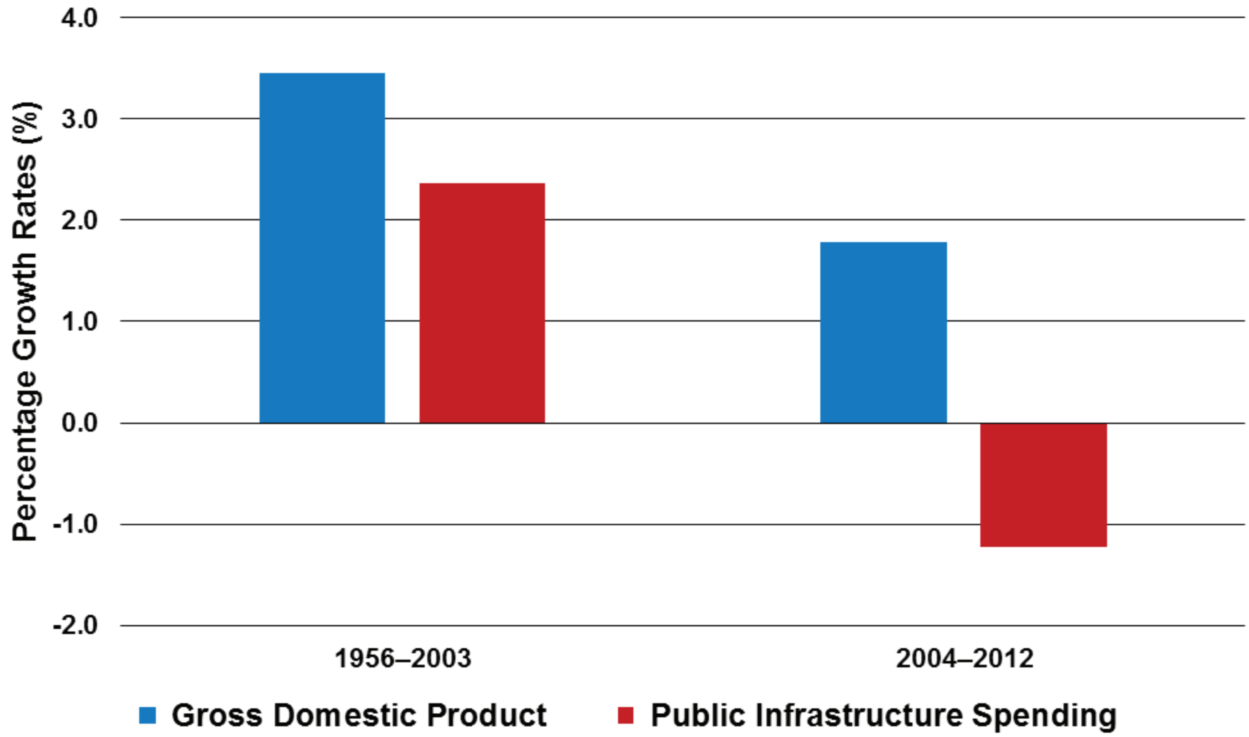
[5] Deloitte and the U.S. Council on Competitiveness (2013). 2013 Global Manufacturing Competitiveness Index. Retrieved from **www.deloitte.com/view/en_US/us/Industries/Process-Industrial-Products/manufacturing-competitiveness/mfg-competitiveness-index/index.htm**.

[6] National Association of Manufacturers and Building America's Future Educational Fund (2013). *U.S. Manufacturers on Vital National Infrastructure.* Retrieved from **www.nam.org/~/media/BB5F7CB7B89349BA9ADA575663AAF499.ashx**.

[7] Congressional Budget Office (2014).

[8] The LIFT model is a dynamic general equilibrium representation of the U.S. national economy. It combines an inter-industry input-output formulation with extensive use of regression analysis to employ a "bottom-up" approach to macroeconomic modeling. In this way, the model works like the actual economy, building the macroeconomic totals from details of industrial activity, rather than by distributing predetermined macroeconomic quantities among industries. More information about the LIFT model may be found at **www.inforum.umd.edu**.

Figure E-1: Real Public Infrastructure Expenditures, Average Annual Percentage Growth



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

Table E-1. Real Public Infrastructure Expenditures, 2003–2012

	Billions of 2012$	Billions of 2012$	Average Annual Percentage Growth	Cumulative Percentage Change
	2003	2012	2003–2012	2003–2012
Real Gross Domestic Product	**13,724.40**	**16,244.60**	**1.7**	**18.4**
Public Infrastructure Spending	**423.87**	**379.19**	**-1.2**	**-10.5**
Highways and Streets	193.22	155.98	-2.4	-19.3
Mass Transit	61.43	58.57	-0.5	-4.7
Rail	1.73	1.78	0.3	3.1
Aviation	42.57	36.89	-1.6	-13.4
Ports and Inland Waterways	11.73	9.58	-2.3	-18.3
Water Resources	11.08	11.42	0.3	3.1
Water Supply and Waste Disposal	102.37	104.97	0.3	2.5

Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

More specifically, the modeling exercise contemplates more robust funding levels for different sectors of public infrastructure during a 17-year period spanning from 2014 to 2030. Recently, the ASCE published a series of reports, titled *Failure to Act: The Impact of Current Investment on America's Economic Future,* that identified the industry and macroeconomic costs of degraded infrastructure (American Society of Civil Engineers, 2012).[9] In these reports, the ASCE compiled and synthesized a large volume of data on the conditions, costs and investment requirements of U.S. infrastructure. The reports estimated that, compared to current investment trends and projections, bringing public infrastructure up to minimum standards would require *an additional expenditure* of well more than $125 billion (2010 dollars) from 2012 to 2020 and more than $175 billion per year from 2021 to 2040.[10]

The modeling exercise in this report prepared for the NAM contemplates a less ambitious addition to investment of about $83 billion in constant 2009 dollars (about $100 billion per year in today's dollars).[11] This enhancement is about 0.6 percent of GDP. Increasing infrastructure formation by these amounts in the LIFT model illustrates how such enhanced investment can generate substantial long-term economic returns that significantly exceed their costs. A sustained multiyear investment boost for public infrastructure could be derived from a combination of funding sources—federal, state and local governments as well as the private sector. Indeed, all sources responsible for supplying funding for public infrastructure would be required to make more significant commitments in this modeling scenario. Compared to a baseline forecast that assumes continued and relatively low levels of public infrastructure investment, the report finds the following:

- In the short term, enhancing the level of infrastructure investments would boost jobs by almost 1.3 million by 2015 and 1.7 million by 2017. This number would fall over time as the productivity effects of better infrastructure take hold. As a result, the economy would improve significantly. By 2020, the level of real GDP would rise about 1.3 percent, and by 2030, 2.9 percent. Over the long term, competitiveness, output and employment across industries would be enhanced largely due to the productivity effects of better infrastructure. Increased productivity would be largely responsible for the higher GDP, but so would higher labor participation within a more dynamic economy.

- The resulting increase in household disposable income is the best indicator of the net welfare gain. The enhanced infrastructure spending raises real disposable income, providing gains of 1.2 percent by 2015 and 3.4 percent by 2030. In this case, net of investment and after taxes, improvements to all types of infrastructure would imply a net gain in real income of $1,300 per household by 2020 and $4,400 per household by 2030, measured in 2009 dollars.

- Sustained infrastructure spending creates a progressively more productive economy. Because of cumulative effects through time, by 2030 infrastructure investments would produce economy-wide returns of close to $3 per every $1 invested.

- Enhanced economic growth from increased infrastructure investments would ultimately provide greater government revenue levels, which would help to recover the costs of higher public investment spending.

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[9] The ASCE reports covered ground transportation infrastructure (including rail); water and sewer facilities; airports, waterways and inland and marine ports; and energy transmission and distribution. Detailed reports for each of the infrastructure systems are provided by the ASCE at **www.asce.org/failuretoact**.

[10] This report reflects figures in 2010 dollars, as published in the ASCE reports. See Table 2 in the referenced report, **www.asce.org/uploadedFiles/Infrastructure/Failure_to_Act/Failure_to_Act_Report.pdf**.

[11] The analysis in this report uses 2009 constant dollars to be consistent with the infrastructure data, the National Income and Product (GDP) Accounts and the LIFT model. The difference between 2009 and 2010 dollars is about 1 percent, depending on the concept in question.

Outlook

As multiple sectors of public infrastructure show signs of aging and decay with no solutions in sight, we are at an appropriate juncture to consider a highly focused infrastructure effort designed to improve safety, increase competitiveness and improve economic throughput. Accelerated private- and public-sector efforts to develop infrastructure, including a significant supply of new spending, allows the pursuit of three economic objectives at once:

1. New funding will help the United States catch up from a well-documented backlog of deferred infrastructure projects that have accumulated over the past 10 years, including maintenance, repair and new capacity. Many of the critical problems already are identified. It is urgent to take immediate action on long-standing and stalled projects.

2. A new national infrastructure strategy that embraces proven innovations in finance and regulatory reform as well as construction and operational efficiencies can help to lower operating costs, increase profitability, mitigate logistical challenges, attract economic development and provide a catalyst for businesses to invest in new expansion and growth.

3. Greater infrastructure investment will improve an economy that continues to suffer from high unemployment and lackluster growth.

The necessity of new investment does not mean we should persist with the same old models. Experts continue to have interesting and important discussions concerning critical reforms and innovative approaches to investing, funding, delivering and operating infrastructure. We highlight four significant themes emanating from these discussions:

1. The allocation of scarce capital can be tied more effectively to an evaluation of net social benefits, with better coordination across infrastructure systems and better reliance on systematic economic analysis.

2. Economic and environmental evaluation processes need to continue to be streamlined and made more efficient. This imperative applies to private infrastructure investment as well as to public projects.

3. Pricing mechanisms in appropriate scenarios can encourage users to make more efficient use of infrastructure when they reflect the costs of its use. The revenue generated can be reserved to finance capacity enhancements.

4. Through cooperative arrangements with government agencies, the private sector can play a greater role in the design, financing, construction and operation and maintenance of infrastructure resources.

Widespread access to high-quality infrastructure is indispensable to the United States' economic development and standard of living. A more focused and outcomes-driven infrastructure effort is needed, and new ideas can and should accompany any increase in investment. Strong support exists within the business and manufacturing communities for building a more competitive, nationwide infrastructure network. This report, prepared for the National Association of Manufacturers (NAM), reinforces the value of such action.

Catching Up:

Greater Focus Needed to Achieve a More Competitive Infrastructure[12]

September 2014

1. Introduction

The World Economic Forum (WEF) publishes rankings of competitiveness and the state of infrastructure for 144 countries (Schwab and Sala-i-Martín, 2012). In 2012–2013, the United States was ranked seventh overall in competitiveness, trailing mainly northern European nations and Singapore. Its ability to supply basic requirements, such as infrastructure, was lower, at 14th among nations, and its infrastructure quality ranked 25th. Roads, railroads and ports faired similarly, with rankings of 20, 18 and 19, respectively. Aviation infrastructure lagged with a ranking of 30. As our trading-partner nations continue to develop modern, efficient and well-maintained infrastructure systems, the United States will face growing competitive pressures. Despite currently strong competitiveness in general, deficient infrastructure will make it increasingly difficult for domestic firms and workers to compete.

The WEF describes infrastructure as the second of 12 pillars of competitiveness. "Extensive and efficient infrastructure is critical for ensuring the effective functioning of the economy, as it is an important factor in determining the location of economic activity and the kinds of activities or sectors that can develop in a particular instance" (Schwab and Sala-i-Martín, 2012).

In the United States, infrastructure investment is both a private and public-sector activity. Table 1-1 contains figures for 2012 showing the public- and private-dollar levels of investment for each type of public infrastructure. Total expenditures in the year exceeded $291 billion with the public sector contributing about $181 billion and the private sector about $110 billion, as displayed in Table 1-1. Transportation infrastructure claimed more than half of the investment at $154 billion, and investment in non-transportation infrastructure was $137 billion. The public sector provides the majority of highways, streets and roads as well as passenger rail and mass transit systems. It also provides investment and management for aviation as well as water ports and inland waterways. The private sector is the primary source of investment for freight rail infrastructure and oil and natural gas pipelines. For non-transportation infrastructure, the public sectors play the primary role in the provision of drinking water and wastewater treatment and water resources as well as a minor role in electric power. Private entities supply most of the electric power facilities and virtually all communications systems.

[12] This research was performed at Inforum at the University of Maryland with the support of the NAM. The authors are Jeffrey Werling and Ronald Horst. Questions may be directed to **werling@econ.umd.edu** or (301) 405-4607. More information about Inforum may be found at **www.inforum.umd.edu**.

Table 1-1. Public and Private Infrastructure Capital Investment, 2012 (in Billions of Dollars)

Infrastructure	Public – Federal	Public – State and Local	Total Public	Total Private	Total
Highways and Streets	43.9	44.5	88.4	0.6	89.0
Mass Transit	9.1	9.5	18.7	0.0	18.7
Rail	1.0	0.0	1.0	9.5	10.4
Aviation	5.8	9.3	15.2	1.0	16.2
Ports and Inland Waterways	1.3	2.4	3.7	0.0	3.7
Pipelines	–	–	–	16.3	16.3
Total Transportation	61.2	65.8	126.9	27.5	154.5
Water Resources	6.4	0.0	6.4	–	6.4
Water Supply and Waste Disposal	4.4	33.2	37.6	2.2	39.7
Electrical Energy	0.9	9.5	10.4	62.8	73.2
Communications	–	–	–	17.3	17.3
Total Utilities and Other	11.7	42.7	54.4	82.3	136.7
Total Infrastructure Spending	72.9	108.5	181.3	109.8	291.2

Notes: Public spending figures are measured in fiscal years ending September 30. Private spending figures are measured in calendar years.

Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

This report provides a historical accounting of infrastructure investment by both the private and public sectors and offers a "whole picture" assessment that is important to the manufacturing economy. This perspective provides new evidence on the state of private-sector infrastructure and offers additional data concerning the deteriorating state of U.S. public infrastructure. In particular, it finds that when accounting for the high relative inflation for infrastructure costs, the volume of infrastructure investment in many private and all public infrastructure categories has fallen for more than a decade. This substantial and durable contraction is consistent with other information, and data warning that ailing infrastructure will become a substantial problem for the economy.

Leveraging the historical data and some previous work on the economic costs of degraded infrastructure, this report considers the implications of future investments on economic performance. We examine four major types of public infrastructure systems: surface transportation (including passenger rail and transit), aviation, marine and inland water transportation and water supply and wastewater systems. In particular, we use the LIFT model of the U.S. economy to show how a boost to public infrastructure investment will enable higher growth, improve trade performance, broaden employment opportunities and enhance the real value of household incomes.[13] Such benefits come through two channels: a short-run demand boost and a long-term supply improvement.[14] In the short run, investment in infrastructure stimulates aggregate demand that will increase activity and create jobs through direct, indirect and induced demand impacts. Because of its inter-industry (input-output) structure, the LIFT model is able to trace all three types of demand across detailed industries.

The longer-run benefits of infrastructure spending are more significant and more durable. Improvement of roads, highways and bridges, for instance, will boost industry competitiveness in proportion to their use by trucking services and other ground transportation infrastructure. Manufacturers that depend heavily on trucking for receiving supplies and delivering products will benefit the most, and their competitiveness will be enhanced. In turn, cost savings are passed on to consumers, both at home and abroad. Competitiveness is advanced, and households realize higher incomes. Using LIFT model simulations, we illustrate this cascade of benefits assuming higher levels of expenditures for highways, mass transit, aviation, ports and inland waterways and water and wastewater facilities. The study projects these impacts to 2030. Results presented in this report show gains for real GDP, disposable consumer income and exports at the macroeconomic level, along with a summary of industrial impacts. These findings confirm that the nation faces an important opportunity not only to increase jobs and income in the short run but also to greatly improve the performance of the economy in the long run through a more focused infrastructure investment effort.

The following four chapters of this report examine the historical spending patterns in detail to provide context for the current public debate on the necessity of additional infrastructure spending. First, we provide an overview of infrastructure spending, tracing its history in proportion to the overall economy. Following that macroeconomic assessment, we review historical spending

[13] For a detailed description, see Section 7-2. The LIFT Model of the U.S. Economy.

[14] See, for example, Leduc and Wilson (2012).

patterns and provide a brief review of private infrastructure investment. Then, we look at public infrastructure and review the trends of overall spending, investment and capital stocks and expansion of public infrastructure in proportion to the economy. Finally, we turn to the modeling analysis to show the potential effects of infrastructure investment over the next two decades. In conclusion, we consider some policy implications concerning the development and maintenance of public infrastructure.

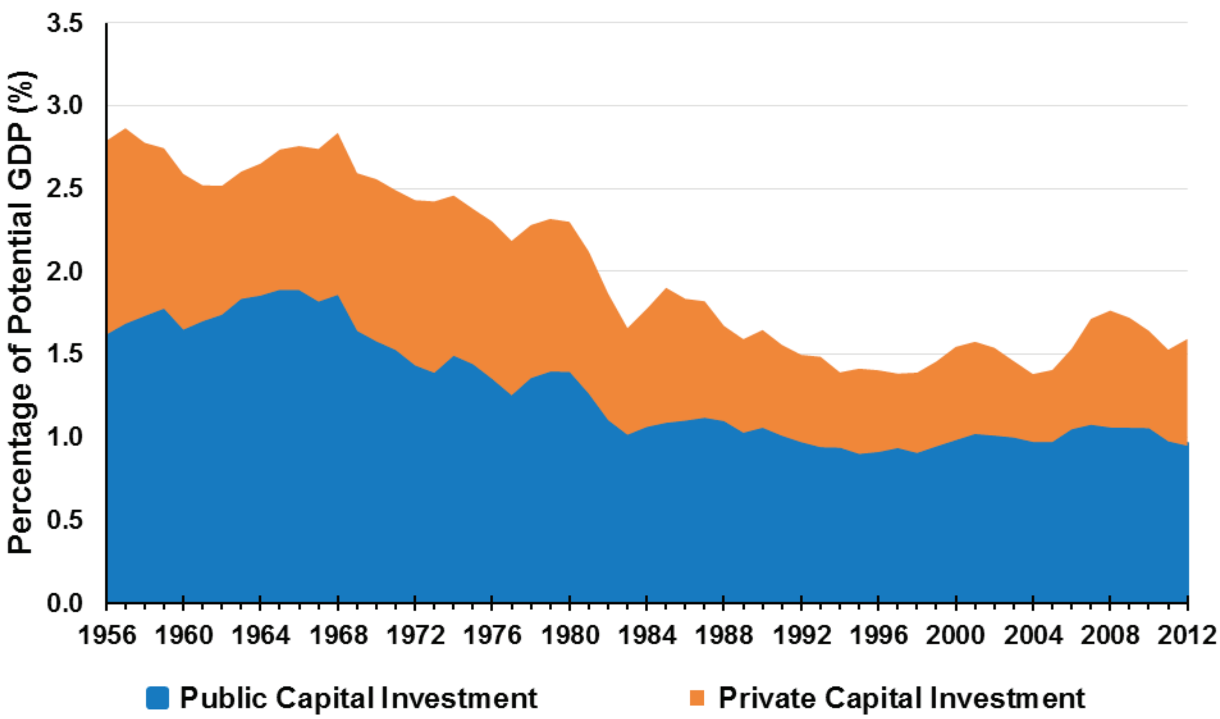
2. Macroeconomic Overview—Infrastructure Spending in Context

Essentially all economic activity depends on infrastructure. A growing economy, therefore, tends to require greater quantities and improving quality of transportation systems, water resources and other basic capital resources. Consistent failure to invest sufficient resources to develop and maintain these assets, measured in proportion to overall economic activity levels, would suggest that future growth may be harmed and that the economy already could be suffering consequences of underinvestment.

This study reveals that real infrastructure spending has been on a decade-long decline. This section provides evidence that when measured in proportion to GDP, the downward trajectory of infrastructure investment becomes even more stark and worrisome. Infrastructure investment has been falling short of overall economic growth, not only as a consequence of the recession, but also over a much longer period. Figure 2-1 shows how these quantities have evolved through time as a percentage of potential GDP.[15] In current dollar terms, infrastructure investment now is about 1.5 percent of GDP compared to a peak of nearly 3 percent in the late 1960s. Public infrastructure investment is now about 1 percent of potential GDP compared to close to 2 percent at the peak, and private infrastructure investment now is about 0.5 percent of GDP compared to previous rates of close to 1 percent.

Is there evidence that the current proportion is too low? Some decline in the investment ratio might be expected considering that the economy has become more intensive in service production and somewhat less intensive in infrastructure use. The trends revealed in Figure 2-1 can be misleading, however, because they fail to show the full extent of the decline in infrastructure investment activity in proportion to the economy. To properly evaluate the volume of infrastructure assets installed through time, this report adjusts the dollar expenditures for infrastructure price inflation.

Figure 2-1. Nominal Infrastructure Investment as Percentage of Nominal Potential GDP

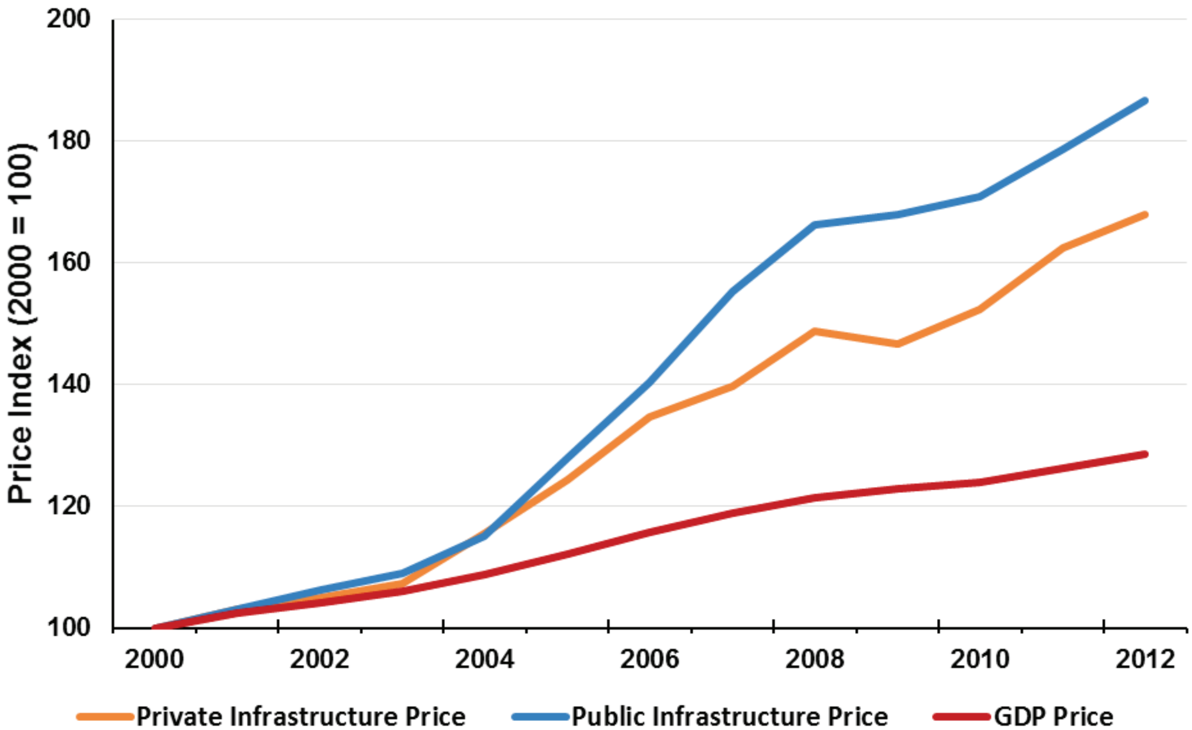


Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimate

15 According to the Congressional Budget Office (CBO), potential GDP is defined as the maximum sustainable amount of output that the economy can produce. The CBO publishes both nominal and real potential GDP. Since potential GDP is a good measure of the capacity of the economy, and because infrastructure itself is such an important component of economic capacity, we prefer to evaluate infrastructure spending in proportion to that capacity. This makes investment ratios less sensitive to the business cycle and, in particular, shows that the loss of infrastructure formation was particularly acute over the Great Recession.

Figure 2-2 displays the rise of infrastructure prices versus general inflation from 2000 to 2012. The cost of construction rose faster than prices in general because labor productivity growth in construction tended to be relatively slow. Other factors affected the inflation differential as well. Figure 2-2 clearly shows that rising costs for construction materials, energy and labor over the past decade as well as new standards and expectations for modern structures greatly accelerated relative construction costs. The highest inflation was at the height of the housing boom between 2004 and 2008. During that period, high costs eroded the infrastructure dollars spent by both private and public sectors. Even as overall infrastructure spending grew with the general economy, each dollar purchased lower quantities of infrastructure capital through time.

Figure 2-2. Growth of Infrastructure Investment Prices, 2000 = 100

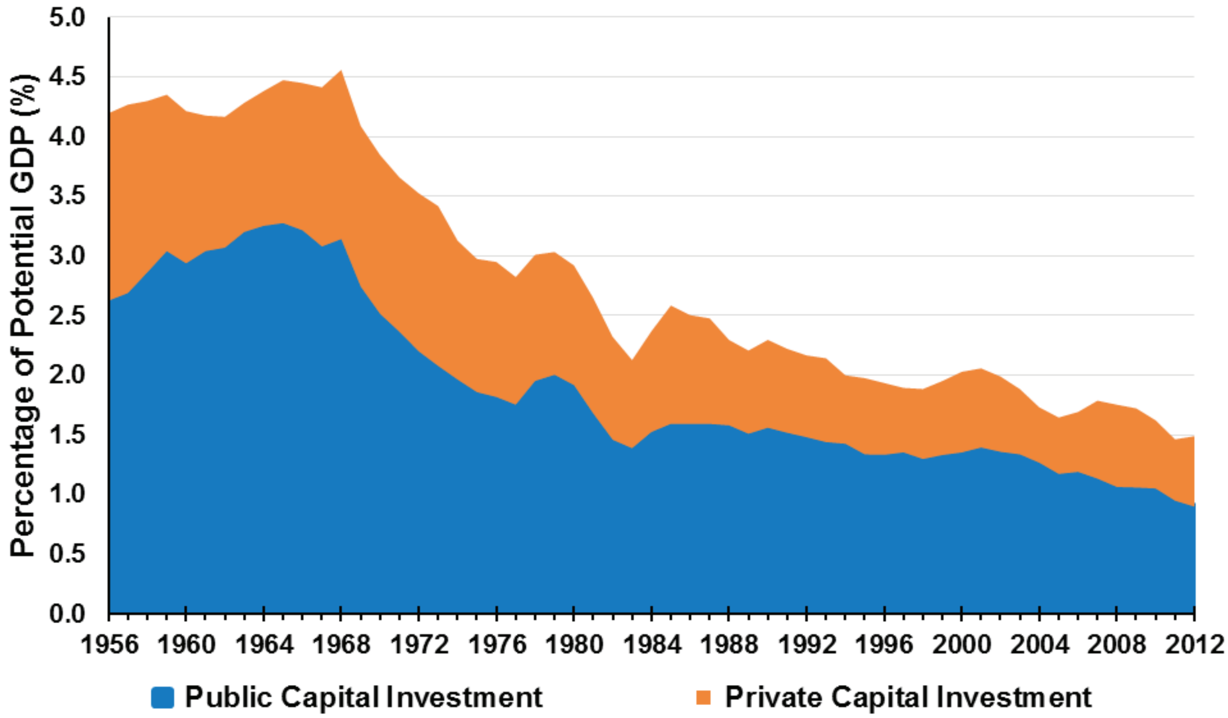


Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

The effect of this inflation is seen in Figure 2-3, which shows the ratio of infrastructure investment to potential GDP in real terms. After adjustment for higher relative construction inflation, the ratios for both private and public sectors fell more quickly over time. In particular, the ratio for public infrastructure has fallen rapidly since 2003. From then until 2008, the biggest cause was rising construction prices as explained above. From the start of the recession in 2008, public spending contracted, particularly at the state and local level. Therefore, the real volume of investment spending continued to fall through 2012 even though construction prices stabilized after a volatile decade. This pattern is particularly evident for the largest sector of infrastructure spending, public expenditures for highways and roads. These numbers suggest an economy “coasting” on the interstate highway system and other projects completed in decades past and a nation with little commitment to expanding the quality and quantity of infrastructure to prepare for future growth.

Policymakers and advocates concerned about the current state of infrastructure often emphasize the low investment spending levels as a percentage of GDP. This chapter showed that investment spending in dollar terms has been falling for several decades in proportion to nominal GDP. When measured in physical quantities (e.g., roads, bridges), investment in proportion to real economic activity levels has fallen even more quickly. The following chapters describe the historical data for private and public infrastructure investment and then illustrate how higher infrastructure investment levels can promote and sustain economic growth.

Figure 2-3. Real Infrastructure Investment as Percentage of Real Potential GDP



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

3. Private Infrastructure Investment

Table 3-1 provides a historical summary of private investment spending growth from 1956.[16] Since this report examines investment through time, the statistics in the table show the growth of real investment by type of infrastructure, where spending is adjusted for the inflation experienced in the corresponding category. To provide perspective, the table also includes the levels of spending for 2012 in billions of dollars. Among transportation systems, private spending was substantial for freight rail and pipelines in 2012. The private sector provides most electric power and nearly all communications infrastructure investment. Its role in providing drinking water systems is relatively small, but private entities have a significant role in purifying water and disposing of waste.

[16] Section 7-1 provides details on the nature of the data and their sources.

Table 3-1. Private-Sector Infrastructure Capital Investment in 2012

	$, Billions	% GDP	Average Annual Growth of Real Capital Investment			
			1956–1980	1980–2000	2000–2012	2007–2012
Gross Domestic Product	16,244.60	100.000%	3.5	3.3	1.7	0.8
Private Infrastructure Investment	**109.85**	**0.676%**	**1.8**	**1.1**	**1.2**	**-0.3**
Highways and Development	0.60	0.004%	7.6	1.0	-5.7	-15.8
Aviation Facilities	1.05	0.006%	2.2	6.6	-7.1	8.1
Rail	9.47	0.058%	0.0	-1.4	4.6	3.3
Mass Transit	0.05	–	0.0	0.0	2.2	12.3
Ports and Inland Waterways	0.03	–	2.7	4.8	-17.1	-43.8
Pipelines	16.34	0.101%	0.8	-1.6	3.1	0.1
Natural Gas	9.31	0.057%	0.4	-1.4	-0.1	-1.6
Petroleum	7.04	0.043%	2.8	-2.2	10.8	2.8
Water Supply, Sewage and Waste	2.18	0.013%	7.1	1.6	-5.5	-0.5
Water Supply	0.89	0.005%	7.0	2.5	-8.6	-7.2
Sewage and Waste Disposal	1.29	0.008%	7.2	0.5	-2.4	5.7
Electric Power	62.81	0.387%	1.8	1.0	4.1	4.2
Wind and Solar	30.29	0.186%	0.0	0.0	44.5	22.1
Other Electric	32.53	0.200%	1.8	0.9	-1.1	-4.1
Communications	17.31	0.107%	3.6	3.1	-5.2	-12.8

Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

For several categories, growth in private infrastructure investment has decelerated over the decades. From the late 1950s through the 1980s, average annual growth of real private spending was 1.8 percent, but growth over the next two decades slipped to 1.1 percent per year. Real spending growth was about the same—1.2 percent per year—between 2000 and 2012. A gradual downward trend would not be surprising given that the need for physical infrastructure per unit of economic output might fall through time as the general economy becomes more service intensive. Still, the recession has badly crimped investment spending. Between 2007 and 2012, real spending fell 0.3 percent per year. Moreover, investment across private infrastructure types has been uneven, and these patterns should be further reviewed by policymakers.

The data show not only that private investment is uneven but also that substantial differences exist among various sectors of infrastructure. On one hand, electric power and freight rail investment grew strongly from 2007 to 2012 at 4.2 percent and 3.3 percent per year, respectively. The nature of these sectors is changing rapidly, and access to private capital markets enables electric utilities and railroads to adapt to dynamic forces that continue to shape these industries.

On the other hand, the volume of water and wastewater investment from 2007 to 2012 fell by 0.5 percent per year, real pipeline spending grew only 0.1 percent annually, and communications structures investment declined by 12.8 percent per year. Pipeline construction is important for the energy boom and expanded far more quickly earlier in the decade. While electronic communications use has grown rapidly for more than a decade, there is plenty of room for further rapid expansion, and a continuation of low and volatile investment could reduce our ability to seize new domestic and foreign opportunities in high-tech venture.

The following sections examine investment in each major private infrastructure sector. In each case, we show the evolution of real investment through time and the level of real capital stock as calculated by the U.S. Bureau of Economic Analysis (BEA). The real capital stock is a comprehensive indicator of the quantity of the infrastructure in place. It is calculated as the accumulation of real investment spending, less depreciation of the assets according to the estimated depreciation patterns.

3-1. Aviation Facilities

The State of Aviation Infrastructure Investment and Stock

Air transportation infrastructure is composed of runways, taxiways, terminals and air traffic control centers. Most aviation infrastructure supporting scheduled airline service is owned and managed by federal, state and local governments as well as other quasi-public entities, though airlines own and develop private terminals at major airports. Private aviation investment often complements government-sponsored projects. While its participation is important, the private share of public air transportation infrastructure is small but holds the potential to expand greatly under the right set of circumstances and policies.

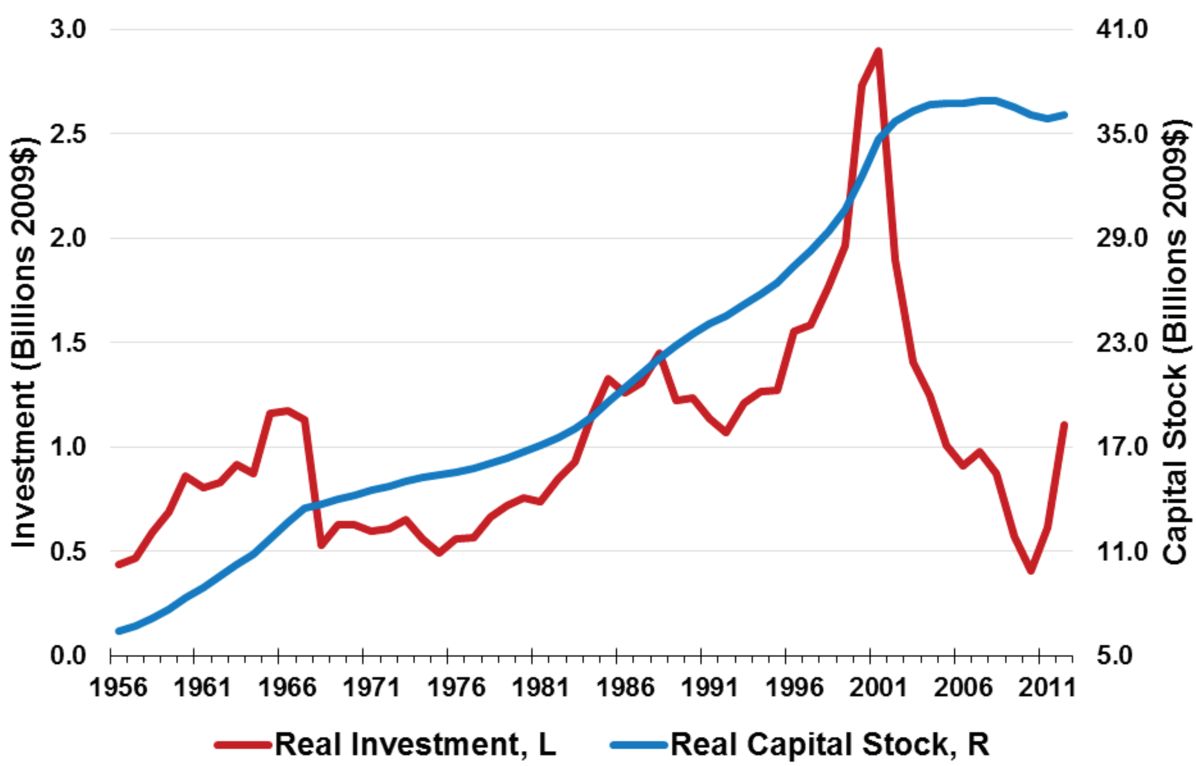
General aviation represents another segment of aviation that responds to a different set of demands than scheduled airline service. It relies heavily on a network of 2,952 landing facilities, known as general aviation airports, for a range of services and functions, including, but not limited to, emergency response, direct transportation services of people and freight and other types commercial operations, including land surveying, energy exploration and agriculture. According to a 2012 Federal Aviation Administration (FAA) study on general aviation airports, nonairline operators at these airports spent more than $12 billion, flying an estimated 27 million flights, while the federal government invested $1.1 billion to help states and localities maintain and improve these airports (Federal Aviation Administration, May 2012).

Figure 3-1 shows the pattern of investment spending and capital asset levels for privately owned aviation facilities. Investment grew strongly between 1996 and 2001, reaching a peak in 2001 of $2.9 billion, measured in 2009 dollars. After the terrorist attacks on September 11, 2001, real private investment plunged for a decade until slightly recovering in 2011 and 2012. Spending remains 62 percent below the previous peak. Because of low investment, the real capital stock of private aviation assets has changed little in the past decade.

Prospects for Aviation Infrastructure Investment

For the private aviation infrastructure detailed above, real private investment is dependent on an economy that is on solid footing and a regulatory climate that supports scheduled airline passenger and freight services as well as general aviation.

Figure 3-1. Private Aviation Facilities Investment and Capital Stock (in Billions of 2009 Dollars)



Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

While historically private aviation infrastructure spending mostly has been an add-on to public investment, the private aviation industry should be afforded opportunities to take a stronger role in this sector of infrastructure. The needs are great and the ability of federal, state and local governments to make financial commitments is uncertain. In 2007, the FAA reported that additional capacity will be needed at many leading airports by 2025 (The MITRE Corporation, May 2007). While that report did not provide an estimate of the cost of improvements, the Airports Council International-North America projected that U.S. airports have annual capital investment needs of $14.3 billion for the period 2013–2017, significantly higher than what is likely to be available (Airports Council International-North America, January 2013).

While revenues eventually will revive with economic growth, the needs of our aviation infrastructure are extensive. In addition, the FAA is charged with building the $37 billion Next Generation Air Transportation System (NextGen) for air traffic modernization. However, NextGen, a satellite-based system, and all its components require critical levels of public- and private-sector investment that have not fully materialized to its maximum potential. The federal government is an important player in aviation infrastructure, but budget pressures will continue to limit federal expenditures for these programs, and there is much more room for the private sector to bring its expertise and resources to the fore.

3-2. Private Freight Rail Infrastructure

The Importance of Freight Rail

Railroads are a vital mode for freight transportation in the United States. Table 3-2 shows the variety and extent of this transport. Freight rail handles significant amounts of bulk commodities, such as coal, chemicals, grain and other food products, and nonmetallic minerals. It also plays a key role in the transportation of shipping containers and other goods. For example, motor vehicles and other merchandise imported from abroad often are shipped by train from marine or inland ports to distribution centers deep inside the nation. From those points, they are shipped to retailers on trucks. Many Americans are not aware that this innovative and efficient multimodal system delivers a great deal of their purchased goods, from food to furniture.

Table 3-2. Freight Rail Cargo by Product, 2012

	Tons Originated		Gross Revenue [1/]	
	Thousand	% of Total	$, Millions	% of Total
Coal	721,567	41.0	14,717	21.6
Chemicals and Allied Products	173,344	9.9	9,216	13.5
Farm Products	139,398	7.9	5,309	7.8
Non-metallic Minerals	130,084	7.4	2,646	3.9
Misc. Mixed Shipments [2/]	111,796	6.4	8,803	12.9
Food and Kindred Products	101,402	5.8	5,413	8.0
Metallic Ores	75,350	4.3	748	1.1
Metals and Products	51,329	2.9	2,730	4.0
Petroleum and Coke	44,277	2.5	2,289	3.4
Stone, Clay and Glass Products	43,664	2.5	1,725	2.5
Waste and Scrap Materials	41,581	2.4	1,284	1.9
Pulp, Paper and Allied Products	31,928	1.8	2,181	3.2
Lumber and Wood Products	25,581	1.5	1,582	2.3
Motor Vehicles and Equipment	19,134	1.1	4,877	7.2
All Other Commodities	49,279	2.8	4,546	6.7
Total	**1,759,715**	**100.0**	**68,067**	**100.0**

Source: Association of American Railroads

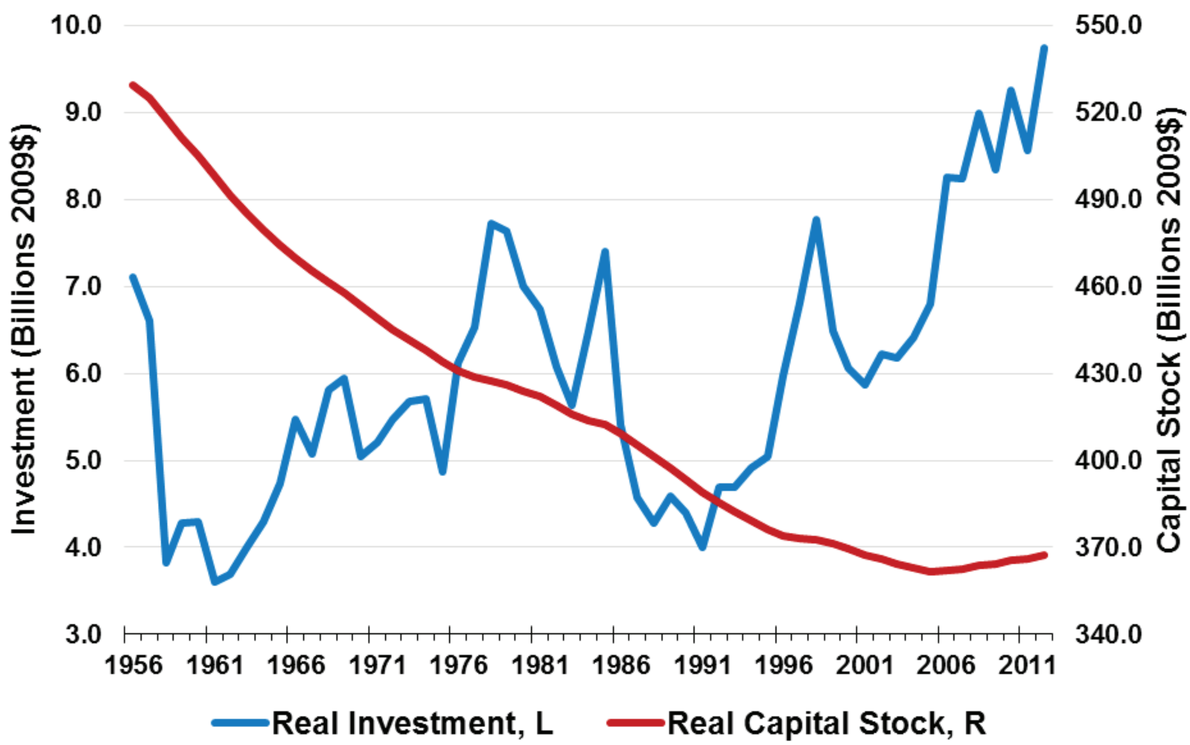
[1/] *Gross revenue is not adjusted for absorption (incentive rebates, etc.) or corrections.*

[2/] *Miscellaneous mixed shipments mostly is intermodal container traffic.*

The State of Freight Rail Infrastructure Investment and Stock

Freight rail infrastructure (i.e., tracks, signals, bridges, tunnels, terminals and service facilities) contributes about 15 percent of total private infrastructure. Figure 3-2 shows private rail investment and the real capital stock from 1956 to 2012. For many decades into the early 1990s, the private rail industry reduced investment levels. Since 1992, however, private-sector investment in freight rail infrastructure has grown steadily despite some volatility. By 2000, real investment reached levels last seen in the 1980s. More recently, investment in 2012 registered an impressive 12 percent jump from 2011, to more than $9 billion in 2009 dollars. Despite the recession, since 2006, the private rail industry expanded its stock of real capital assets for the first time in many decades.

Figure 3-2. Private Freight Rail Investment and Capital Stock (in Billions of 2009 Dollars)



Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

Railroads are becoming increasingly important both as energy-efficient freight haulers and for intercity passenger service. Amtrak relies heavily on privately owned tracks and other facilities, and it experienced record passenger traffic in 2012 with 31.2 million passengers, nearly double the demand seen in 2000. “Both freight and passenger rail have been investing heavily in their tracks, bridges and tunnels as well as adding new capacity for freight and passengers. In 2010 alone, freight railroads renewed the rails on more than 3,100 miles of railroad track, equivalent to going coast to coast. Since 2009, capital investment from both freight and passenger railroads has exceeded $75 billion, actually increasing investment during the recession when materials prices were lower and trains ran less frequently” (American Society of Civil Engineers, 2013b).

Prospects for Freight Rail Infrastructure Investment

Prospects for freight rail infrastructure investment depend on demand, current system capacity, expansion costs and regulatory policies. As shown in Table 3-2, coal shipments currently account for the most rail ton-miles, reaching about 41 percent of total weight and 22 percent of gross revenue in 2012 (Cambridge Systematics, Inc., September 2007). Coal is produced in relatively few states, but consumption is dispersed across the country and in export markets overseas. This dispersion is made possible by extensive coal transportation systems, led by railroads. According to the Energy Information Administration (EIA), in 2012, 70 percent of U.S. coal shipments were delivered to their final domestic destinations by rail.

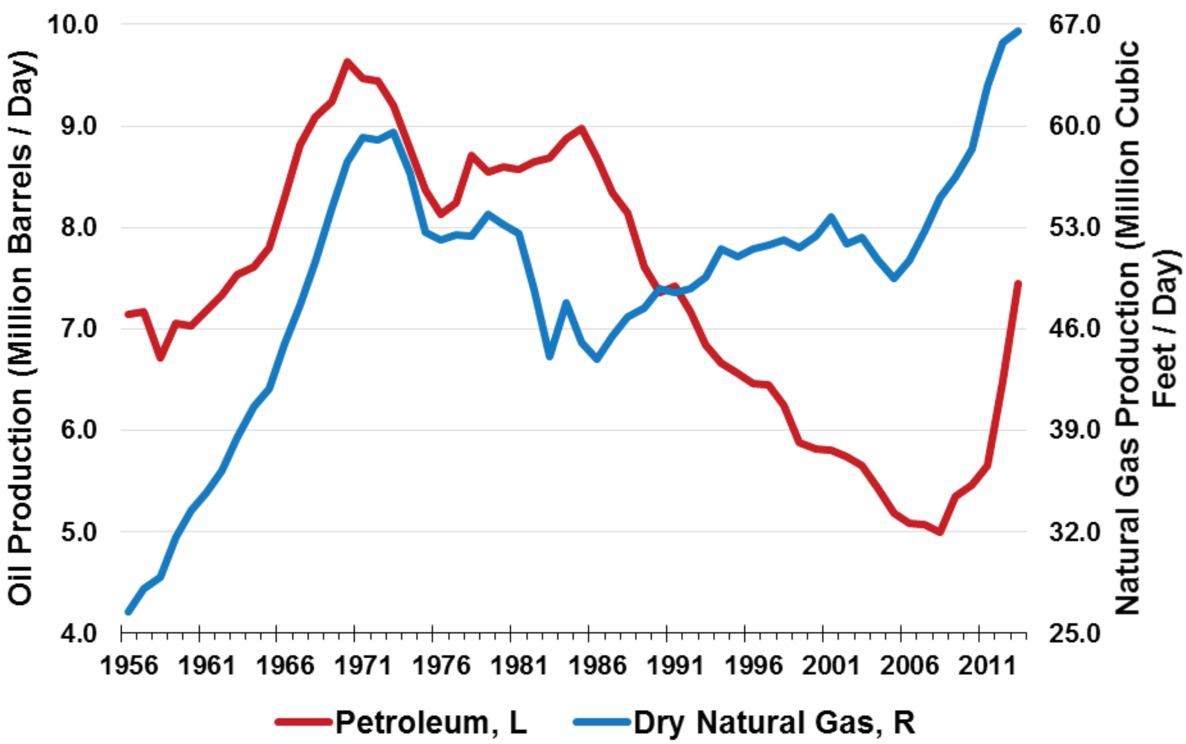
Despite the changing market conditions for coal, transportation demand from other commodities should continue to expand. The U.S. Department of Transportation (DOT) estimates that freight rail transportation demand in 2040 will be more than 50 percent greater than in 2011.[17] Projected growth is not extraordinary, but it follows two decades of freight tonnage growth that has absorbed much of the excess capacity in the existing freight rail system.[18] Meeting expected demand will require freight railroads to keep up investment in infrastructure.

3-3. Petroleum and Natural Gas Pipelines

The State of Pipeline Infrastructure Investment and Stock

Domestic oil and gas production increased dramatically over the past five years, largely thanks to advances in unconventional oil and gas production methods. The combination of horizontal drilling and hydraulic fracturing technologies enable oil and gas companies to tap large new sources of oil and gas that are held in shale and other tight geological formations. As a result, domestic oil production jumped nearly 50 percent, from 5 million barrels per day (mbpd) in 2008 to 7.5 mbpd in 20 (See Figure 3-3). Natural gas production surged 21.4 percent, from 55.1 billion cubic feet per day (bcfpd) in 2008 to 66.5 bcfpd in 2013.[19] The United States now is the global growth leader in crude oil production capacity, and it has become the largest natural gas producer.

Figure 3-3. U.S. Oil and Natural Gas Production



Source: U.S. Energy Information Administration

Unfortunately, the pipeline system has not kept up with this expansion. Figure 3-4 shows that pipeline investment has a volatile history. Investment declined in the 1990s and early 2000s but surged starting in 2007, spurred by unconventional oil and gas production activities. For the period 2007–2012, real investment averaged $14.7 billion per year in 2009 dollars, about 57.0 percent above the 2001–2006 average of $9.3 billion per year.

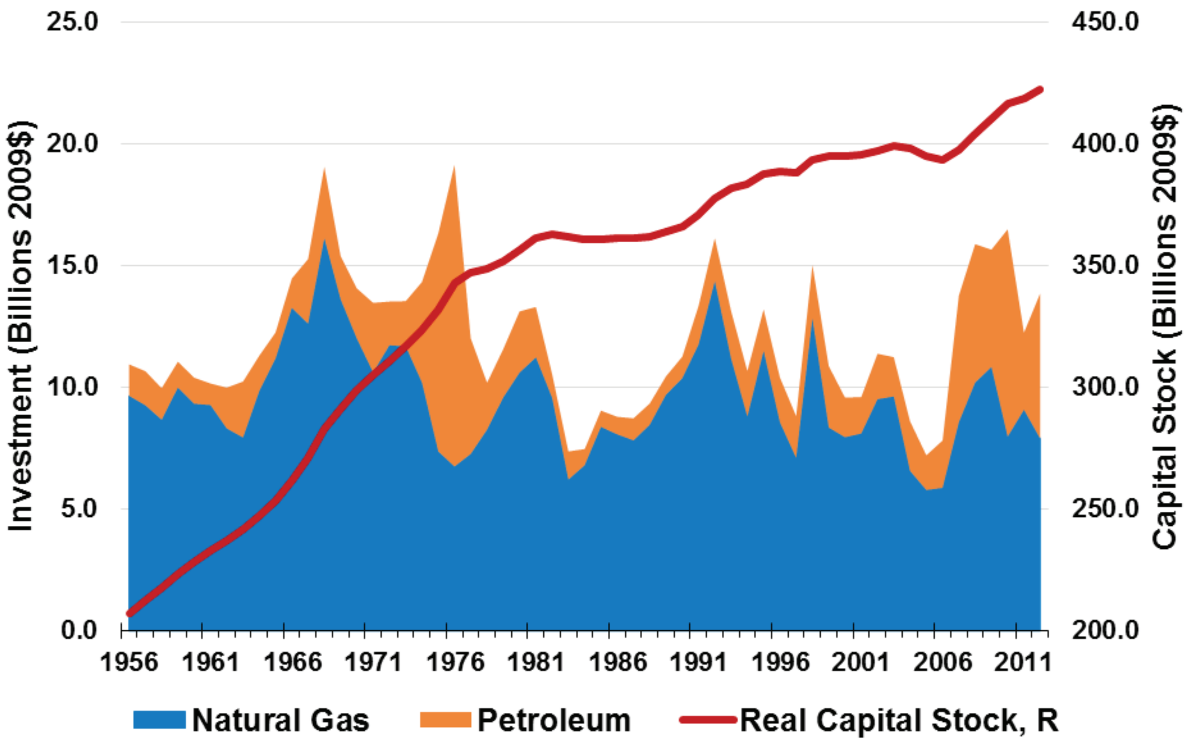
[17] The Freight Analysis Framework currently provides projections through 2040. More information is available at **www.ops.fhwa.dot.gov/freight/freight_analysis/faf**.

[18] See Cambridge Systematics, Inc. (September 2007, p. 5-5, Figure 5.4).

[19] Oil and natural gas production levels were published by the EIA: **www.eia.gov**.

Figure 3-4 shows that this robust investment has increased the real stock of pipelines since 2007, but the recent construction is fundamentally different from earlier pipeline investments. Previous pipeline configurations rested upon the presumption that the United States would import an ever-increasing percentage of its energy needs in the form of crude oil, refined products, natural gas liquids and liquefied natural gas (LNG). The major crude oil pipeline investments made during the late 1970s and early 1980s largely were designed to move crude oil from the coastal regions to the midcontinent where crude oil production was declining.

Figure 3-4. Private Pipelines Investment and Capital Stock (in Billions of 2009 Dollars)



Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

A similar trend emerged in the early 2000s in the natural gas segment. Increasing natural gas use for electricity production and expected domestic natural gas production declines prompted the construction of LNG regasification plants to facilitate imports. As many of these facilities neared completion, the full potential of the U.S. shale gas resource became clear, and utilization of these plants has been less than expected.

The sharp rise in shale oil and gas production changes the energy flows and pipeline requirements. Initially, unconventional production primarily increased the supply of natural gas, and early development largely focused on natural gas gathering systems, natural gas interstate pipelines and natural gas storage. More recently, the development of shale basins in the southeast United States spawned a boom in transmission pipeline construction in that part of the country. A second phase of infrastructure investment centers on the prolific production from the Marcellus shale development. The BEA figures show that natural gas pipeline investment largely held up from 2010 to 2013 (shown in Figure 3-4), despite low natural gas prices across the United States.

A continued expansion of petroleum and natural gas pipeline investment is needed if the nation is to realize the full benefit of the energy revolution. Starting with the original Keystone XL pipeline commissioned in 2010 and the reversal of several other existing pipelines, a substantial reshaping of domestic crude oil flow patterns is underway (IHS Global Insight, December 2013).

Prospects for Pipeline Investment

Most industry experts expect both oil and natural gas production growth to continue, with production peaks not likely until 2019 and 2023, respectively (IHS Global Insight, December 2013). A lack of petroleum and natural gas pipelines already hampers growth in energy production. Rising production coupled with the reshaping of flows should continue to spur pipeline investment.

The forecast of oil and gas gathering, processing, refining, pipeline and storage infrastructure investment over the next 12 years (2014 to 2025) shows cumulative spending of $890 billion (in 2012 dollars), with crude oil and natural gas gathering systems and direct production support facilities receiving 60 percent of total investment (IHS Global Insight, December 2013). Pipelines and related infrastructure will remain the primary mover of oil and gas, despite a recent shift toward the use of rail and water. As major pipeline corridors and projects are completed, the efficiency and economics of long-distance pipeline movements will leave rail and water transportation less competitive.

The approval process for new pipelines often is slow, with the recent difficulties for the TransCanada Keystone XL pipeline as a prime example. If built, the 1,700 new miles of pipeline will take Canadian tar sands oil from Alberta to the Gulf Coast. It would pass through the booming Bakken Shale region of Montana and North Dakota and provide transportation for some of the crude oil produced there.

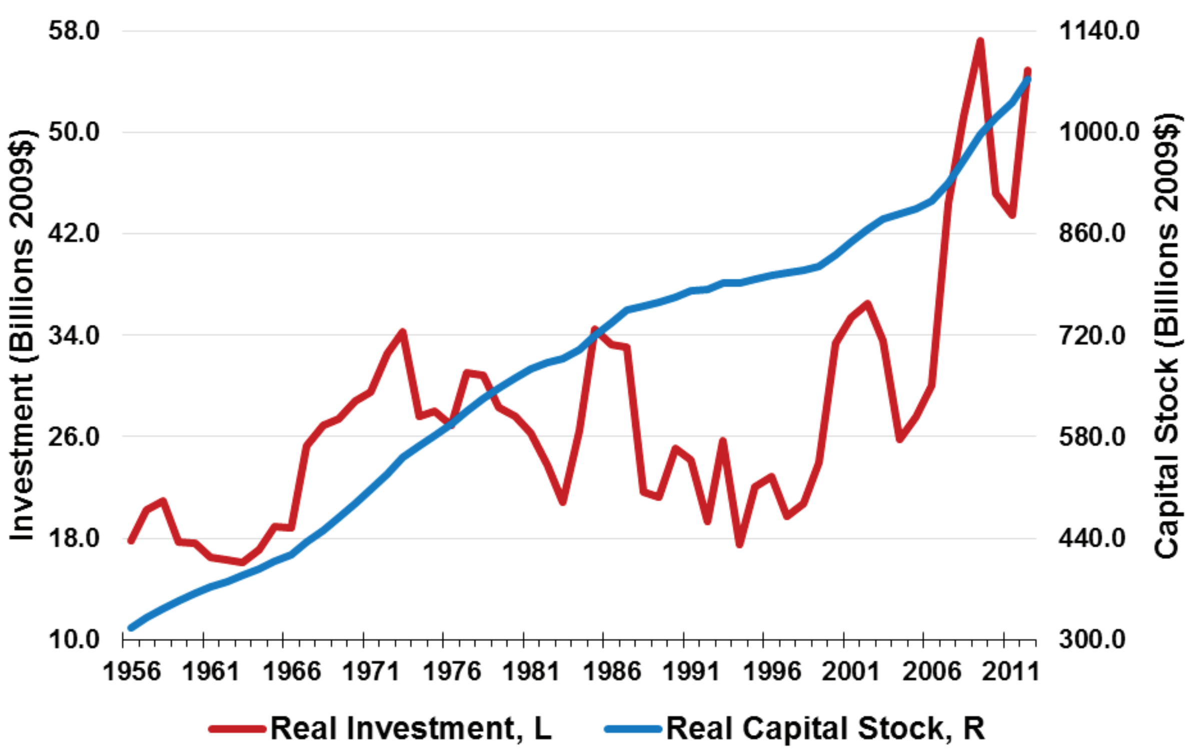
TransCanada has been attempting to get a permit for Keystone for more than five years. Because the Obama Administration rejected the original request for a permit to pipe tar sands crude from Alberta to Texas, TransCanada officials are planning to build the project incrementally. The northern segment, from Alberta to Texas, again has been submitted for approval at the U.S. federal level.

3-4. Electric Power

The State of Electric Power Infrastructure Investment and Stock

Despite the recession and weak recovery, private electric power infrastructure investment rose dramatically from 2007 to 2012. Even after adjusting for inflation, real investment averaged $49.4 billion per year between 2007 and 2012, in 2009 dollars, a 57 percent increase above the prior six-year average (see Figure 3-5). Wind and solar investment led the expansion, as they are driven at least partly by state renewable portfolio standards (RPS)[20] and federal renewable fuels standards and tax credits.

Figure 3-5. Electric Power Investment and Capital Stock (in Billions of 2009 Dollars)



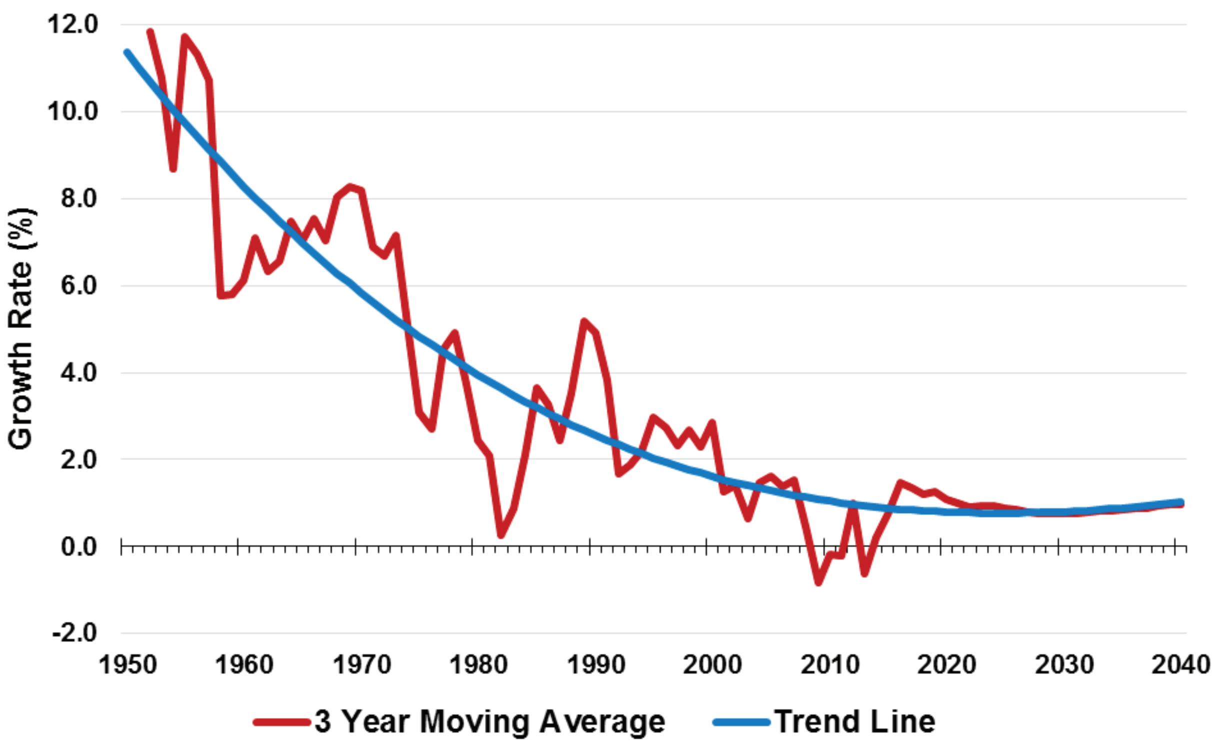
Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

[20] RPS, also called renewable electricity standards (RES), are policies designed to increase generation of electricity from renewable resources. These policies require or encourage electricity producers within a given jurisdiction to supply a certain minimum share of their electricity from designated renewable resources. Such resources generally include wind, solar, geothermal, biomass and some types of hydroelectricity, but also may include other resources, such as landfill gas, municipal solid waste and tidal energy.

Prospects for Electric Power Investment

Figure 3-6 shows that electricity demand growth slowed each decade since the 1950s, from 9.8 percent per year in the 1950s to 0.7 percent per year in the first decade of the 21st century. The EIA forecasts similarly low long-term electricity demand growth, as increasing economic growth is offset by efficiency gains from new appliance standards and investment in energy-efficient equipment and structures (Energy Information Administration, May 7, 2014). Still, the electricity demand forecast shows growth of almost 1.0 percent per year between 2011 and 2040, and so generating capacity will need to continue to grow.

Figure 3-6. Electricity Consumption, Percentage of Growth Rates



Source: U.S. Energy Information Administration

Because the mix of electricity-generation technologies will be changing—due to market dynamics, state renewable electricity and energy-efficiency laws and federal environmental regulations—older and less efficient power sources will be phased out earlier than originally intended, creating a need for new investment. As an example, the EIA forecasts that U.S. Environmental Protection Agency (EPA) regulations will force early retirement of 60 gigawatts (GW) of coal-fired capacity over the next five years, representing 20.0 percent of coal-fired electricity generation (March 10, 2014). Finally, because many renewable sources of electricity tend to be smaller scale and distributed across the countryside, investments in modern and reliable electricity transmission assets are required as soon as possible.[21]

3-5. Communication

The State of Communication Infrastructure Investment and Stock

Communication infrastructure is the backbone of the information and technology sector that is transforming much of the economy and consumer activities. Access to broadband communications provides increased opportunities to advance technology, innovation, investment and job creation. The system is built with copper cable, fiber and wireless technologies. The infrastructure connects upstream production, such as voice, data and audiovisual services, to downstream consumers.[22]

Voice services traditionally have been the main component of telecommunications companies, representing about 80 percent of the end-market and using mostly fixed telephone networks. However, mobile phones are the main component of the voice

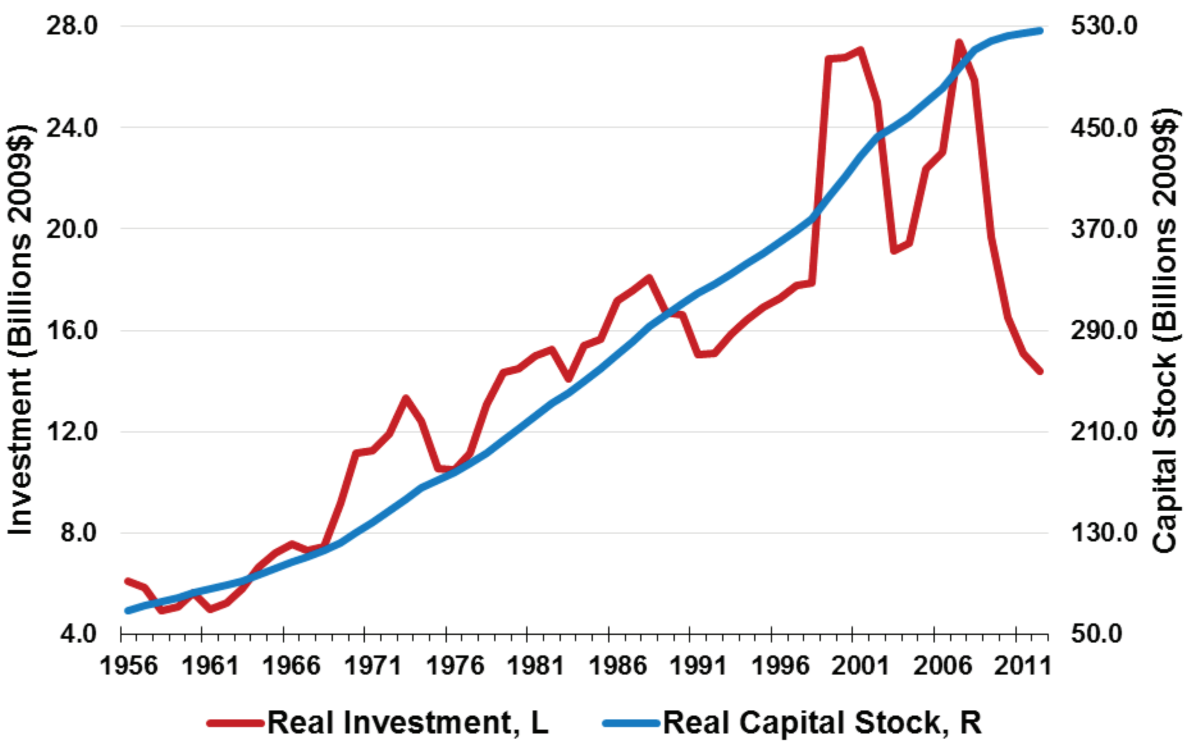
[21] Renewables include conventional hydroelectric, geothermal, solar, wind power, wood, wood waste, all municipal waste, landfill gas and other biomass.

[22] The International Encyclopedia of Communication, available at **www.communicationencyclopedia.com**.

market now, Voice over Internet Protocol (VoIP) services are soaring, and these changes have boosted new data, video and TV entertainment services.

Increasing demand, technological advances and changing regulation have spurred communication infrastructure investment. Despite volatility, real investment followed a clear upward trend between 1956 and 2007, as shown in Figure 3-7. The Telecommunications Act of 1996 encouraged robust competition by removing the protection of franchised monopolies that kept competitors out of the wire line telephony and cable markets. Real communication infrastructure investment surged between 1999 and 2002, averaging $26.4 billion per year in 2009 dollars, up 59 percent from the annual average of $16.6 billion between 1989 and 1998. After a sharp decline, the next surge came in 2007 and 2008 with real investment expenditures focused on fiber optics, 3G wireless and satellite technologies. The fall in communications investment since then has been dramatic. Much of this is due to slow economic growth after the recession, but renewed expansion of demand has not spurred an acceleration of investment. Figure 3-7 shows that the real capital stock of communications infrastructure is leveling off, which could portend shortages of bandwidth ahead.

Figure 3-7. Private Communications Investment and Capital Stock (in Billions of 2009 Dollars)



Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

Prospects for Communication Infrastructure Investment

Strong demand growth for telecommunications services likely will continue. Average real consumer spending growth for telecommunications services and Internet access was above 4 percent in 2012 and 2013.[23] However, there has been a migration from traditional wireline to wireless services. Real consumer spending on wireline services declined more than 5 percent each year on average between 2010 and 2013, while real consumer spending on wireless services grew more than 8 percent annually. Data services represent about 20 percent of the end-market and are growing rapidly, while video and TV entertainment remain small but are surging. Personal consumption is a key component of data services, but businesses increasingly are relying on data transfers. Real communication infrastructure investment might continue to slide in the near term while existing capacity is able to meet demand for voice service, but demand for faster data and video streaming services ultimately will spur investment.

[23] Real consumption spending for telecommunications services and Internet access data are provided in the National Income and Product Accounts published by the Bureau of Economic Analysis (**www.bea.gov**). Real consumption spending for wireline and wireless services is provided in the Underlying Detail tables of the same accounts.

3-6. Water Supply and Wastewater

The State of Water Supply and Wastewater Infrastructure Investment

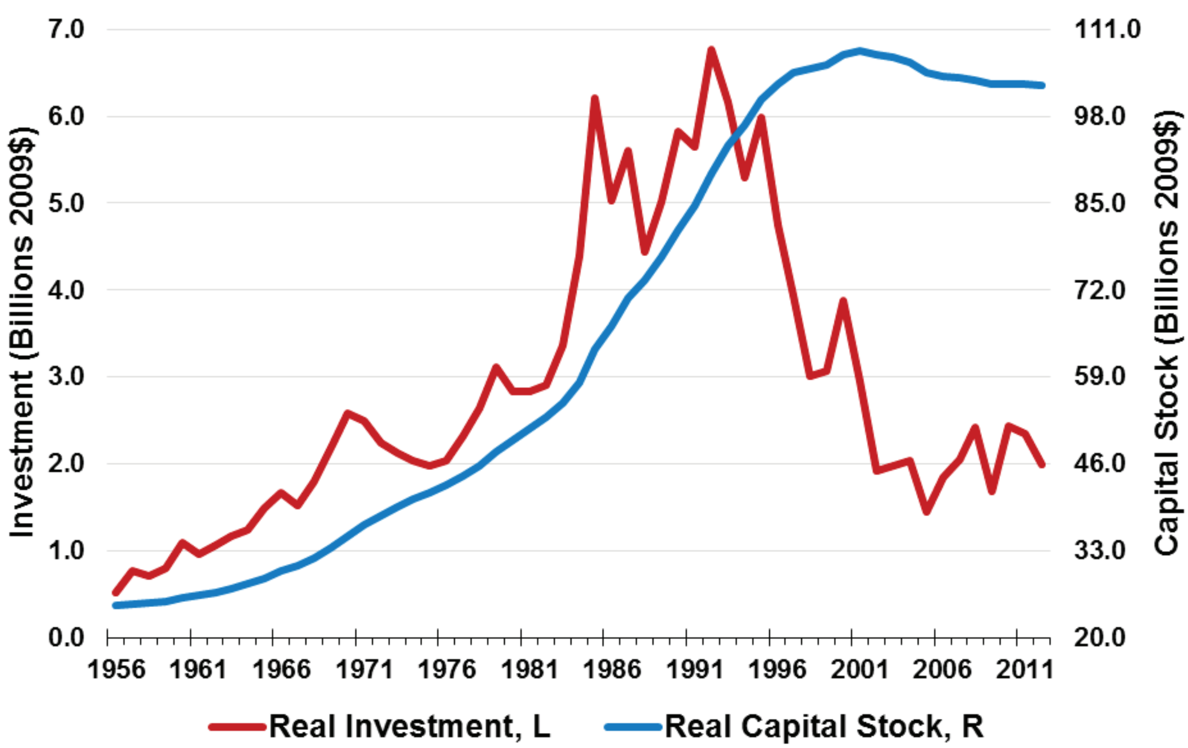
Water supply infrastructure includes treatment plants, pipelines and other structures. They take water from natural sources, such as rivers, lakes and groundwater aquifers, treat it and then deliver it for drinking and other uses. Wastewater infrastructure includes collection systems, tanks, treatment equipment and other equipment to transport wastewater from homes, businesses and elsewhere for treatment and discharge, typically into a nearby body of water.

Municipalities and other government entities operate about 85 percent of water systems, with the remaining 15 percent owned and operated by the private sector (American Water, March 9, 2011). Between 1985 and 1996, private investment in water supply, sewage and waste disposal infrastructure was strong, averaging $5.6 billion per year in 2009 dollars. Since the mid-1990s, however, investment has cooled significantly, according to data shown in Figure 3-8. Real private investment between 2010 and 2012 averaged only $2.3 billion per year, a decline of nearly 60 percent from the 1985 to 1996 average.

Prospects for Water Supply and Wastewater Infrastructure Investment

The EPA reports that the nation's water systems have entered a rehabilitation and replacement era in which much of the existing infrastructure has reached or is approaching the end of its useful life (April 2013). In many cases, water supply infrastructure is 50 to 100 years old. The EPA estimates that $384 billion of improvements to the nation's water supply infrastructure is needed through 2030 for continued provision of safe drinking water (June 4, 2013). Current funding and financing mechanisms are not designed to meet this growing need across communities as systems age and deteriorate.

Figure 3-8. Private Water Supply and Wastewater Investment and Capital Stock (in Billions of 2009 Dollars)



Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

4. Public Infrastructure Expenditures

Public infrastructure enhances public welfare directly by providing services to consumers, indirectly by supporting business and public-sector activities and by supporting national defense. This infrastructure allows efficient and convenient transportation, provides water supplies and treats wastewater in addition to controlling floods, providing locations for recreational activities and augmenting private provision of energy. Continued development and maintenance of this infrastructure is vital to daily commerce, jobs, economic growth and public safety.

The Congressional Budget Office (CBO) provided federal infrastructure spending estimates from fiscal years 1956 through 2009 (2007, 2010).[24] It published corresponding state and local spending estimates from 1956 to 2007. The following analysis uses Inforum's extension of the CBO dataset. The construction of the data used many of the same sources as the original CBO estimates, including data from the U.S. Office of Management and Budget (OMB) for federal expenditures, and data from U.S. Census Bureau for state and local spending. Where data were missing, particularly in 2011 and 2012, Inforum used calculations based on available information on infrastructure from the National Income and Product Accounts (NIPA) produced by BEA.[25]

There are two functions for public infrastructure spending. As in the private sector, government capital expenditures cover both the extension and replacement of infrastructure asset stock. In addition, the discussion in this section includes operations and maintenance spending, such as administration, research and development, patching potholes and replacing burst pipes. Especially for streets and highways, maintenance expenditures are key for sustaining high-quality assets. Other activities, such as security, law enforcement and disaster cleanup, are not included in operations and maintenance.[26]

4-1. Federal, State and Local Government Infrastructure Funding

In fiscal year 2012, the federal, state and local governments spent an estimated $380 billion on transportation and water infrastructure, including operations and maintenance as well as direct investment. From an operational standpoint, state and local governments actually do most infrastructure spending. In 2012, for instance, data show that the state and local sector spent $346 billion, or 91 percent, of the $380 billion total. Therefore, state and local government programs have a large influence over the composition and efficiency of infrastructure spending.

Nevertheless, federal financial grants actually underwrite about 19 percent of state and local spending. The data indicate that these grants totaled about $64 billion in 2012, which is down from a peak of almost $70 billion in 2010. Therefore, state and local entities are estimated to have independently funded $281 billion in infrastructure spending in 2012, and the federal government funded an additional $98 billion, including the grants to state and local governments.

Figure 4-1 summarizes the public infrastructure spending as a percentage of potential GDP and by the levels of government financing it. In general, all three ratios fell gradually but steadily over the decades. Including its grants, the federal government spent $98 billion, or 0.6 percent, of potential GDP on infrastructure in 2012. State and local funding contributed 1.7 percent of economic potential, and so overall spending in 2012 was 2.3 percent of potential GDP. This is down from between 2.5 and 3.0 percent from 1956 through about 1980, but is only a little lower than the ratios over the past two decades.

The biggest reduction in spending levels came about as federal spending ratcheted downward since the early 1980s by about 0.5 percent of GDP as new construction of interstate highways wound down. Over the past 15 years, state and local funding has averaged about three-quarters of total spending, at about 1.8 percent of potential GDP. More recently, the ratios have fallen more rapidly. Between 2000 and 2007, public dollars spent on infrastructure increased by an average of 5.5 percent per year, but this rate fell to only 2.3 percent from 2007 to 2012, well short of potential nominal GDP growth, estimated to be between 5 and 6 percent in any given year. Without a new push of additional levels of investment, public infrastructure expenditures could fall below 2.0 percent of potential GDP.

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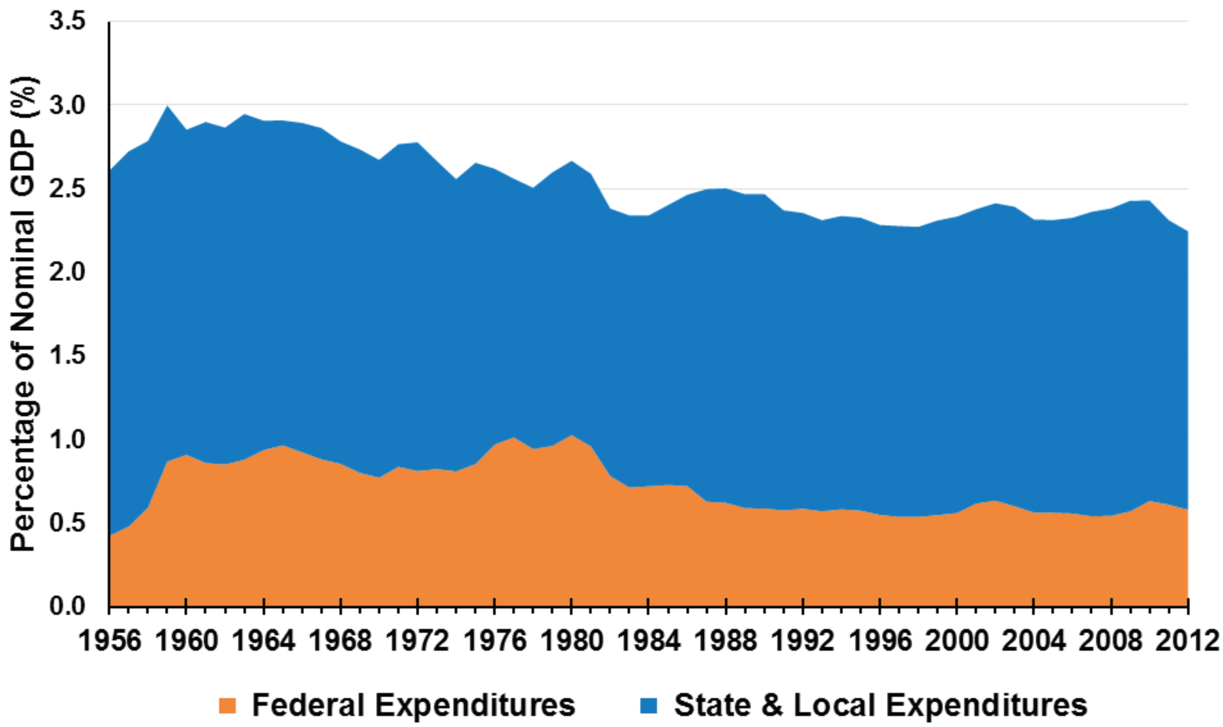
[24] In this section, all public sector expenditure figures apply to the fiscal year ending on September 30.

[25] For additional information on the data employed in this study, see Section 7-1.

[26] In contrast, the private-sector infrastructure data examined in the previous section included only capital expenditures. The difference mainly is due to the nature of available data. It also reflects the fact that operation and maintenance of public infrastructure, such as highways, is important for the quality and quantity of infrastructure. The operation of infrastructure in the cases of freight rail, pipelines and electrical energy production and distribution are mostly production activities.

Figure 4-1. Nominal Public Infrastructure Spending by Level of Government (Percentage of Nominal GDP)



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

4-2. Real Public Infrastructure Expenditures

In addition to nominal value figures, public spending data are presented in real terms. This latter indicator measures the physical quantity of infrastructure purchased, with nominal spending adjusted for the rise of price of the goods and services used in construction. Table 4-1 shows real public infrastructure expenditure over time. Spending levels for 2012 are included again for perspective. Data are presented for seven categories of public infrastructure: five concern transportation (i.e., highways and streets; mass transit; rail; aviation; and ports and inland waterways) and two concern water (i.e., water resources infrastructure, and water supply and waste disposal facilities).

Table 4-1 shows the evolution, in real terms, of the total, capital and operation and maintenance spending for public infrastructure through time. Despite cyclical volatility around the recessions in the 1970s and 1980s, annual real spending expanded steadily from the mid-1950s into the first years of this century, approximately tripling from $125 billion in 1956 to more than $385 billion in 2003. The nearly 50-year trend reversed course in 2003, however, with real spending falling in each year, except for brief respite in 2009 and 2010. The figure shows that inflation-adjusted spending for operations and maintenance grew through 2010, though it appears to have slipped in 2011 and 2012. The decade-long overall decline was concentrated in expenditures for physical capital assets. Total real spending has returned to levels last seen in the 1990s.

Table 4-1. Public Infrastructure Expenditures, 1956–2012

	Nominal $, Billions	Percentage of GDP	Average Annual Percentage Change of Real Infrastructure Spending				
	2012	2012	1956–1980	1980–2003	2003–2012	2003–2008	2008–2012
Real Gross Domestic Product	**16,244.60**	**100.00%**	**3.5**	**3.1**	**1.7**	**2.2**	**1.1**
Public Infrastructure Spending	**379.19**	**2.33%**	**2.8**	**2.1**	**-1.2**	**-1.5**	**-0.9**
Capital Investment	170.94	1.05%	2.1	2.2	-2.8	-3.9	-1.5
Operations and Maintenance	208.25	1.28%	3.5	1.9	0.2	0.6	-0.4
Highways and Streets	155.98	0.96%	1.6	1.8	-2.4	-2.3	-2.4
Capital Investment	88.43	0.54%	1.2	2.1	-3.5	-3.8	-3.2
Operations and Maintenance	67.56	0.42%	2.2	1.4	-0.8	-0.2	-1.5
Mass Transit	58.57	0.36%	5.4	3.4	-0.5	-1.6	0.8
Capital Investment	18.67	0.11%	7.3	5.5	-3.3	-8.1	2.7
Operations and Maintenance	39.90	0.25%	4.9	2.5	1.0	1.8	0.0
Rail	1.78	0.01%	18.8	-6.2	0.3	-0.9	1.9
Capital Investment	0.98	0.01%	-	-6.6	1.7	2.1	1.2
Operations and Maintenance	0.81	0.00%	15.7	-5.8	-1.1	-4.1	2.8
Aviation	36.89	0.23%	6.7	3.7	-1.6	-3.0	0.2
Capital Investment	15.16	0.09%	5.7	5.4	-3.1	-6.3	0.9
Operations and Maintenance	21.73	0.13%	7.2	2.7	-0.5	-0.6	-0.2
Ports and Inland Waterways	9.58	0.06%	2.5	2.8	-2.3	-4.5	0.5
Capital Investment	3.71	0.02%	3.1	3.3	-6.6	-11.9	0.1
Operations and Maintenance	5.87	0.04%	2.0	2.3	1.6	2.2	0.8
Water Resources	11.42	0.07%	2.5	-1.9	0.3	-4.5	6.3
Capital Investment	6.44	0.04%	1.5	-1.1	0.4	-5.6	8.0
Operations and Maintenance	4.97	0.03%	3.8	-2.6	0.2	-3.1	4.3
Water Supply and Waste Disposal	104.97	0.65%	3.8	2.3	0.3	0.9	-0.6
Capital Investment	37.56	0.23%	3.4	1.4	-0.7	0.2	-1.8
Operations and Maintenance	67.41	0.41%	4.2	3.0	0.8	1.4	0.1

Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Census Bureau, State and Local Government Finances; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

Two major developments have influenced the course of public infrastructure investment from the past decade. First, from 2003 to 2008, the rapid growth of prices for construction eroded the spending power of the public dollars capital investment. Strong price growth, particularly for materials like steel, cement, asphalt and diesel fuel, substantially diminished the buying power of infrastructure dollars. Even as infrastructure budgets grew in dollar terms, they actually bought smaller quantities of infrastructure. The report more closely examines this issue below.[27]

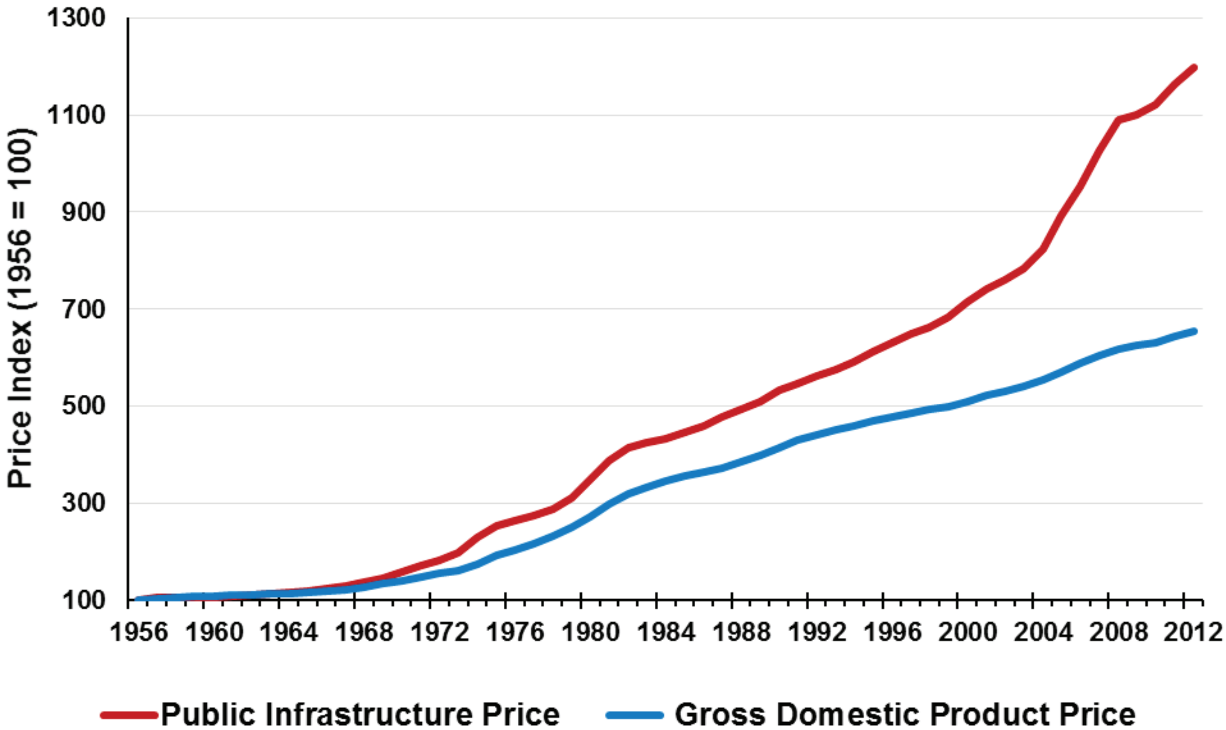
Second, responding to the recession, the American Recovery and Reinvestment Act (ARRA) of 2009 provided state and local governments with funds to boost infrastructure spending in 2009 and 2010 (Congressional Budget Office, 2010). The amount of extra federal spending devoted to transportation infrastructure was $48.1 billion (Congressional Budget Office, January 5, 2012). Those funds mostly were exhausted by the end of 2010, and the infrastructure expenditures of federal, state and local governments fell once again in 2011 and 2012. Inforum does not yet have solid figures for 2013, but it is expected that capital formation remained stagnant.

[27] See also CBO (2010, pp. 3-5) for additional description of the price escalation and its effect on infrastructure investment.

4-3. Infrastructure Price Inflation

Figure 4-2 portrays annual price growth since 1956 for public infrastructure and economy-wide (GDP) prices. Table 4-2 provides inflation rates for several periods across public infrastructure categories. These exhibits show that the price of public works construction normally rises faster than general inflation, shown here by the GDP price index. Modern infrastructure is built to rigorous and evolving standards, and expensive quality enhancements are not necessarily captured by price statistics. Moreover, projects increasingly are built side-by-side with existing (and operating) facilities, and investments are becoming ever more sensitive to environmental considerations. These circumstances entail extra design, development and logistics costs that gradually but steadily increase through time. Moreover, construction and the manufacturing industries that support it are increasingly intensive in skilled labor. These factors contribute to an imbalance: prices for infrastructure investment grow faster than general inflation.

Figure 4-2. Public Infrastructure Versus General Prices, 1956–2012 (Price Index 1956 = 100)



Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database

This inflation differential accelerated substantially in the past decade. Table 4-2 shows that despite moderate overall inflation, infrastructure prices rose between approximately 5 and 10 percent annually between 2003 and 2008. Inflation for capital expenditures was especially high. The worldwide economic recovery that started in 2002 resulted in rapid increases in the prices of many commodities, especially those most relevant to construction, such as fuel, asphalt, cement and steel. While nominal expenditures for public infrastructure spending climbed from 2003 to 2008, it was not enough to offset high construction inflation. Rising prices particularly eroded capital spending, and inflation especially was problematic for highway investments.[28]

[28] For additional discussion, see CBO (2010).

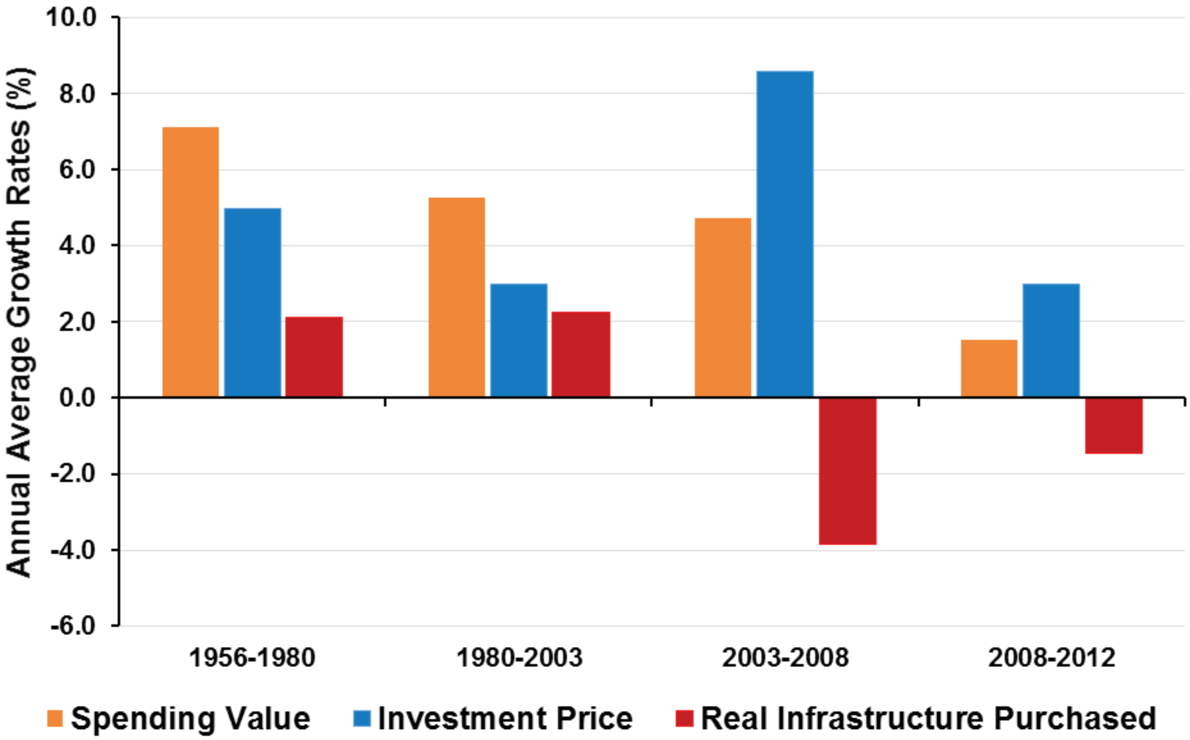
Table 4-2. Growth in the Price of Public Infrastructure Expenditures, 1956–2012

	Average Annual Growth of Prices				
	1956–1980	1980–2003	2003–2012	2003–2008	2008–2012
Real Gross Domestic Product	4.2	2.9	2.1	2.7	1.4
Public Infrastructure Spending	5.2	3.5	4.7	6.6	2.4
Capital Investment	5.0	3.0	6.1	**8.6**	3.0
Operations and Maintenance	5.5	4.0	3.5	4.7	1.9
Highways and Streets	5.0	3.6	5.5	7.7	2.6
Capital Investment	4.7	3.2	6.9	**9.7**	3.2
Operations and Maintenance	5.5	4.1	3.5	4.8	1.9
Mass Transit	5.5	3.7	4.5	6.3	2.2
Capital Investment	5.0	3.0	6.0	**8.6**	2.9
Operations and Maintenance	5.5	4.1	3.5	4.8	1.9
Rail	5.0	3.3	3.8	4.9	2.3
Capital Investment	-	3.0	4.8	**6.5**	2.6
Operations and Maintenance	5.0	3.5	2.9	3.6	2.0
Aviation	5.1	3.3	4.3	5.9	2.3
Capital Investment	5.1	3.0	5.8	**8.1**	2.8
Operations and Maintenance	5.2	3.6	3.2	4.2	1.9
Ports and Inland Waterways	5.2	3.4	4.6	6.4	2.3
Capital Investment	5.0	2.9	5.8	**8.2**	2.8
Operations and Maintenance	5.4	3.9	3.3	4.3	1.9
Water Resources	5.1	3.3	3.7	4.7	2.5
Capital Investment	5.3	2.8	4.4	**5.6**	2.8
Operations and Maintenance	5.1	3.9	2.9	3.6	2.0
Water Supply and Waste Disposal	5.2	3.5	3.9	5.4	2.1
Capital Investment	5.1	2.8	4.6	**6.3**	2.6
Operations and Maintenance	5.5	4.1	3.5	4.9	1.9

Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Census Bureau, State and Local Government Finances; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

Figure 4-3 reveals how high construction inflation affects the volume of infrastructure purchases of capital. The increase in the volume of infrastructure purchased is equal to the growth in the level of money spent minus the inflation of infrastructure prices. From 1956 through 1980, years of strong spending growth, outlays tended to increase faster than prices and so infrastructure formation increased by about 2.0 percent, on average, per year. From 1980 to 2003, spending growth was slower but so was inflation, and infrastructure investment again increased by almost 2.0 percent per year. From 2003 to 2008, rapid inflation meant that real investment declined by almost 4.0 percent per year.

Figure 4-3. Growth of Nominal Prices and Real Public Infrastructure (Average Percentage Rate of Annual Growth)



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

In 2009, infrastructure price inflation fell with the collapse of residential construction, financial markets and the national and world economies. In particular, prices for diesel fuel, steel, asphalt and other materials fell sharply, and commodity prices have been more stable since then. However, while inflation has subsided since 2008, the low growth of public infrastructure funding meant that real investment continued to fall, by an average of almost 2 percent per year.

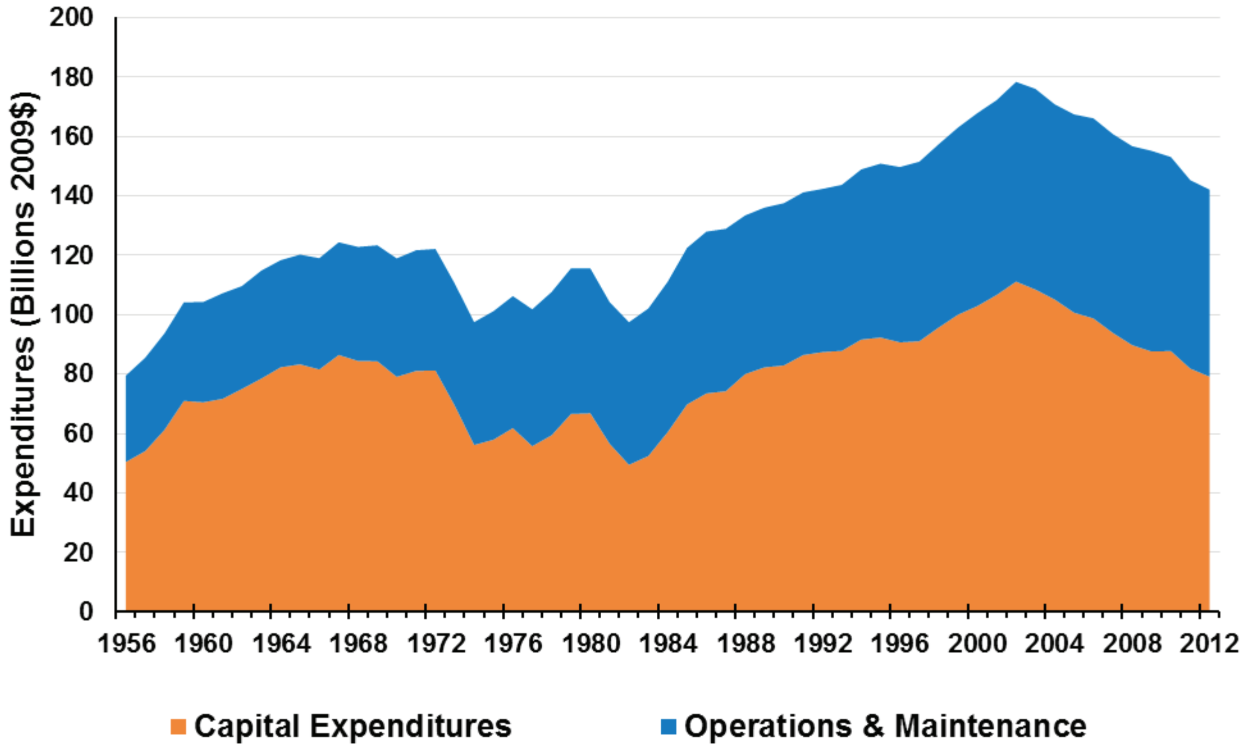
Through 2012, substantial slack remained in construction markets and economies worldwide, but recovering economic growth likely will spur demand for commodities and renew upward pressure on infrastructure prices. Public infrastructure policy should anticipate such future costs increases.

4-4. Highways and Streets

Refer again to Table 4-1 to examine the state of investment across categories. Public streets and highways are the largest and most important of the public infrastructure categories. Estimated spending in 2012 was $156 billion, an amount well in excess of levels for other categories; only spending for water supply and wastewater treatment also exceeded $100 billion. Capital investment was $88 billion, and operations and maintenance was $68 billion.

Figure 4-4 shows historical highway real expenditures for total, capital and operations and maintenance expenditures. Total real highway spending has fallen for a decade. Spending for other infrastructure categories show similar patterns, but those declines are less marked. The highway sector was the most vulnerable to construction inflation as prices rose by almost 10 percent per year from 2003 to 2008; this was shown in Table 4-2. Consequently, inflation-adjusted capital investments in highways fell by an average of 3.5 percent per year between 2003 and 2012. Real operations and maintenance expenditures essentially were flat during the same period.

Figure 4-4. Real Public Expenditures for Streets and Highways (in Billions of 2009 Dollars)



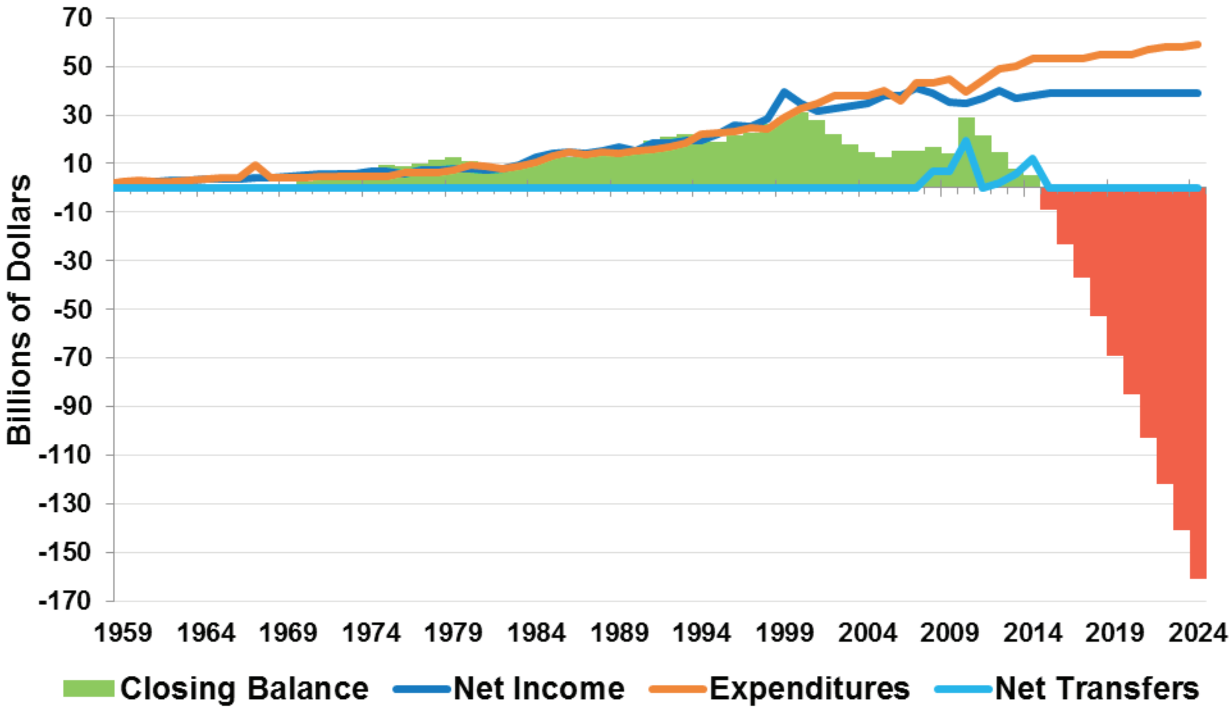
Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

These figures represent a year-by-year decline in the purchase of new physical capital destined to replace and extend current assets. The data are consistent with the "D+" grade assigned to roads by the ASCE (2013), and they are confirmed by surveys of business leaders and consumers. The deterioration in the quality of highways is especially problematic for the broader welfare of the nation. Highways are particularly important for the following reasons:

- According to the infrastructure data in Table 4-1, highways and streets account for 40 to 50 percent of all public infrastructure spending. Federal, state and local levels of governments all make key funding decisions and have substantial stakes and influences for the sector.
- While some people fly, cruise or ride the rails, ground transportation is the primary basis for consumer transportation, and it accounts for about 10 percent of consumers' budgets.[29] Households depend on good highway and street systems for getting to work and play, whether across town or across the country.
- All other transportation modes depend on roads to complete the first and last few miles of most sea, rail or air journeys. Benefits of world-class seaport, rail and air facilities largely may be negated by poor roads.

[29] Calculated from expenses related to consumption of ground transportation goods and services in 2012, as published in the National Income and Product Accounts by the Bureau of Economic Analysis (**www.bea.gov**).

Figure 4-5. Shortfall of the Highway Trust Fund, Highway and Transit Accounts (in Billions of Dollars, by Fiscal Year)



Source: U.S. Department of Transportation Federal Highway Administration

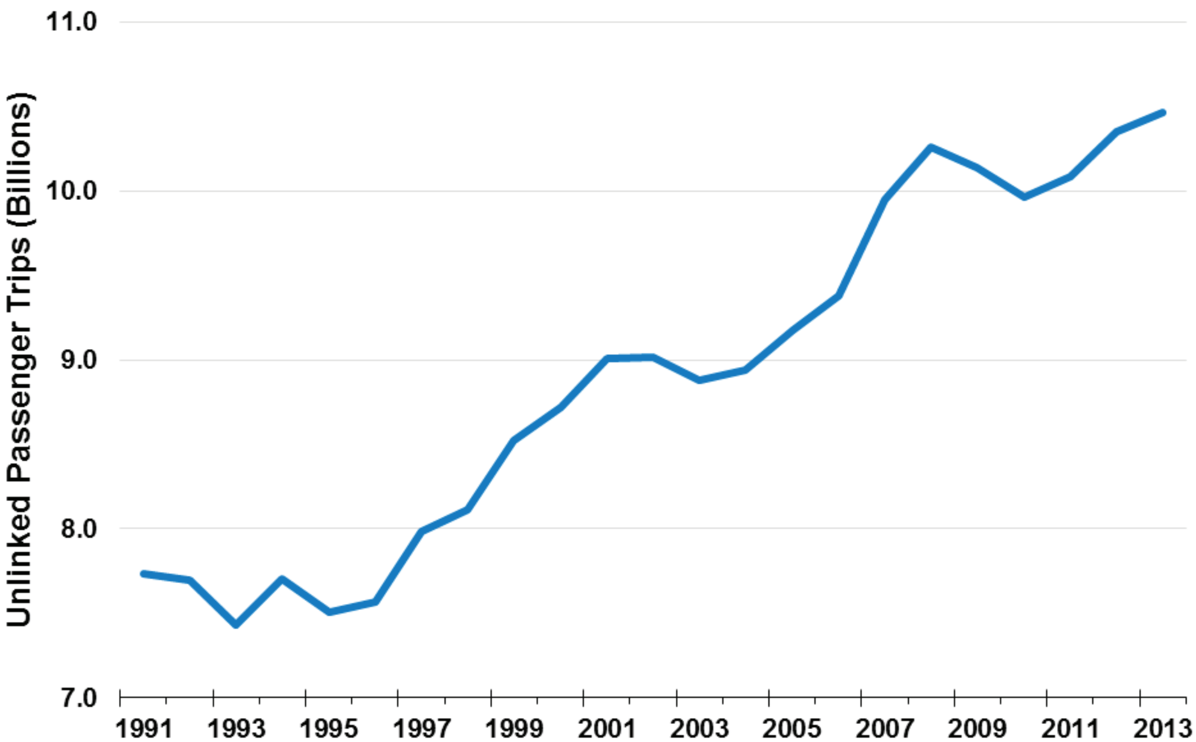
The current situation is particularly dire. The federal Highway Trust Fund is a particularly important means of providing funds for critical infrastructure. While Congress took the necessary steps to avoid the crisis facing the Highway Trust Fund and provided $10.8 billion in stopgap funding in July 2012, the shortfall for highway and transit systems continues.[30] This shortfall, along with anticipated spending and revenue levels, is shown in Figure 4-5 and is especially relevant if Congress addresses the matter of long-term solvency. Without new and substantial funding, investment could plummet later in 2014 and through 2015.

4-5. Mass Transit and Passenger Rail Infrastructure

Mass transit includes buses, vanpool and ferry systems, and commuter, subway and light rail networks. In 2010, there were 709 public and 21 private urban transit agencies in the National Transit Database (Federal Transit Administration, 2014). All but 148 of these systems operated multiple transit modes, such as integrated subway, rail and bus systems. Bus and heavy rail systems, such as subways provide 51.6 percent and 35.6 percent of all trips, respectively, but commuter rail is responsible for 20 percent of all passenger miles. Light rail is the fastest-growing mode and is popular in small and medium-sized cities. Ridership on mass transit has risen steadily over 20 years. The Federal Transit Administration estimated that there were 10.5 billion passenger transit trips in 2013 compared to 7.7 billion in 1991, an average increase of 1.4 percent per year (2014). This growth of "unlinked passenger trips" is shown in Figure 4-6, where passengers are counted each time they board vehicles, sometimes multiple times between origin and destination. About 89 percent of transit trips and 77 percent of vehicle revenue miles occur in the 42 urban areas with populations of more than 1 million.

[30] For additional legislative detail, see **https://beta.congress.gov/bill/113th-congress/house-bill/5021**.

Figure 4-6. Unlinked Passenger Trips (in Billions of Trips)



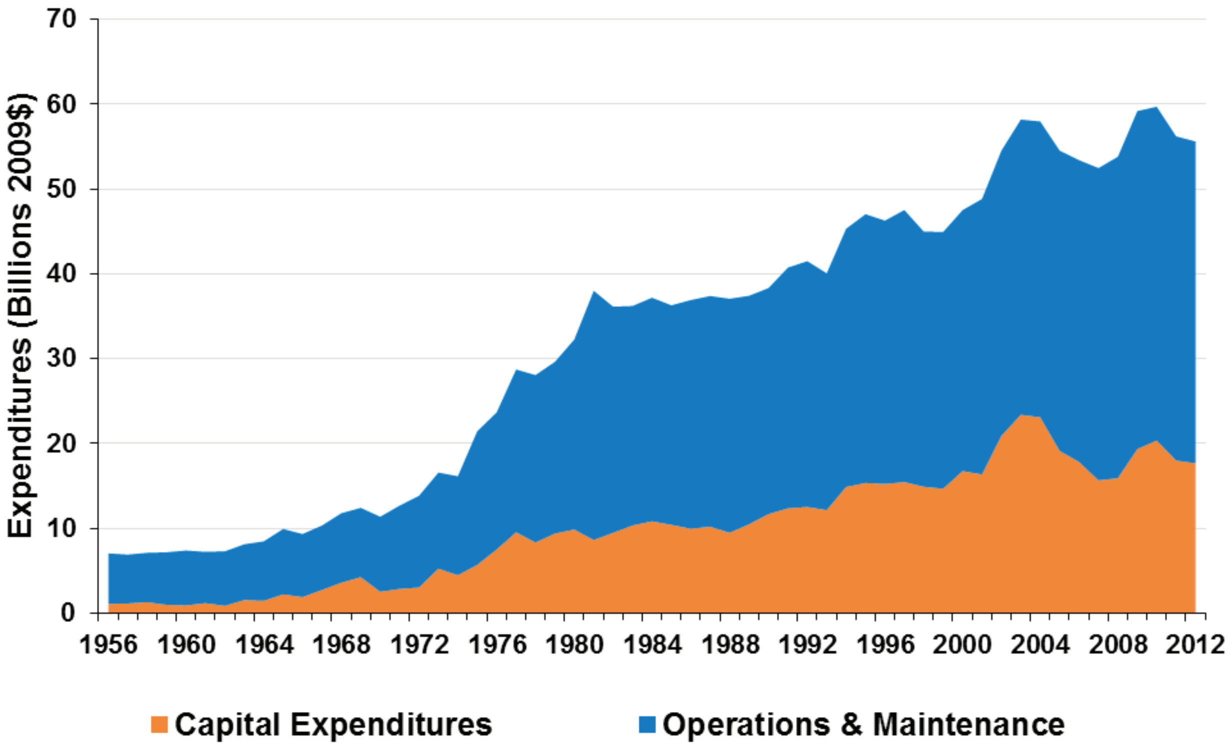
Source: U.S. Federal Transit Administration

Urban transit systems are becoming an ever more important feature of the modern city. The U.S. economy is driven increasingly by high-value, high-technology clusters in professional services, biology, research and development and computer services (see Economic Development Research Group (December 2013) and Venables (September 2004)). Such industries tend to cluster in dynamic urban areas where they can enjoy the "economies of agglomeration" that include industry networks, large and diverse workforces and efficient infrastructure services. Most world-class cities have not been able to reach critical urban mass without highly developed transit systems. New York, Chicago, San Francisco, Tokyo and London are just five examples among dozens. If U.S. cities are to continue to attract new businesses and jobs, transit systems must be expanded and maintained.

According to the Federal Highway Administration, the replacement and upgrade of transit "guideway" elements (track, ties, switches, ballast, tunnels and elevated structures) is a major challenge for the industry (U.S. Department of Transportation, 2014). Of the $213 billion replacement value of current guideway assets, $35.8 billion (17 percent) is in poor condition and an additional $22.6 billion (15.0 percent) is in marginal condition. This implies that more than $50 billion of new investment is needed just to maintain current system size and performance. Network expansion will require billions more.

Investment spending levels for mass transit are shown in Figure 4-7. Real capital expenditures have been volatile in the past decade, with a surge beginning around 2000 and peaking in 2004. Some of the subsequent decline was reversed by stimulus spending, but capital expenditures have fallen beginning in 2010 to levels seen a decade ago. Real operations and maintenance spending has been far less volatile, but in recent years, it has also begun to slip.

Figure 4-7. Real Public Expenditures for Mass Transit and Passenger Rail (in Billions of 2009 Dollars)



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

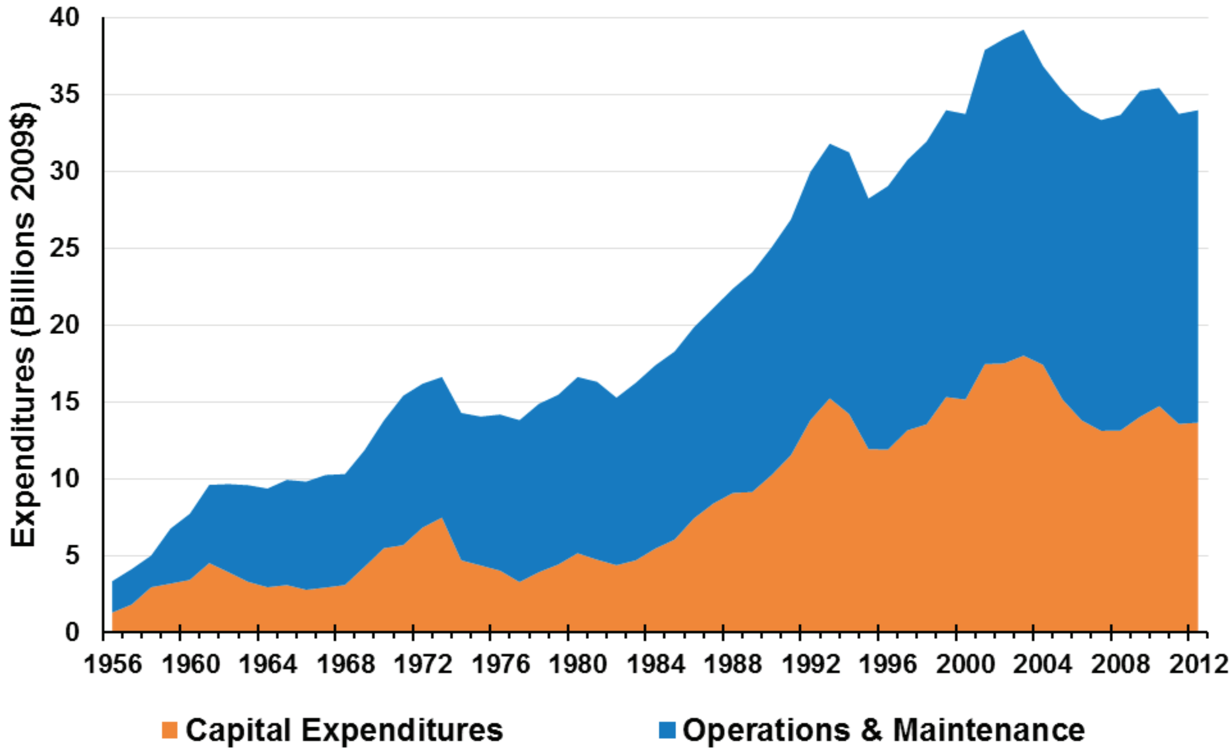
4-6. Aviation Facilities

Investment spending levels for public aviation facilities are shown in Figure 4-8. Real operations and maintenance expenditures have been flat for about a decade, while real capital expenditures have fallen substantially from peak levels in the early 2000s. The predictable consequences of underinvestment have been realized. In its compilation of the world's 100 best airports, the Skytrax consultancy (*The Economist*, 2014) reports that Cincinnati/Northern Kentucky International Airport commanded the highest rating of U.S. airports. It was 27th. After examining data for more than 1 million flights in 2013, *The Economist* found that 67.0 percent of people flying out of the United States land at airports with higher ratings than the one from which they departed.

The federal government plays key roles in the aviation industry, including in the operations of airports. In 2012, FAA air traffic control towers directed 36.3 million takeoffs and landings, and FAA contract towers handled 14.4 million operations. FAA traffic controllers and federal contractors directed flights for 727 million passengers, nearly all of the 731 million air travelers in 2012 (Federal Aviation Administration, 2014).

The FAA reports that 29 large hub airports enplaned 517 million passengers in 2012, and it predicts that the same airports will see a 68.9 percent increase by 2040, reaching 873 million passengers per year. Medium hub airports should see similar growth, at 63.5 percent, between 2012 and 2040 (Federal Aviation Administration, 2014). Growth in air freight traffic might prove even higher. The U.S. Department of Transportation projects that air freight imports will grow about 180 percent by weight and 245 percent in value between 2011 and 2040, while air freight exports will rise almost 300 percent in weight and 350 percent in value (U.S. Department of Transportation, April 28, 2014).

Figure 4-8. Real Public Expenditures for Aviation Facilities (in Billions of 2009 Dollars)



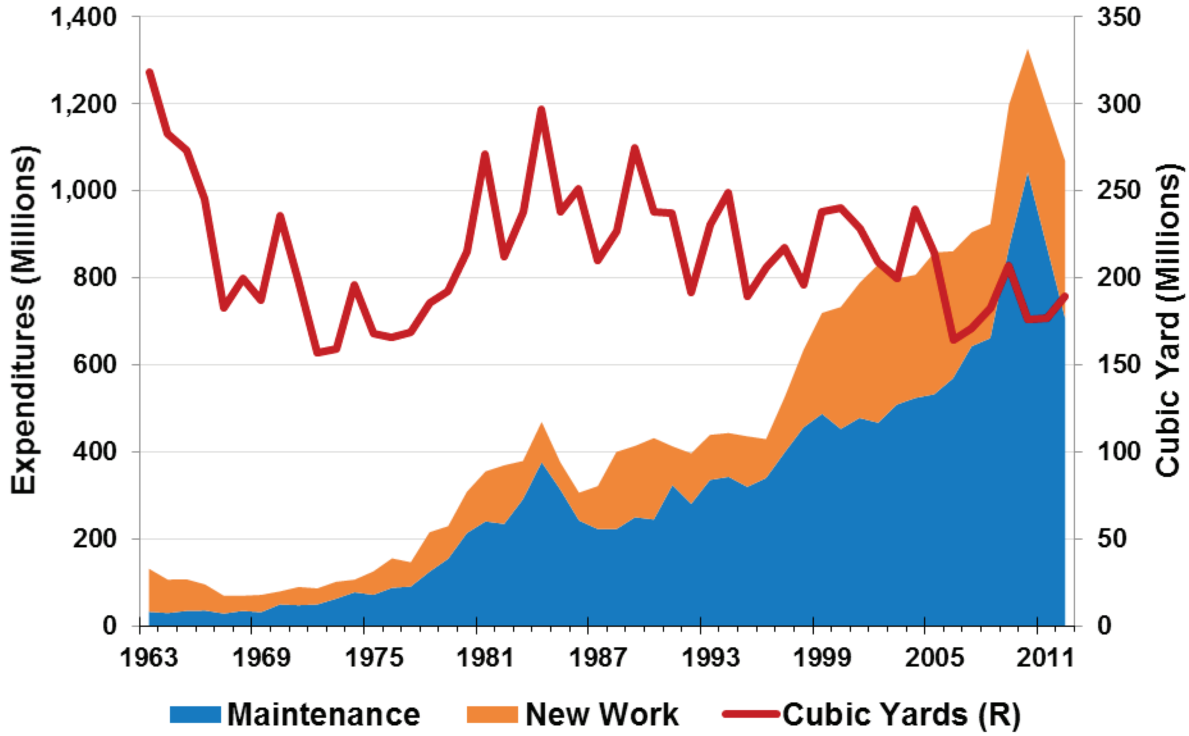
Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

4-7. Ports and Inland Waterways

According to the U.S. Army Corps of Engineers (USACE) (November 2013), 885 million tons of commodities were shipped among U.S. lakes, inland waterways and coastal waterways in 2012. Petroleum products and crude petroleum are the leading products, by weight, at 75 million and 35 million short tons, respectively. Total tons shipped fell 0.5 percent in 2012, led by declines in petroleum products. Foreign shipments totaled 1,422 million short tons. Imported shipments fell to 805 million tons, down 7.4 percent from 2011. Though crude petroleum imports fell 12.4 percent, it still leads commodity imports at 361 million tons. Exports by weight increased 1.1 percent in 2012 to 617 million tons. Petroleum products gained 1.8 percent to reach 151 million tons. By weight, 13.7 percent of waterborne commerce was shipped in containers, including 2.4 percent of domestic shipments and 20.8 percent of foreign trade shipments. More than 2 million containers[31] were shipped domestically, and more than 17 million were shipped internationally in 2012. These shipments passed through 8,214 cargo-handling docks, with 76 serving only foreign shipments, 6,154 serving only domestic traffic, and the rest serving both. The shipments also depend on highways, railways and pipelines to bring outbound freight to the port and to move inbound freight from the port to its destination.

[31] Measured as Twenty-Foot Equivalent Units (TEU).

Figure 4-9. Army Corps of Engineers' Dredging Activity (in Millions of Dollars and Millions of Cubic Yards)

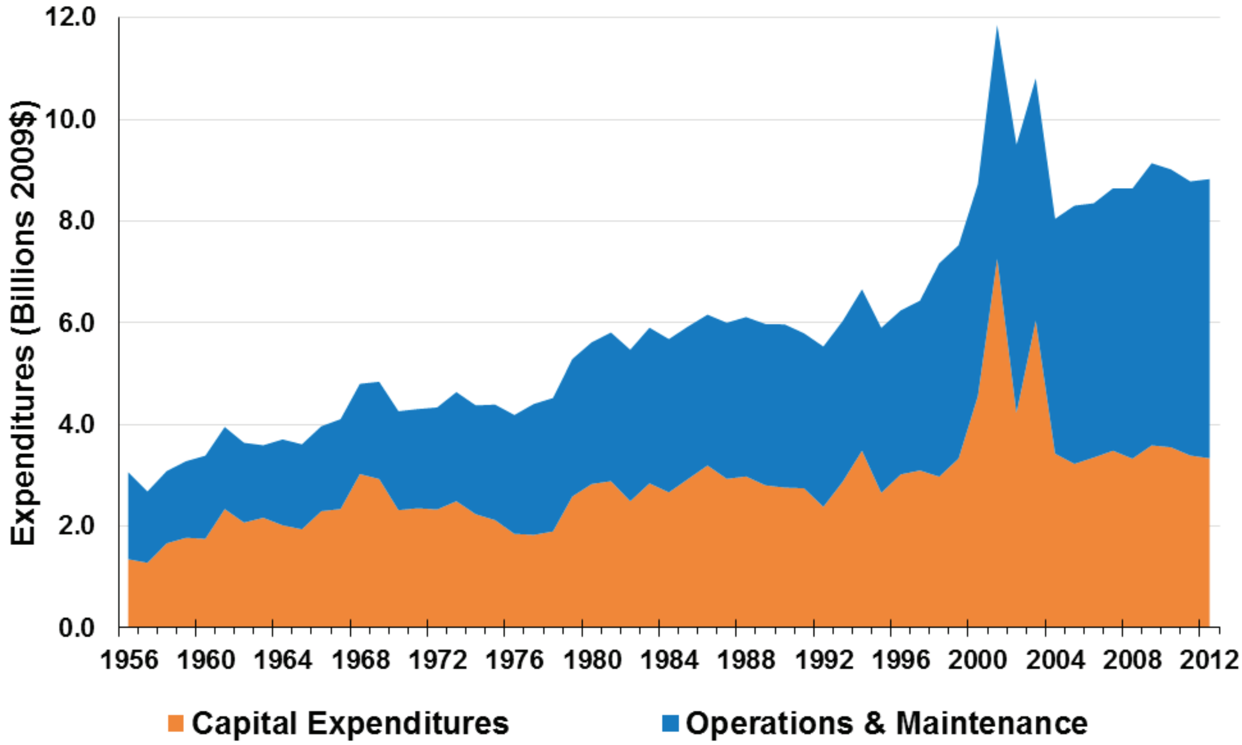


Source: U.S. Army Corps of Engineers

The federal government plays important roles in the development and maintenance of marine and inland waterways and ports. For example, the USACE owns and operates locks at 193 sites. Of the 239 lock chambers, 143 are more than 50 years old, and the overall average age is 60 years. The USACE either directly, or through contractors, dredged 238 million cubic yards of material from shipping channels in 2012, at a cost of $1.2 billion. Maintenance work accounted for 84 percent of the material dredged, another 6 percent was removed through supplemental hurricane work, 9.2 percent was new construction and channel deepening and 0.3 percent was ARRA-funded maintenance (U.S. Army Corps of Engineers, November 2013). Figure 4-9 shows the amount spent by the USACE on dredging activities over the past 50 years. Following a surge of spending in 2009 and 2010, maintenance spending has fallen sharply. Despite improvements in efficiency, cubic yards removed for maintenance remains on a three-decade-long downward trend, and new work remains at historically low levels (U.S. Army Corps of Engineers, November 4, 2013).

Because so much commodity traffic is moved by water, including a large percentage of U.S. exports of manufactured goods and agricultural and energy products, it is essential to maintain the water transportation infrastructure along our coasts and inland waterways. Unscheduled delays and congestion caused by broken locks and inadequate capacity at ports and waterways add considerable costs, leaving domestic products less competitive in international markets and driving up prices for U.S. consumers.

Figure 4-10. Real Public Expenditures for Ports and Inland Waterways (in Billions of 2009 Dollars)



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

Spending levels for ports and waterways are shown in Figure 4-10. In the mid-1990s, real operations and maintenance spending accelerated, though spending since 2010 has been flat. Real capital expenditures essentially have been flat for decades, except for five years of increased spending levels in the early 2000s.

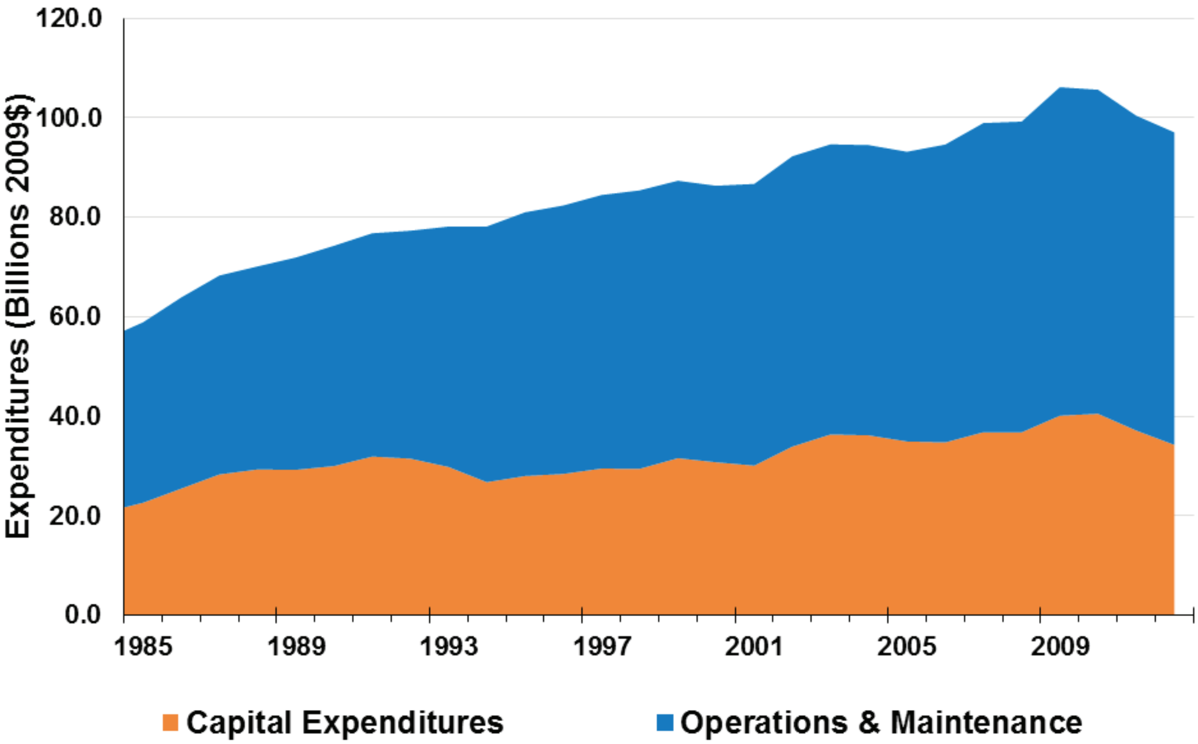
4-8. Public Utilities

Water Supply and Wastewater Treatment

Approximately 170,000 public systems supply water in the United States, including 54,000 community systems that supply water year-round to residences. Of the community water systems, 43 percent are publicly owned, with the rest owned by private or other entities (U.S. Environmental Protection Agency, September 2002). In 2011, the EPA estimated that the nation will need to spend $384.2 billion on community water systems over the next 20 years (U.S. Environmental Protection Agency, April 2013).

The nation has more than 16,000 publicly owned treatment facilities for municipal wastewater. In 1996, these facilities served 73 percent of the population. About 25 percent of households use on-site systems rather than these public systems (U.S. Environmental Protection Agency, September 2002).

Figure 4-11. Real Public Expenditures Water Supply and Wastewater Disposal (in Billions of 2009 Dollars)



Sources: U.S. Congressional Budget Office; U.S. Office of Management and Budget; U.S. Bureau of Economic Analysis, National Income and Product Accounts and Fixed Assets Database; and authors' estimates

Failure to invest can result in water shortages and rationing through higher prices. Some households and businesses will react by building their own water supply and wastewater systems, others will invest in conservation technologies, and some will relocate to where infrastructure is more adequate (American Society of Civil Engineers, 2012).

Water supply and treatment are particularly important to the private economy. Pereira reports an annual rate of return of 9.7 percent for public investment spending on water and wastewater infrastructure, in terms of private output. This rate is substantially higher than for other types of infrastructure, except public electric and gas facilities, and it is higher than the average return of 7.8 percent (Pereira, 2000).

Investment spending levels for water supply and wastewater treatment are shown in Figure 4-11. Despite some volatility, total real expenditures trended upward for several decades but reversed course in 2010. Operations and maintenance spending has risen faster and more steadily, but although capital expenditures have been volatile, investment spending also rose substantially. However, since 2010, real capital expenditures have fallen sharply, and operations and maintenance spending also has slipped.

4-9. Summary

Real capital investment spending for highways and streets fell at 3.8 percent annually from 2002 to 2008, and the slide continued through 2012 at 3.2 percent per year. Real capital spending for mass transit, aviation and water transportation infrastructure all fell sharply from 2003 to 2008, though each has leveled out since then. Capital spending for water supply and waste disposable expenditures grew at 0.2 percent per year between 2003 and 2008, but then it fell by nearly 2 percent per year through 2012.

This data show that real public infrastructure investment has fallen steadily for a decade and disturbingly so for highways and streets. From 2003 to 2008, relatively high construction cost inflation pushed down real investment spending, so each dollar of infrastructure investment bought less physical infrastructure. Some relief came in 2009 and 2010 through federal stimulus spending, but these amounts were relatively small (Congressional Budget Office, January 5, 2012), and simultaneously, state and local governments cut back their spending. From 2010, overall investment fell as the federal government trimmed its budget to reduce deficits.

These patterns provide economic evidence that is consistent with the ASCE's quadrennial engineering analysis and its *Failure to Act* series, the competitive analysis of the World Economic Forum and the U.S. Council on Competitiveness as well as the views of U.S. manufacturing executives. The nation's infrastructure base has lost much ground over the past decade. Therefore, it is not just a matter of restoring growth to infrastructure budgets. A more focused effort is needed to meet a growing backlog of deferred projects. In the next section, this report presents an assessment of the effects of a more dedicated effort that puts the United States on the path to spending closer to 3.0 percent of its GDP in public infrastructure.

5. The Economic and Industry Impacts of Infrastructure Investment

In 2014, the state of public infrastructure continues to remain a key domestic policy issue. The expansion of expenditures on highways, mass transit, airports, waterways and water utilities generally enjoys strong bipartisan support from state houses to the U.S. Congress. As discussed above, greater access to sufficient and high-quality infrastructure improves industry performance across the economy and enhances the day-to-day lives of consumers by providing a strong return on investment. Every industry depends on infrastructure to transport goods, workers and energy. To the extent that efficiency gains in transportation and utilities lower relative costs across the economy, better infrastructure enhances the competitiveness of all industries and the economy as a whole. To the extent that better roads, public transit, airports and water systems save consumers time and money, they also directly enhance standards of living.

This study connects the dots between industry-level cost effects and the national economy. We use information drawn from a series of studies sponsored by the ASCE and conducted by the EDR Group and Inforum. Published in 2011 and 2012, *Failure to Act: The Impact of Current Investment on America's Economic Future* identified the industry and macroeconomic costs of degraded infrastructure (American Society of Civil Engineers, 2012).[32] In particular, these reports compiled and synthesized a large volume of data on the conditions, costs and investment requirements of U.S. infrastructure. The industry-level cost implications of deficient infrastructure were used in the Inforum LIFT model to show the long-term economic consequences of allowing American infrastructure to continue to decline at current rates.

This report leverages the industry-level cost information with the LIFT model to illustrate how enhanced infrastructure investment can benefit the economy, particularly in the context of current economic conditions. A baseline "low investment" scenario, or business-as-usual case, is developed that is similar to the ASCE deficient investment scenarios. A second "high investment" model simulates an immediate and substantial boost to infrastructure investment, compared to the baseline, where the higher level of investment is maintained in the long term. In the latter scenario, improved infrastructure quantity and quality reduces transportation and water utility costs for businesses and consumers across the economy. The potential benefits of infrastructure investment shown here stand in contrast to those of the recent stimulus spending program of 2009 (ARRA), which proved too brief an increase in spending to make a substantial difference in the quality and capacity of U.S. infrastructure.

The LIFT model is especially suited to tracing the long-run cost and competitiveness impacts of higher-quality infrastructure. In the model, benefits of improved infrastructure first are calculated at the industry level, either as labor productivity gains or as direct cost reductions for such things as vehicle repairs and fuel. Therefore, the competitive enhancement allowed by better roads, highways and bridges, for example, accrue to industries in proportion to their direct and indirect use of ground transportation infrastructure. Manufacturers that depend intensively on trucking for receiving inputs and delivering products see large cost reductions. In turn, the model simulations show that these cost savings are passed to their customers both at home and abroad, allowing domestic producers to gain advantages over imports. Furthermore, LIFT provides a meaningful accounting of consumer transactions. In many cases, the benefits of improved infrastructure are realized through explicit purchases and time savings by consumers. The net impact of these forces increases real output, employment and income over the long run. It is important to realize that the supply-side benefits of enhanced infrastructure investment will take time to materialize, especially given the current poor state of many facilities. However, under certain circumstances, infrastructure investment can boost the economy substantially in the short run as well.

The LIFT model provides a business cycle context for evaluating the "multiplier" effects of increased investment expenditures over the short term. Greater investment in infrastructure will increase aggregate demand in the economy and stimulate greater growth. The extent of the multiplier effect is dependent on conditions in the greater economy. If the economy is fully employed, increased government expenditures can "crowd out" private spending, at least partly and over time. Therefore, the multiplier effect would be relatively small. On the other hand, when the economy has substantial idle capacity and underemployment, the crowding-out effect is minimal. Several studies have shown that so long as interest rates and inflation remain low, then the fiscal multipliers are especially high, usually exceeding one by an ample margin.[33] Multipliers may be especially large for infrastructure spending during times of high economic slack (Leduc and Wilson, 2012).

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[32] Detailed reports for each of the individual infrastructure systems are provided by the ASCE at **www.asce.org/failuretoact**. The ASCE studies covered ground transportation infrastructure (including rail); water and sewer facilities; airports, waterways and inland and marine ports; and energy transmission and distribution.

[33] See Blanchard and Leigh (2013) and DeLong and Summers (Spring 2012).

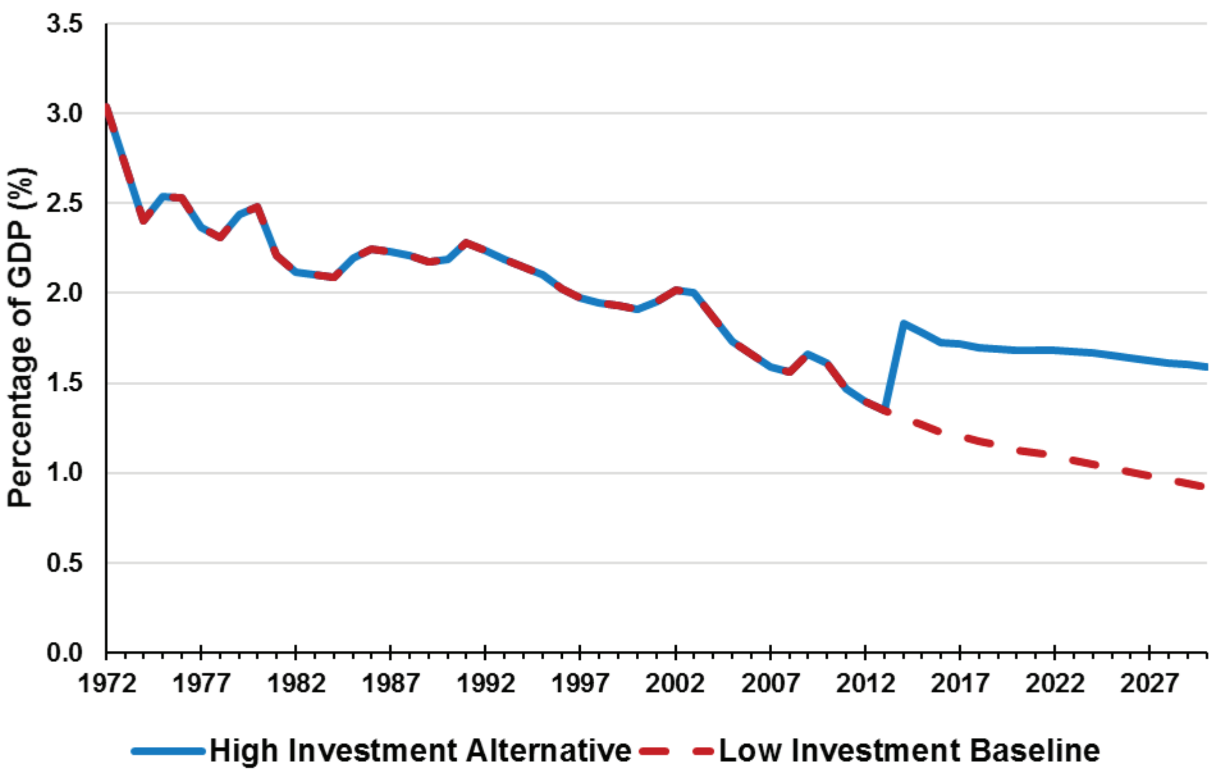
In the current case, the large increase to infrastructure investment is made in an economy still struggling with unemployment and anemic growth. The extra spending stimulates construction and supporting industries, such as materials and equipment manufacturing. Much of this stimulus does not immediately reduce demand in other sectors, so economic growth and employment is enhanced in the short term. Over the long term, however, supply forces—available labor, capital (including infrastructure) and productivity—determine the level of aggregate output. It is precisely because the extra infrastructure investment enhances the productive capacity of the economy that it produces durable benefits over the longer term.

5-1. Alternate Levels of Spending

Figure 5-1 shows the trajectory of infrastructure investment as a percentage of GDP for the two scenarios. The "low infrastructure investment" baseline forecast assumes that total federal and state real infrastructure spending across categories starts to grow again at 0.4 percent per year from 2014 through 2030. This rate is relatively anemic compared to the 2 to 3 percent average growth rates between 1956 and 2003. Economic growth is moderate in this scenario, averaging about 2.4 percent per year. Therefore, while positive real infrastructure investment growth is a departure from recent trends and will be welcome, the proportion of investment as a percentage of GDP continues to contract rapidly in this scenario, and it will not be sufficient to reverse the 10-year deterioration of infrastructure conditions. The ASCE, Federal Highway Administration and other expert organizations point to a large backlog of essential infrastructure projects that require a large catch-up jolt to current spending. Instead, under the low investment baseline scenario, infrastructure degradation continues over the coming years.

The alternative "high investment" scenario involves an improvement to infrastructure quality and a boost to the quantity of investment relative to economic output, extending through the coming decades. The ASCE *Failure to Act* final report estimated that compared to current investment trends and projections, bringing public infrastructure up to minimum standards would require an additional average expenditure of $125 billion per year, in 2010 dollars, from 2012 to 2020. From 2021 to 2040, the average investment gap is another $175 billion per year.[34]

Figure 5-1. Real Low Investment and High Investment (Percentage of GDP)



Source: LIFT Modeling Analysis by Inforum

[34] See especially Table 2 in the summary report: *The Impact of Current Infrastructure Investment on America's Economic Future* (American Society of Civil Engineers, 2012).

The exercise in this report contemplates a somewhat less ambitious addition to investment than the ASCE. This "high investment alternative" starts with an injection of $83 billion (in 2009 dollars, or about $100 billion in 2014 dollars) of new public investment into infrastructure in each year from 2014 to 2016. After that initial injection, real infrastructure spending rises by about 1.7 percent per year from the new levels, compared to 0.4 percent growth per year in the low investment alternative. This higher relative level and growth of investment is preserved throughout the simulation, but as Figure 5-1 shows, the ratio of total spending to GDP still falls a bit over the longer term. Overall, the high investment scenario boosts spending by 0.5 to 0.6 percent of GDP through 2030, compared to the low investment baseline.

Table 5-1 displays the infrastructure spending increases for each public infrastructure category. Investment assumptions are tailored for highways and streets, mass transit and rail, ports and inland waterways, aviation facilities (i.e., airports, runways and air traffic technology) and water and wastewater systems. Table 5-1 shows that almost three-quarters of the total enhancement investment is allocated to streets and highways.

Table 5-1. Enhanced Investment in Public Infrastructure by Category (in Billions of 2009 Dollars)

	Difference in Investment				
	2015	2017	2020	2025	2030
Highways and Streets	60.0	63.3	73.8	93.0	114.4
Mass Transit and Rail	8.0	8.3	9.2	10.9	12.7
Ports and Inland Waterways	2.0	2.0	2.1	2.2	2.4
Aviation Facilities	5.0	5.2	5.7	6.7	7.7
Water and Wastewater	8.0	8.4	9.7	11.9	14.2
Total Public Investment	**$83.0**	**$87.3**	**$100.6**	**$124.7**	**$151.4**
As Percent of GDP	**0.5**	**0.5**	**0.5**	**0.6**	**0.6**

Source: LIFT Modeling Analysis by Inforum

5-2. The Effects of Enhanced Infrastructure Investment

Improvements to infrastructure quantity and quality yield cost and productivity effects that vary from system to system. The ultimate effects of the various infrastructure improvements, measured across industries and across time, are products of several mechanisms built into the model assumptions and parameters. Each are described in turn:

- Highways and roads: The largest impact of improved roads is to increase labor productivity not only in surface transportation but also in any industry dependent on delivery or service vehicles. Reduced congestion on highways lowers labor costs and reduces the time required to deliver given amounts of goods and services. Businesses and consumers also enjoy significantly lower costs for depreciation, fuel, tires, motor vehicle parts and insurance.

- Mass transit: When transit and train systems operate according to design, costly passenger delays are avoided, and the overall costs of operation are lower. Since the majority of transit trips entail commuters traveling to and from workplaces, reduced delays yield more than a gain of leisure time; they boost economically productive time spent at work as well.

- Ports and inland water transportation: As with surface transportation, better ports and waterways reduce the direct costs of shipping by increasing productivity and reducing other costs, such as spoilage and maintenance. Reduced bottlenecks in water transportation can have particularly favorable effects on the cost of imports and the competitiveness of exports. Indeed, when inadequate infrastructure causes missed opportunities for exporters, the damage to the economy is especially large. The interruption of grain exports caused by broken locks on the Mississippi River, for example, could have devastating effects on the agriculture sector and Midwestern economies.

- Air transportation: Improved air transportation facilities and a more expeditious transition to a NextGen Air Transportation System will enhance airline productivity, decrease the costs of services and reduce flight delays, helping to boost productivity across dependent sectors. An important competitive advantage for air freight is its speed to market. If this advantage is enhanced, then U.S. competitiveness will rise.

- Water and wastewater systems: Economies of scale are especially important in the supply of clean water and the processing of wastewater, and so these systems usually are centralized within cities and towns. Greater efficiencies and extensions in centralized water and sewer systems mean that new businesses and consumers can access relatively inexpensive facilities, creating new opportunities for growth. Centralized systems also typically are better for public health and the environment.

How do infrastructure improvements affect overall macroeconomic performance in terms of production and income? In general, business and manufacturing firms respond to productivity enhancements and cost reductions by lowering prices for the goods and services they produce, leading to increased demand for their products and improving their comparative advantages versus foreign competition. Moreover, one industry's prices are another industry's costs. Therefore, as costs of transport and utilities fall, the benefits cascade across the economy, boosting the income and welfare of each industrial sector and each household. The LIFT model's linkages among industries and from industries to consumers provide a framework to make a full assessment of how improved infrastructure affects the whole economy.

5-3. Macroeconomic Results

Table 5-2 shows the modeling results. For the most part, results are shown as the percentage differences between the high investment alternative case and the low-investment base case. The enhanced investment of about 0.5 percent of GDP starts in 2014, and it significantly boosts the economy by 2020, by about 1.3 percent of real GDP. By 2030, real GDP is 2.9 percent larger than the baseline level. Improvements to real personal consumption and in real exports are similar.

Since they are complementary to public infrastructure investment, private investment in equipment and nonresidential structures is significantly higher in the short term. In 2015, for instance, private nonresidential structures investment is 1.6 percent greater than in the baseline, and equipment investment is 1.4 percent up compared to the baseline. These compare to GDP, which is up only 0.9 percent. Since the assumed change in infrastructure spending comes from the surge in government investment, it is especially elevated in the high investment scenario: 2.7 percent greater than the baseline in 2015, 3.4 percent in 2020 and 4.9 percent in 2030.[35]

On the supply side, the larger GDP is supported both by greater employment and by increased labor productivity. In the short run, infrastructure investment boosts jobs by almost 1.3 million in 2015 and 1.7 million by 2017. This number falls over time as the productivity effects of better infrastructure take hold. Because the initial employment formation is skewed toward construction, a sector with relatively low productivity growth, aggregate labor productivity falls a bit in the short run. Output across industries is enhanced over the longer term, however, mainly through the positive productivity effects of better infrastructure. Labor productivity is 1.2 percent and 2.2 percent greater than baseline levels in 2025 and 2030, respectively. That is, of the 2.9 percent enhancement of GDP in 2030, 76 percent of the increase is made possible by productivity enhancements due directly to infrastructure investments. The rest is due to higher labor participation.

[35] The modeling results presented here do not depend on which branch of government makes the enhanced investment. For sake of convenience, we assume that the federal government finances most of the new investment. However, since the federal government is responsible for the most investment spending, state and local governments could be the source of much of the funding. Public–private partnerships (PPP) also could become an important source of financing; see the next section for details.

Table 5-2. Macroeconomic Results (2015–2030)

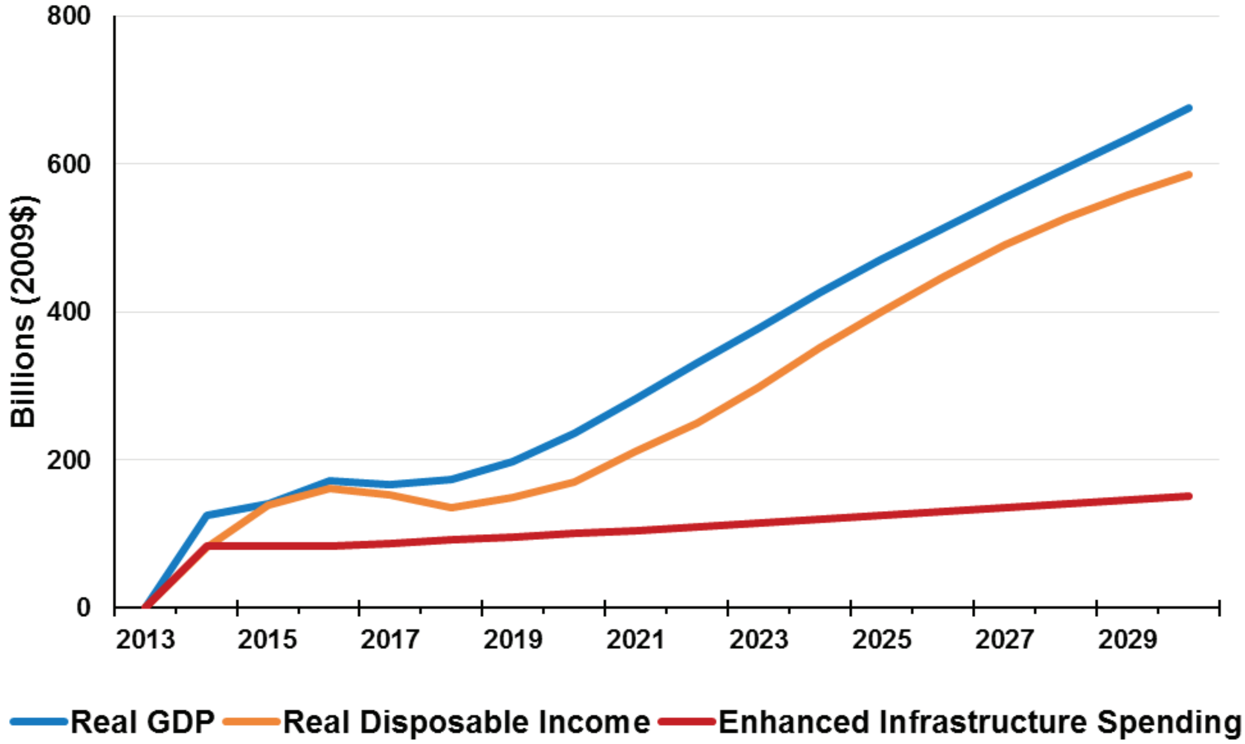
	2015	2017	2020	2025	2030
Enhanced Real Investment					
In Billions of 2009 Dollars	83.0	87.3	100.6	124.7	151.4
As Percent of GDP	0.5	0.5	0.5	0.6	0.6
Real GDP by Final Demand Category					
Gross Domestic Product	0.9	1.0	1.3	2.3	2.9
Personal Consumption	0.4	0.6	1.0	2.0	2.7
Nonresidential Structures	1.6	1.3	0.9	2.2	2.4
Equipment Investment	1.4	0.9	0.7	1.6	1.7
Residential Investment	0.9	1.3	0.7	2.7	3.0
Exports	0.2	0.5	1.0	2.0	2.8
Imports	1.3	1.2	1.6	2.8	3.4
Government	2.7	2.8	3.4	4.3	4.9
Price Indicators					
GDP Deflator	0.1	0.3	0.2	-0.3	-0.4
PCE Deflator	0.0	0.1	0.0	-0.8	-1.0
Exports Deflator	0.0	0.0	-0.2	-0.7	-1.0
Labor Force, Employment and Productivity					
Labor Force	0.1	0.3	0.5	0.5	0.5
Thousands	159.5	447.2	835.3	867.6	912.1
Total Employment	0.8	1.1	0.8	1.0	0.6
Thousands	1282.8	1721.0	1298.5	1580.0	1129.8
Total Lab Productivity (12$/hr)	-0.1	-0.2	0.4	1.2	2.2
Real Disposable Personal Income					
Percent Difference	1.2	1.2	1.2	2.6	3.4
In Billions of 2009 Dollars	140.0	152.9	170.3	401.0	586.9
2009$ per Household	1121.8	1201.0	1300.1	2916.0	4072.3
Nominal Fiscal Balances (in Billions of Dollars)					
Public Infrastructure Spending	98.6	109.1	136.2	189.1	253.0
as Percent of GDP	0.5	0.5	0.6	0.6	0.6
Government Net Borrowing	94.4	76.4	1.4	-25.5	-55.7
as Percent of GDP	0.5	0.3	-0.1	-0.1	-0.2
Government Net Debt	161.5	320.8	404.3	254.5	124.7
as Percent of GDP	0.1	0.5	0.4	-0.8	-1.6

Note: Alternatives are shown in percentage deviations from baseline, except where noted.

Source: LIFT Modeling Analysis by Inforum

The best indicator of the net welfare gain provided by enhanced investment is household real disposable income. This statistic not only includes the gain of income resulting directly from increased economic activity and efficiency (as measured by GDP), but also measures the enhancement to purchasing power due to lower prices and lower need for consumer direct and indirect expenditures on transportation, utilities and other goods and services. It also reflects the implied cost of paying for the infrastructure investment. The benefit of infrastructure spending is increased real disposable income above baseline levels, from 1.2 percent in 2015 to 3.4 percent by 2030. Net of investment, improvements to all types of infrastructure imply a gain in per-household real income of $1,300 in 2009 dollars by 2020 and exceeding $4,400 per household in 2030.

Figure 5-2. Changes to Infrastructure Investment, Real GDP and Real Disposable Income, Magnitude and Effects of Higher Investment Spending, 2014–2030 (in Billions of 2009 Dollars)



Source: LIFT Modeling Analysis by Inforum

The overall macroeconomic dynamics of infrastructure spending are summarized in Table 5-2, and the increases in GDP and income are displayed in Figure 5-2. It shows, in billions of 2009 dollars, how higher infrastructure investment raises both GDP and disposable household income. From 2014 to 2017, the economy is boosted through the multiplier on investment demand, but this effect dissipates through time. The supply-side effect initially is muted, but improved infrastructure eventually produces greater GDP by raising productivity. The graph shows that by 2020, every $1.00 spent on infrastructure returns about $1.60 in disposable income and $1.90 in GDP.[36] Sustained infrastructure spending, however, means that the economy becomes progressively more productive. Because of the benefits of cumulative investments over time, infrastructure investments by 2030 produce returns of close to $3.00 per every $1.00 invested.

Industry Results

Table 5-3 shows the impact of higher infrastructure investment on real gross output for major industries of the economy. These measures show the effects of higher spending on industry production levels, after adjusting for inflation. Not surprisingly, the industry most helped in the high investment scenario is construction. Compared to the baseline, construction spending is more than 4 percent greater in the short run and even more in later years. Transportation service industries also enjoy a boost to real output as various modes capitalize on better underlying infrastructure to move more merchandise and people. Manufacturing is affected positively as well, particularly for durable goods sectors that make construction materials. Overall, Table 5-3 shows that positive effects of better infrastructure are spread throughout the economy.

[36] These results are similar to estimates by the U.S. Congressional Budget Office. They found that that one dollar of infrastructure spending yields another 60 cents in economic activity, leaving GDP $1.60 higher (reported in Deloitte (2013)). Leduc and Wilson (2012) report multipliers of at least 2.0 for federal highway grants to states.

Table 5-3. Real Gross Output by Industry, Percentage Differences

	2015	2017	2020	2025	2030
Gross Domestic Product	**0.9**	**1.0**	**1.3**	**2.3**	**2.9**
Agriculture, Forestry and Fisheries	0.4	0.7	1.1	1.9	2.5
Mining	1.0	1.0	1.2	1.8	2.2
Construction	4.3	4.4	4.4	6.5	7.4
Manufacturing					
Nondurables	0.7	0.8	1.2	2.2	2.8
Durable materials and products	1.7	1.6	1.9	3.1	3.6
Nonelectrical Machinery	1.3	1.1	1.2	2.3	2.7
Electrical Machinery	0.6	0.6	0.9	2.0	2.9
Transportation Equipment	0.8	0.7	1.1	2.1	2.6
Instruments and Miscellaneous	0.5	0.5	0.8	1.6	2.1
Transportation	1.0	1.2	1.7	3.1	4.1
Utilities	0.3	0.4	0.7	1.4	1.7
Trade	0.6	0.8	1.2	2.5	3.2
Finance, Insurance and Real Estate	0.5	0.6	1.0	2.2	2.9
Services	0.9	0.9	1.2	2.2	2.8

Note: Figures show the percentage difference between high and low investment scenarios.

Source: LIFT Modeling Analysis by Inforum.

Table 5-4 shows the boost to exports across the economy. The figures show differences in real exports between the low investment baseline and the high investment scenario, in 2009 dollars. By 2020, the high investment economy exports $28 billion more than in the baseline, a figure that grows to $120 billion by 2030. Manufacturing activities directly supply about 50 percent of the enhanced exports. Moreover, much of the increases of exports for transportation, trade and royalty income are associated directly with manufacturing-industry exports.

Table 5-4. Exports by Industry (in Billions of 2009 Dollars)

	2015	2017	2020	2025	2030
Total Exports	**5.0**	**11.5**	**28.0**	**69.5**	**120.3**
Agriculture, Forestry and Fisheries	0.4	0.8	1.6	3.2	5.1
Mining	0.0	0.1	0.1	0.2	0.3
Manufacturing	2.4	5.4	13.8	34.0	58.0
Nondurables	0.9	2.3	5.6	12.6	20.7
Durable Materials and Products	-0.1	0.1	1.0	2.6	4.8
Nonelectrical Machinery	0.7	1.2	2.3	4.9	7.8
Electrical Machinery	0.2	0.5	1.5	4.2	8.0
Transportation Equipment	0.5	0.8	2.4	6.5	10.9
Instruments and Miscellaneous	0.1	0.4	1.1	3.1	5.7
Transportation	0.4	1.0	2.5	6.5	11.9
Utilities	0.0	0.1	0.3	0.7	1.2
Trade	0.4	0.9	2.2	5.4	9.3
Finance, Insurance and Royalties	0.8	1.8	4.7	12.0	21.1
Services	0.3	0.6	1.6	4.0	7.0
Scrap and Other Industry	0.3	0.8	1.2	3.4	6.3

Note: Difference between high and low investment scenarios is in billions of 2009 dollars.

Source: LIFT Modeling Analysis by Inforum.

Table 5-5 shows the employment impacts across sectors. The most outstanding figure is the large fall of transportation services employment compared to the baseline. This signifies the major benefit of better infrastructure: the productivity of moving goods and passengers expands so much that employment in the sector falls significantly despite increased transportation volumes. These workers then become available to work in other sectors. Most of the other sectors, including manufacturing, see the familiar pattern of enhanced short-run employment but lower long-run employment as productivity rises compared to the baseline.

Table 5-5. Employment by Industry (Differences in Thousands of Jobs)

	2015	2017	2020	2025	2030
Total Employment	**1282.8**	**1721.0**	**1298.5**	**1580.0**	**1129.8**
Agriculture, Forestry and Fisheries	-2.3	0.5	-22.8	-55.4	-95.6
Mining	8.7	10.1	7.2	4.7	0.8
Construction	671.8	741.5	693.5	917.9	985.0
Manufacturing	112.6	155.1	102.5	123.5	75.2
Nondurables	27.8	48.7	38.3	52.2	45.4
Durable Materials and Products	48.3	53.3	36.7	41.6	24.3
Nonelectrical Machinery	21.6	27.9	15.4	15.9	4.0
Electrical Machinery	5.2	7.4	4.0	3.3	-0.2
Transportation Equipment	7.6	13.4	7.8	11.8	6.3
Instruments and Miscellaneous	2.2	4.3	0.4	-1.3	-4.7
Transportation	1.4	-13.7	-80.0	-178.4	-314.7
Utilities	1.6	10.0	3.5	-0.1	-11.4
Trade	104.5	222.8	170.3	262.2	172.2
Finance, Insurance and Real Estate	24.2	56.0	40.0	51.4	30.7
Services	359.7	536.8	381.9	449.0	282.3

Note: Difference between high and low investment scenarios in thousands of jobs.

Source: LIFT Modeling Analysis by Inforum

6. Conclusion and Policy Comments

Widespread access to high-quality infrastructure is indispensable to the United States' economic growth and high standard of living. Unfortunately, falling levels of real public infrastructure investment can be identified for at least the past decade, and the Great Recession did even more to discourage investment. It is possible that the current and prospective conditions of our infrastructure systems will significantly undermine prosperity in coming years. The adverse economic effects of degraded infrastructure have important implications for public policy because the development of infrastructure inevitably involves government administration, activity and often, public funding. In all cases, federal, state and local governments contribute the primary institutional underpinnings (e.g., legal system, regulation and supporting services) for infrastructure markets. This role is critical. Not surprisingly, however, the administration of infrastructure systems is a complex process spanning different levels of government and involves large and various segments of the private sector, requiring high levels of coordination. Therefore, there always is a case for improvement of the traditional processes of infrastructure investment, project delivery and maintenance and operations.

Global manufacturing executives judged physical infrastructure to be the sixth most important driver of competitiveness (Deloitte and the U.S. Council on Competitiveness, 2013), noting that the quality of infrastructure plays important roles in the determination of cost and process efficiencies and productivity. High-quality infrastructure is essential for moving physical goods, information and energy. While U.S. infrastructure ages, emerging economies are developing advanced infrastructure of their own, and U.S. businesses are becoming less competitive. Not only are traditional types of infrastructure important, such as roads and ports, but also manufacturing executives note that their operations depend heavily on electricity, information technology and telecommunications systems to maintain their competitiveness.

Manufacturers in the United States are particularly sensitive to the quantity and quality of infrastructure. Last year, the NAM and Building America's Future Educational Fund commissioned a survey of manufacturers concerning their perspectives on the state of U.S. infrastructure. Manufacturers' responses included the following:

- U.S. infrastructure is old, inefficient and badly in need of modernization. Some 70 percent of 400 surveyed manufacturers communicated that U.S. infrastructure is in fair or poor shape and needs a great deal or quite a bit of improvement. A unanimous view emerged that not one sector of infrastructure is performing at a pace to keep up with the needs of business.

- A majority of respondents—65 percent—doubt that infrastructure is positioned to respond to the competitive demands of a growing economy. The survey results underscored a widespread recognition among manufacturers: U.S. infrastructure continues to rest on a legacy of past investments, and it can and should be improved.[37]

The respondents to these surveys understand that a principal purpose of infrastructure investment is to enable private industries to produce and distribute their goods and services more efficiently. Poor-quality infrastructure increases costs for key activities, such as surface, air and water transportation, energy distribution, telecommunications and water and sewer systems. In turn, elevated costs in these enabling industries are passed downstream to agriculture, manufacturing, distribution and service sectors, where they reduce the economy's competitiveness. For instance, an exporter that produces an otherwise globally competitive product might lose its advantage if forced to ship its product via degraded and congested highways or seaports.

Surprisingly, relatively few studies provide empirical evidence of how the degradation of U.S. infrastructure affects economic performance. Some studies have linked changes in the investment, stock or quality of infrastructure to macroeconomic performance, often by considering effects of infrastructure on aggregate productivity growth.[38] They use econometric analysis to investigate how GDP and other performance variables are influenced by public or private infrastructure expenditures. Several pioneering macroeconomic studies by David Aschauer and others found significant economic productivity and growth effects from infrastructure investment.[39] Susanne Trimbath and colleagues developed the Transportation Performance Index to track the capacity and quality of infrastructure over time and to identify its effects on U.S. competitiveness and economic performance.[40] Their study shows that better transportation infrastructure can lead to economic growth—that, in fact, transportation is a leading indicator of economic activity.

Indeed, experts are having interesting and important discussions concerning innovative models for the financing, construction and maintenance of infrastructure.[41] This report highlights four major issues emanating from these discussions:

1. The allocation of scarce capital for infrastructure investments can be tied more effectively to an evaluation of net social benefits. Decision-making currently is compartmentalized according to transportation mode, and thus, planning among transportation sectors is poorly coordinated, and there is inadequate reliance on systematic economic analysis.[42] Investment in the upgrade and maintenance of existing infrastructure typically offers a high rate of return, and efforts to maximize the flow of vehicles substantially can improve efficiency of existing networks.[43] Especially when upgrades to existing systems strengthen the competitiveness of existing urban areas, they can promote regional economic clusters and reduce sprawl.

2. Greater economic scrutiny of projects should not mean longer development and evaluation periods. Most infrastructure projects naturally are large in scale and scope, and their construction and operation can affect nearby residents and the environment. Still, the procedures of evaluation cannot be used to obstruct and delay when the underlying facts support the economic viability and environmental sustainability of important projects. Government at all levels must streamline processes of approval, to the fullest extent possible, and insulate projects from the influence of narrow interests. This imperative applies to private infrastructure investment as well as to public projects.

3. Pricing mechanisms in appropriate scenarios can encourage users to make more efficient use of infrastructure when they reflect the full costs of its use. Residential consumers of water and wastewater services already pay metered pricing for the cost of investment and maintenance of necessary infrastructure, and other forms of infrastructure could benefit from similar pricing systems. For example, congestion pricing systems, such as high-occupancy toll (HOT) lanes and variable rates for mass transit, can help to reduce delays and improve system throughput. The case for placing more of the cost burden on users of infrastructure services with marginal cost pricing is well established.[44] The revenue generated can be employed to finance capacity enhancements, and so the pricing mechanisms serve two important roles: to improve efficient use of existing infrastructure and to finance extensions to its capacity.

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[37] See Timmons, J. (February 12, 2014). Comments of the NAM before the Senate Committee on Environment and Public Works on "MAP-21 Reauthorization: The Economic Importance of Maintaining Federal Investments in Our Transportation Infrastructure."

[38] See, for example, Mamuneas and Nadiri (2003).

[39] See Aschauer (Is Public Expenditure Productive?, 1989); Aschauer (Public Investment and Productivity Growth in the Group of Seven, 1989); Munnell (1992); Fernald (1999); and Pereira (2000).

[40] See U.S. Chamber of Commerce (2011) and Trimbath (2011).

[41] See, for example, National Surface Transportation Policy and Revenue Study Commission (December 2007); Galston and Davis (December 2012); and GAO (July 2007).

[42] See GAO (July 2007).

[43] See GAO (July 2007), Gramlich (1994) and Pereira (2000).

[44] See, for example, the Report of the National Surface Transportation Infrastructure Financing Commission (February 2009); Langer, Winston and Baum–Snow (2008); and GAO (July 2007).

4. The private sector can play a greater role in the design, financing, construction, maintenance and operation of infrastructure resources.[45] PPPs, for example, are not as developed in the United States but have worked well abroad, particularly in Europe, South America and Australia. The private sector can contribute much needed financial capital, but "PPPs also can (1) prioritize projects that generate the highest returns, (2) improve life-cycle investing and (3) provide incentives for more efficient operations and maintenance."[46] PPPs are not a complete solution to filling current infrastructure gaps, but evidence suggests that there are opportunities for broader applications in the United States.

The results from this study demonstrate the positive economic effects of a new commitment to public infrastructure. This includes financing coming from the private sector as well as from various levels of government. It is a good time for such investment. In the short run, spending on infrastructure can stimulate the economy and create additional activity and jobs in upstream and ancillary businesses. Moreover, because the economy remains well below its productive potential, and unemployment and underemployment remains high, the "multiplier effects" of infrastructure investment will boost activity. Therefore, accelerated private and public sector efforts on infrastructure development, including a significant supply of new spending, allow pursuit of three objectives at once:

1. New funding will help the United States to catch up from a decade of deferred infrastructure development and maintenance and will usher in an era of renewed and necessary development. Many of the most critical problems are well-identified by engineers, the business community and public authorities. From an economic perspective, it is imperative to address them soon.

2. A new national infrastructure strategy that embraces proven innovations in finance and regulatory reform, as well as construction and operational efficiencies, can help to lower operating costs, increase profitability, mitigate logistical challenges, attract economic development and provide a catalyst for businesses to invest in new expansion and growth.

3. Greater infrastructure investment will improve an economy that continues to suffer from high unemployment and lackluster growth.

Therefore, calls for new, substantial and focused expansion of both public and private expenditures are coming from all corners, including calls from President Obama's former National Economic Council Director, Larry Summers (2014), and from Reagan-era budget hawks, such as Martin Feldstein (2013).

Widespread access to high-quality infrastructure is indispensable to the United States' economic development and standards of living. It is possible, however, that the poor current and prospective conditions of our infrastructure systems will significantly undermine prosperity in coming years. A new infrastructure effort is needed, and new ideas can and should accompany this investment. There is no better time than now to address the problem.

[45] See, for example, the U.S. Department of Transportation (May 2006).

[46] National Surface Transportation Policy and Revenue Study Commission (December 2007).

7. Appendix

7-1. Data Sources for Public Infrastructure Spending

In 2010, the CBO published federal infrastructure spending estimates from fiscal year 1956, the year that the Federal-Aid Highway Act provided funding for the interstate highway system, through 2009. The CBO published corresponding state and local spending estimates from 1956 to 2007. The OMB provided most federal spending data, and the U.S. Census Bureau provided most state and local data. In this report, public spending data rests on the published CBO (2010) figures from 1956 through 2000 or later. Newer information provided by many of these same sources was used to extend the CBO estimates.

The report used current OMB publications to extend the estimates of federal spending. For each type of infrastructure, estimates include measures of capital investment and of operations and maintenance spending, and they distinguish federal grants and loan guarantees and other federal spending. In most cases, OMB data could be used to extend federal spending estimates through fiscal year 2012. Water supply and wastewater treatment spending estimates were extended through 2011 using OMB figures, and calculations based on NIPA data provide estimates for 2012.

Total state and local spending estimates, for both capital investment and operations and maintenance spending, are obtained from the latest Census Bureau publications. These provide spending estimates through fiscal year 2010. Total state and local spending estimates for 2011 and 2012, for both investment and operations and maintenance spending, are based on NIPA growth rates for similar categories. Net spending estimates are calculated as the differences between total state and local spending and federal grants and loan subsidies.

For each of the spending categories, a relevant indicator of price growth was identified within the NIPA publications. These price estimates were used to adjust the spending levels for inflation, and the results indicate the quantities of infrastructure assets and maintenance efforts that are purchased each year.

The data reveal annual details of federal, state and local spending levels, but they do not immediately indicate the quantities of infrastructure capital that are in place. These capital stocks provide infrastructure services to consumers, businesses and government entities. The fixed assets dataset, published by the BEA, was used for alternative estimates of public investment in structures and for corresponding levels of capital stock. The fixed assets accounts also provided most private investment spending and capital stock data.

7-2. The LIFT Model of the U.S. Economy

The Inforum approach to modeling attempts to provide both the dynamics and high-level accounting of macroeconomic models and the industry structure featured in the general equilibrium approach to modeling. The LIFT model is a dynamic general equilibrium representation of the U.S. national economy. It combines an inter-industry I-O formulation with extensive use of regression analysis to employ a "bottom-up" approach to macroeconomic modeling. In this way, the model works like the actual economy, building the macroeconomic totals from details of industry activity, rather than by distributing predetermined macroeconomic quantities among industries. For example, aggregate investment, total exports and employment are not determined directly, but are calculated as the sum of their parts: investment by industry, exports by commodity and employment by industry. LIFT contains full demand and supply accounting for 110 productive sectors.[47]

This bottom-up technique provides several desirable properties for analyzing the economy. First, the model describes how changes in one industry, such as increasing productivity or changing international trade patterns, affect related sectors and the aggregate quantities. Second, parameters in the behavioral equations differ among products, reflecting differences in, for instance, consumer preferences, price elasticity in foreign trade and industrial structure. Third, the detailed level of disaggregation permits the modeling of prices by industry, allowing the exploration of the causes and effects of relative price changes.

Another important feature of the model is the dynamic determination of endogenous variables. LIFT is an annual model, solving year by year, and it incorporates key dynamics that include investment and capital stock formation. For example, investment depends on a distributed lag in the growth of investing industries, and international trade depends on a distributed lag of foreign price changes. Moreover, parameter estimates for structural equations largely are based on time-series regressions, thereby reflecting the dynamic behavior of the economic data underlying the model. Therefore, model solutions are not static; instead, they project a time path for the endogenous quantities. The LIFT model thus simulates the economy year by year, allowing analysts to examine both the ultimate economic impacts of projected energy or environmental policies and the dynamics of the economy's adjustment process over time.

Despite its industry basis, LIFT is a general equilibrium model, using bottom-up accounting to determine macroeconomic quantities that are consistent with the underlying industry detail. It includes macroeconomic variables that are consistent with the NIPA and other published data. This macroeconomic "superstructure" contains key functions for household savings behavior, interest rates, exchange rates, unemployment, taxes, government spending and current account balances. Like many aggregate macroeconomic models, this structure is configured to make LIFT exhibit "Keynesian" demand-driven behavior over the short term but neoclassical growth characteristics over the longer term. For example, while monetary and fiscal policies and changes in exchange rates can affect the level of output in the short-to-intermediate term, supply forces—available labor, capital and technology—will determine the level of output in the long term.

The LIFT model is particularly suited for examining and assessing the macroeconomic and industry impacts of the changing composition of consumption, production, foreign trade and employment as the economy grows through time.

The inter-industry framework underlying the model is composed of five blocks: final demand, supply, factor income, prices and the accountant. The first block of LIFT uses econometric equations to predict the behavior of real final demand (i.e., consumption, investment, imports, exports and government expenditures). The components are modeled at various levels of detail. For example, aggregate consumption is the sum of 83 consumption products, and aggregate construction investment is the sum of expenditures for 19 types of private structures. Demand by product, with product sectors consistent with the input-output table (matrix), is determined using bridge matrices to convert final demand to the commodity level. Following Wilson (2001), this equation is specified as:

$$f_{110} = B^{C}_{110\times 83}c_{83} + B^{E}_{110\times 65}e_{65} + B^{S}_{110\times 25}s_{25} + g_{110} + v_{110} + x_{110} - m_{110}$$

where *B* represents a bridge matrix for the various components (i.e., consumption, equipment investment by purchasing industry and construction by type[48]) and where remaining variables represent consumption by product, equipment investment by purchasing industry, structures by type, inventory change, exports and imports and government spending.

[47] Additional details may be found in Meade (2002).

[48] Note that some details presented here are simplified accounts of the actual model, such as the presentation of the government demand vector. Government spending by commodity type within the model is constructed as the sum of several bridged demand vectors that provide detail for federal defense, federal nondefense and state and local spending.

In the supply block, these detailed demand predictions then are used in an input-output production identity to calculate real gross output:

$$q = A \times q + f$$

where *q* and *f* are vectors of output and final demand by commodity, respectively, each having 110 elements, and where *A* is a matrix of input-output coefficients. Input-output coefficients and the bridge matrix coefficients vary over time according to historical trends evident in available data and, in some cases, using assumptions about how technology and tastes might develop in the future (Almon, 2008).

Commodity prices are determined in a similar fashion. In the factor income block, econometric behavioral equations predict each value-added component (including compensation, profits, interest, rent and indirect taxes) by industry. Labor compensation depends on industry-specific wages that are determined by industry-specific factors as well as overall labor market conditions. Profit margins are dependent on measures of industry slack (i.e., excess supply or demand) and, for tradable sectors, on international prices. Depreciation depends on capital stock levels. Indirect taxes and subsidies are imposed, in most cases, through exogenous ad valorem rates on overall nominal output.

The industry value-added levels are allocated to production commodities using a make matrix. Then the fundamental input-output price identity combines value added per unit of output with unit costs of intermediate goods and services to form an indicator of commodity prices:

$$p' = p' \times A + v'$$

where *p* and *v* have 110 elements to represent production prices and unit value added, respectively. This identity ensures that income, prices and output by sector are directly related and are consistent. In turn, relative prices and income flows are included as independent variables in the regression equations for final demand, creating simultaneity between final demand and value added.

As noted above, LIFT also calculates all of the major nominal economic balances for an economy: personal income and expenditure, the government fiscal balance (at the federal, state and local government levels) and the current account balance. It also contains a full accounting for population, the labor force and employment. This content is important for building alternative simulations because it ensures consistency between economic growth determined on the product side and the inflation and income components. The model may be used to examine how alternative microeconomic conditions or policies will affect other aspects of the economy. Because the input-output structure allows a bottom-up approach to modeling the macroeconomy, macroeconomic results fully are consistent with simulated industry disruptions.

Recent projects include analyses of the effects of the sequester and other recent changes to fiscal policy (Werling, *Fiscal Shock: America's Economic Crisis*, 2012) and analysis of the harm done by policies that allow deterioration of infrastructure (Werling, *Failure to Act: The Economic Impact of Current Investment Trends in Airports, Inland Waterways, and Marine Ports Infrastructure*, 2012). Long-run economic effects of technological development were assessed in Meade (2010), in the case of vehicle electrification, and in Meade (2009) for the case of policies that encourage technological development to combat climate change. Examples of impact analysis conducted with the LIFT model include a study of the economic effects of port closures following a terroristic attack (reported in Arnold, et al. (2006) and in two private studies) and the economic impacts of the September 2001 attacks (Werling and Horst, 2009). Other studies of macroeconomic and industry impacts of supply constraints include "Macroeconomic and Industrial Effects of Higher Natural Gas Prices" (Henry and Stokes Jr., 2006) and "Immigration Impacts on the U.S. Economy."[49]

[49] The Inforum study of immigration was delivered to the U.S. Department of Commerce in 2006. For additional discussion of the Inforum modeling methodology in relation to Vector AutoRegression (VAR), Computable General Equilibrium (CGE) and other approaches to economic modeling, see Wilson (2003), Grassini (2005) and Grassini (2005), and Almon (2008). For a survey of methodology and input-output techniques, see Almon, et al. (1974), Almon (1991), McCarthy (1991), Manprasert (2004) and Almon (2008). Details on consumption modeling are available in Almon (1979), Almon (1998), Chao (1991), Bardazzi and Barnabani (2001) and Li (2006). Wilson (2001) and Wilson (2003) describe modeling of productivity and employment. Details on treatment of international trade in the Inforum modeling system are presented in Nyhus (1991) and Qing (2000). Many of these papers and additional details and references may be found on the Inforum web site: **www.inforum.umd.edu**.

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