Inforum Studies of Public Infrastructure

Economic Data and Modeling

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Outline

Introduction to Inforum Infrastructure Studies

- Data Expertise
  - Macroeconomic Accounts
  - Industry and Detailed Investment Accounts
  - Other Accounts (Detailed Federal and Regional budgets, etc.)
  - Worked with specialist to develop micro data and parameters
- Macro-InterIndustry Model
  - Useful medium-long forecast horizons, typically 15-30 years
  - Consistency and detail of structural model particularly useful

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Purpose of Data Analysis and Modeling

- Provide context of historical data for the proposed policies and spending plans.
- Few details in current proposals, but historical data suggests how policy might be designed.
- Potential Uses: Investigate
  - Demand-side effects (e.g. feasibility with low unemployment)
  - Supply-side effects (long-run benefits; costs and competitiveness)
  - Financing requirements for government and private sector
  - GDP growth, labor requirements, inflation effects, crowding of private activity, government debt, ...

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Inforum Infrastructure Studies

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  - Investigated excess costs and productivity loss due to bad infrastructure
  - Studies included land, water, and air transportation; water supply and wastewater; and electricity infrastructure
- Catching Up (National Association of Manufacturers, 2014)
  - Incorporated ASCE work on costs of bad infrastructure
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Inforum Infrastructure Studies (Continued)

- Infrastructure: Economic Impact Analysis of FY 2018-2026 Investments (Department of Commerce, Forthcoming 2018)
  - Adapted and extended earlier work (ASCE costs, NAM public investment)
  - Reflect policy proposal sketched by the Administration
    - Small role for Federal funding
    - Large role for private participation
- Economic Impact Analysis of 2019-2028 and Longer-Run Infrastructure Investments (Forthcoming 2018)
  - Similar to DOC analysis, but with smaller spending plan
  - Greater role for Federal government (more traditional role)
  - Smaller role for private provision of "public" infrastructure
  - Will include regional analysis
- Several working papers on data and modeling

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Traditional Investments: Mixture of Public and Private

Traditional Public Infrastructure

- Highways and streets (99% public, 1% private)
- Mass transit and local passenger rail (100% public)
- Aviation facilities (94% public 6%, private)
- Marine ports and inland waterways (100% public)
- Water Resources (flood control, etc.; 100% public)
- Water Supply and Waste Water (94% public, 6% private)

Traditional Private Infrastructure

- Freight and long-distance passenger rail (100%)
- Petroleum and natural gas pipelines (100% private)
- Electric power (14% public, 86% private)
- Communication (100% private)

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- Based on Trump Administration Proposal in 2017
- Investment Spending
  - $1 Trillion over 9 years (budgets 2018-2026, assumed construction 2018-2028) (Later proposal was $1.5 Trillion)
    - $200 Billion from Federal Government (much smaller than traditional role)
      - Assume that most Federal funds transferred to regional governments (traditional practice)
      - Other Federal involvement: changes in regulation, coordination, etc. to reduce costs and reduce time to build
    - $800 Billion from Regional Governments and Private Sector (we assumed 50% each)
- Few other details provided (e.g. revenue to cover costs)

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Assumptions for FY 2018-2026: Funding Distribution (DOC 2018)

Figure: Assumed Provision of Funds (Percent)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Federal										
Direct Spending	20	20	20	20	20	20	20	20	20	20
Capital Transfers / Other	80	80	80	80	80	80	80	80	80	80
Other										
State and Local	50	50	50	50	50	50	50	50	50	50
Private	50	50	50	50	50	50	50	50	50	50

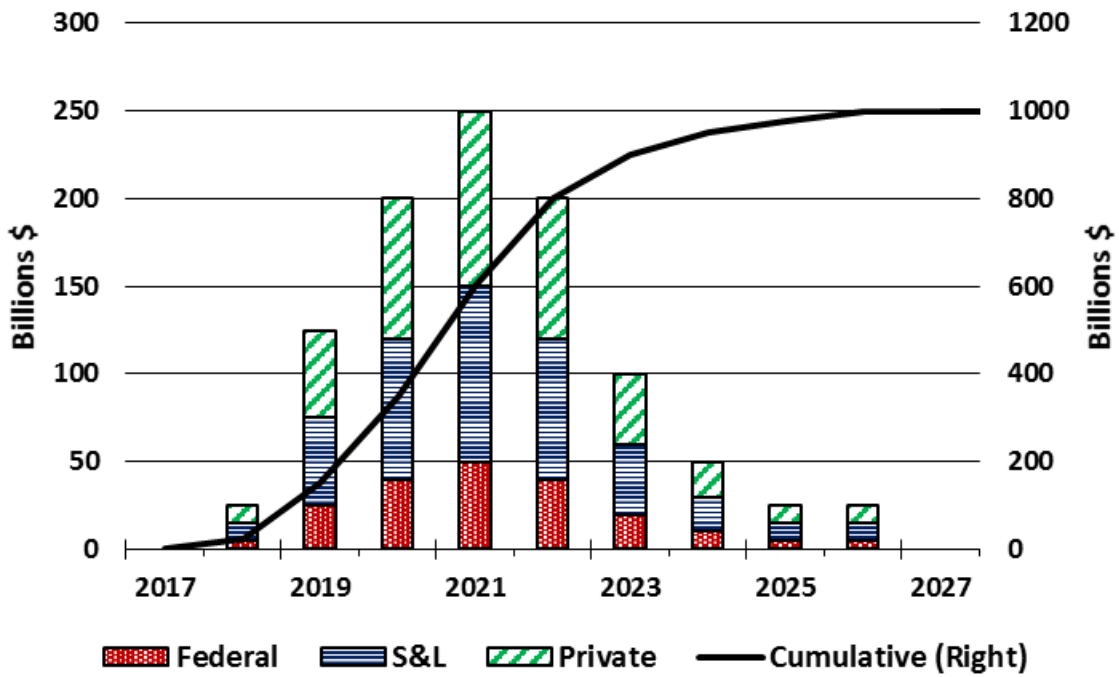
Assumptions for FY 2018-2026: Spending Authorization (DOC 2018)

Figure: Proposed Authorization Levels

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Cumulative
Federal	0	5	25	40	50	40	20	10	5	5	0	200
S&L	0	10	50	80	100	80	40	20	10	10	0	400
Private	0	10	50	80	100	80	40	20	10	10	0	400
Total	0	25	125	200	250	200	100	50	25	25	0	1,000
Cumulative	0	25	150	350	600	800	900	950	975	1,000	1,000	

Assumptions for FY 2018-2026: Spending (DOC 2018)

Figure: Proposed Spending Authorization



Assumptions for FY 2018-2026: Spending (DOC 2018)

Figure: Nominal Spending Levels (Assumptions and Results)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Total Investment Spending	0.0	17.0	75.0	125.0	150.0	150.0	150.0	125.0	100.0	50.0	35.0	25.0
Percentage of GDP	0.0	0.1	0.4	0.6	0.7	0.6	0.6	0.5	0.4	0.2	0.1	0.1
Total Federal Spending	0.0	5.0	15.0	25.0	30.0	30.0	30.0	25.0	20.0	10.0	7.0	5.0
Percentage of GDP	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
State & Local Spending	0.0	6.0	30.0	50.0	60.0	60.0	60.0	50.0	40.0	20.0	14.0	10.0
Percentage of GDP	0.0	0.0	0.1	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0
Private Spending	0.0	6.0	30.0	50.0	60.0	60.0	60.0	50.0	40.0	20.0	14.0	10.0
Percentage of GDP	0.0	0.0	0.1	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0

Assumptions for FY 2018-2026: Spending (DOC 2018)

Figure: Assumed Investment by Type (Percent)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Structures	75	75	75	75	75	75	75	75	75	75
Equipment	10	10	10	10	10	10	10	10	10	10
Intellectual Property	10	10	10	10	10	10	10	10	10	10
Land Acquisition	5	5	5	5	5	5	5	5	5	5

Outline

Historical Data Work

- Most from national accounts (macro/IO/capital), but infrastructure data often are scattered and obscured
  - Best data compiled by CBO from low-level data, but not obvious whether data are consistent with national accounts
    - Much of this work reproduced and updated by Inforum (2014)
  - Recent working paper shows at least broad consistency
  - Completed work will show a much richer picture of spending of infrastructure spending
  - Until then, results suggest that we can use CBO studies to inform our own work built on national accounts
- Careful review raises questions about accepted analysis
  - e.g. CBO deflates nominal with national account prices
  - Price indicators poor and affect results (somewhat obvious to those familiar with national accounts)
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Government-Sponsored Infrastructure (Expenditure)

- Expenditure:
  - Investment:
    - Mostly structures (assumed 75%), also equipment (10%) and intellectual property (10%) (parts of GDP)
    - Real estate purchases (5%) (in Net purchases of non-produced assets; not part of GDP)
  - Operations and Maintenance (O&M)
    - Obscured in national accounts (part of government consumption), but some information available in other data (e.g. CBO)
    - Not obvious how to model: ambiguity between replacement investment and maintenance, not clear whether investment raises or lowers O&M requirements
    - Therefore, changes from baseline in O&M often are ignored in modeling work (but not very satisfactory)

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Government-Sponsored Infrastructure (Revenue 1)

- Revenue
  - Could assume long-term debt financing (Federal level)
  - Could assume collection through general revenue (e.g. income taxes, corporate taxes, etc.)
  - Sometimes assume payment through specific taxes and fees
    - **Taxes on Production and Imports (TOPI)** (Commercial motor vehicle licenses, fuel taxes, airport fees, public utilities, commercial property taxes, etc.)
    - **Personal Taxes** (Personal motor vehicle licenses, residential property taxes)

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Government-Sponsored Infrastructure (Revenue 2)

- Revenue: Few details specified in Administration proposal
- Assume governments raise infrastructure fees to recover costs
  - Alternative: assume partial long-term Federal debt financing
- Assume new revenue recovers investment costs over 20-25 years

Personal license fees (S&L)	$ 6.7 billion
Public utilities TOPI (S&L)	$ 0.3 billion
Transportation TOPI (S&L)	$18.6 billion
Transportation TOPI (Federal)	$15.0 billion
Total (Federal), per year	**$15.0 billion**
Total (S&L), per year	**$25.6 billion**

- Federal: $t = 19.4 years = \ln\left(1 - \frac{\$200\,Billion \times r}{\$15\,Billion}\right) / \ln(1/r)$
- S&L: $t = 24.3 years = \ln\left(1 - \frac{\$400\,Billion \times r}{\$26\,Billion}\right) / \ln(1/r)$

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Private Provision of "Public" Infrastructure

- Two relevant private commodity/industry sectors
  - **Transportation Support:** Bridge, tunnel, and highway operations; bus and train stations; airports; ....
  - **Transit and Ground Passenger Transportation:** local and suburban commuter rail, local passenger rail systems, subway, etc....
- Other transportation industries provide only services, not infrastructure (e.g. trucking, airlines, water transportation)

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Public-Private Partnerships (PPP)

- Any contractual arrangement that transfers more risk from the public sector to the private sector than is the case under the traditional (design-bid-build) approach (most general definition, CBO 2014)
- Limited use in U.S: 1.5% of spending on highways (1989 – 2013), but about half came in the last five years.
- U.S. statistical agencies have not adopted standards for PPP accounting; no guidance offered.
  - e.g. trouble when statistics depend on ownership of capital (government) or operating industry (private)

Public-Private Partnerships (PPP)

- Three types used in the United States (CBO 2014):
  - **Design-Build:** Most common. Fixed-price contracts to jointly manage the design and construction. Private party accepts risk of higher costs. Revenue from taxes or tolls. Public partner retains ownership, control of revenues, O&M.
  - **Design-Build-Finance:** Private partner also provides the necessary capital and is repaid through tolls or by regional government. Private partner often joint venture between design, construction, project development, management firms, ...
  - **Design-Build-Finance-Operate-Maintain:** Private partner also performs O&M for specific period, repaid through tolls/fees or payments from regional government (with income or other tax revenue not linked to the use of the infrastructure).

Public-Private Partnerships (PPP)

- Private financing increases availability of funds only when government has imposed constraints on itself. Revenue from users and taxpayers remain ultimate source of money.
- The cost of private financing roughly equal to the cost of financing it publicly after factoring in the costs associated with the risk of losses from the project, which taxpayers ultimately bear, and the financial transfers made by the federal government. Remaining cost differences stem from incentives and conditions established in the contracts.
- PPPs have built highways slightly less expensively and slightly more quickly, compared with the traditional public-sector approach. (CBO 2014)

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    - Can learn something about O&M from A matrix columns
- Historically small role for private sector (very limited in roads and highways), but quite large in Administration proposal (assumed $400 Billion investment)
  - Assume private O&M, with tolls & fees
  - Assume large consortia of investing firms over many industries
  - Assume firms invest according to earnings from expected O&M sales (direct and intermediate)

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PPP Modeling

- Assume transportation, construction, and other industries provide investment funds
- Assume motivation is additional sales of capital services and to support capital O&M
  - Use of public roads (mostly) currently not market transactions. Expand market transactions for use of infrastructure
  - Derive expected sales levels by industry with A and Make matrices (direct sale of capital services and indirect sales)
  - Expected capital earnings then imply willingness to invest
    - PDV of investment equals PDV of additional capital income

Outline

Modeling Infrastructure Investment, Operation, and Funding

Interindustry-macroeconomic models allow extensive dynamic analysis of

- Investment (Public and private; various assets)
- Operations and Maintenance (O&M)
- Revenue (fees and tolls, taxes, private sales)
- Effects of improved quality and quantity (e.g. labor productivity, industry cost structure)

Project Goals

- Identify effects of construction program
  - Effects on labor market (unemployment rate already low)
  - Effects on inflation and interest rates
  - Effects on GDP, governement debt, etc.
- Identify effects on long-run economy
  - Effects on labor productivity
  - Effects on industry cost structure and consumer prices and quantities
  - Effects on GDP

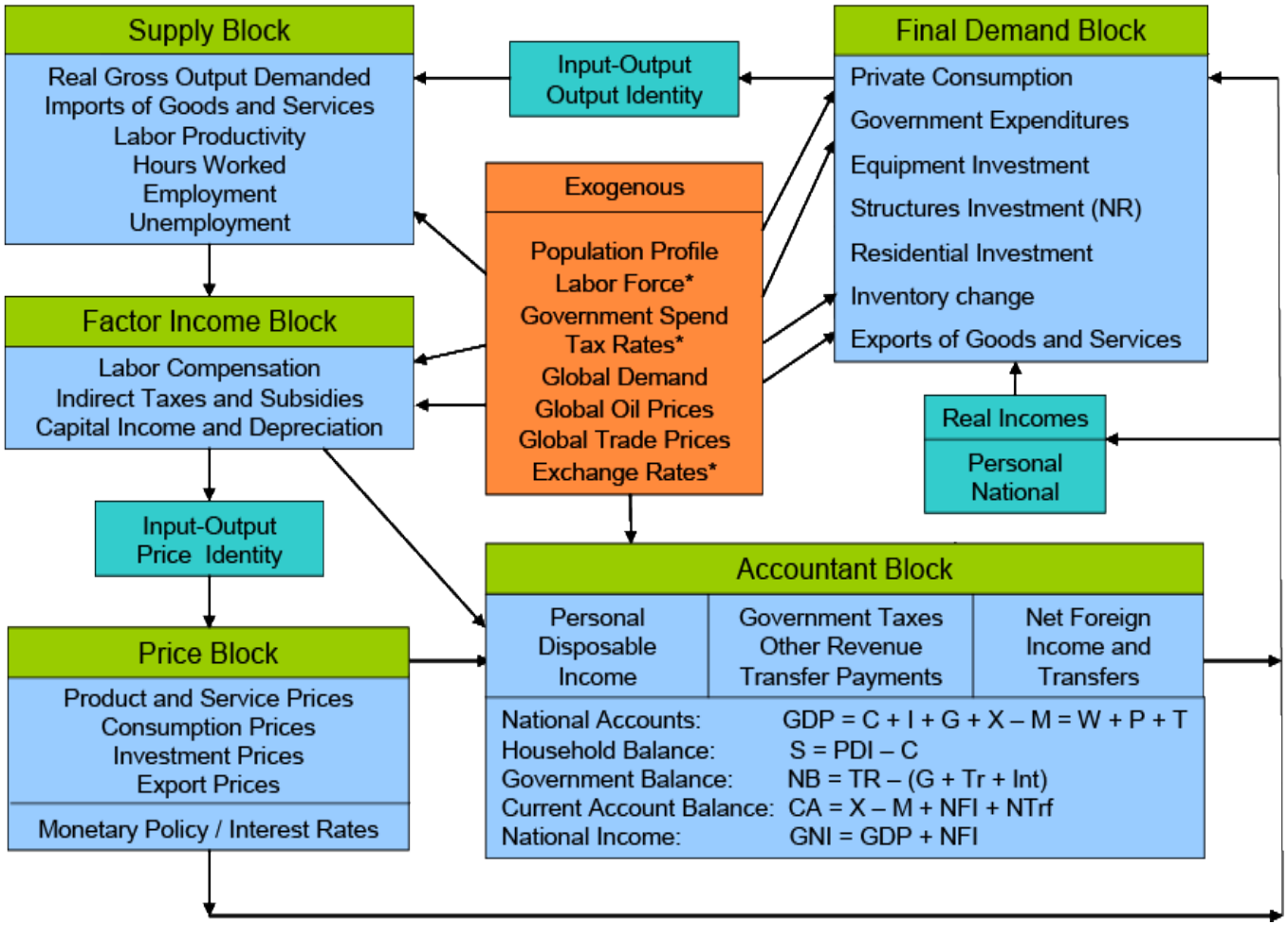
LIFT – Adjustments for Quality and Quantity of Infrastructure

- Worked with study partners to derive and incorporate industry-level & PCE effects (ASCE 2011-2012)
  - Effects on labor productivity by industry (imposed with fixes on labor productivity)
  - Effect on cost structure by industry (affects domestic prices and international competitiveness; imposed with fixes on value added)
  - Identify implications for Personal Consumption: quantities (e.g. on auto repairs) and prices (e.g. for public transportation; imposed with fixes on PCE quantities and prices)

LIFT – Long-run Forecasting Tool

- 121 Commodities: Output, Prices, Final Demand
- 71 Industries: Employment, Productivity, Value Added, Equipment and Software Investment Purchasing
- 83 Personal Consumption Types
- 26 Private Construction Types
- Federal and State and Local Government: Consumption, Investment, Transfers, Revenue
- 121X121 A Matrix: Commodity by Commodity
- Full Macro Accounting: Real GDP, Inflation, Aggregate Productivity, Personal Income, ...

LIFT – A Diagram



Study Results: Summary

- Tight labor markets; unemployment low before construction program
- Prices and interest rates pushed up, particularly in years of peak activity; lower inflation later
- Substantial crowding of private markets (increased imports, reduced residential construction)
- Long run: real GDP level +1%, higher output for all industries, but reduced employment for transportation industries

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Enhanced Infrastructure Impacts: Real Macro

	2018	2020	2021	2022	2023	2024	2028	2030
Enhanced Nominal Investment								
New Investment Spending ($Billions)	15.0	125.0	150.0	150.0	150.0	125.0	25.0	0.0
Percentage of GDP (%)	0.1	0.6	0.7	0.6	0.6	0.5	0.1	0.0
Real GDP by Final Demand Category								
Gross Domestic Product	0.1	0.9	1.1	1.2	1.1	1.0	0.9	1.1
Personal Consumption Expenditures	0.1	0.4	0.5	0.6	0.5	0.5	0.7	0.8
Gross private domestic investment	0.1	2.0	2.2	2.1	1.7	1.2	0.6	1.2
Nonresidential Fixed Investment	0.2	2.0	3.0	3.0	2.9	2.3	1.3	1.4
Residential Investment	-0.1	1.2	-0.2	-0.5	-1.5	-1.8	-1.3	0.5
Government Consumption & Investment	0.3	2.1	2.5	2.6	2.7	2.4	1.0	0.6
Exports	0.0	0.8	1.1	1.3	1.4	1.5	2.3	3.3
Imports	0.1	1.0	1.1	1.1	1.0	0.9	1.2	1.4
Real Net Exports (Billions 2009$)	-4.5	-13.3	-8.5	-5.0	1.8	6.7	23.4	47.3
Employment and Productivity								
Labor force	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Thousands	162.2	495.6	500.0	504.3	508.5	512.4	525.6	708.1
Total Employment	0.1	0.8	0.9	0.9	0.7	0.6	0.4	0.5
Thousands	166.2	1,345.4	1,504.9	1,538.1	1,205.0	989.0	613.5	785.5
Unemployoment Rate	0.0	-0.5	-0.5	-0.5	-0.3	-0.2	-0.1	-0.1
Total Labor Productivity (2009$/hr)	0.0	-0.1	-0.1	0.0	0.1	0.1	0.4	0.5

Note: Estimates are percent deviations from the baseline, except where noted otherwise.

Enhanced Infrastructure Impacts: Nominal Macro

	2018	2020	2021	2022	2023	2024	2028	2030
Price Indicators								
GDP Deflator	0.0	0.3	0.5	0.7	0.9	1.0	0.8	0.5
PCE Deflator	0.0	0.2	0.3	0.5	0.7	0.7	0.7	0.5
Exports Deflator	-0.1	0.1	0.3	0.5	0.7	0.8	0.9	0.6
Interest Rates (annual avg.)								
Treasury bills, 3-month	0.0	0.2	0.4	0.5	0.4	0.3	0.1	0.0
Treasury bonds, 10-year	0.0	0.1	0.2	0.3	0.3	0.3	0.1	0.0
Real Disposable Personal Income								
Real Disposable Income	0.1	0.9	1.1	1.2	1.1	1.0	1.0	1.1
Billions 2009$	15.2	121.7	153.2	175.7	163.7	153.3	158.0	194.9
2009$ per Household	117.5	919.2	1,146.1	1,301.7	1,201.7	1,114.7	1,109.9	1,347.9
Nominal Fiscal Balances ($Billions)								
Federal Net Borrowing ($Billions)	-3.2	-20.1	-3.3	6.5	11.1	7.7	-16.0	-70.2
Percentage of GDP (%)	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.2
State & Local Net Borrowing ($Billions)	1.2	20.5	28.8	28.8	28.8	17.6	-44.2	-72.0
Percentage of GDP (%)	0.0	0.1	0.1	0.1	0.1	0.1	-0.1	-0.2

Note: Estimates are percent deviations from the baseline, except where noted otherwise.

Enhanced Infrastructure Impacts: Real Output

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gross Domestic Product	**0.1**	**0.4**	**0.9**	**1.1**	**1.2**	**1.1**	**1.0**	**0.9**	**0.8**	**0.8**	**0.9**	**1.0**	**1.1**
Farms, Forestry, fishing	0.1	0.3	0.4	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.8
Mining	0.1	0.9	1.4	1.6	1.6	1.4	1.3	1.4	1.2	1.3	1.4	1.6	2.0
Utilities	0.1	0.3	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.7
Construction	0.8	3.7	6.1	6.9	6.6	5.9	4.4	3.5	1.9	1.4	1.2	0.7	1.1
Nondurables Manufacturing	0.2	0.6	1.1	1.1	1.2	1.0	0.9	0.9	0.7	0.7	0.7	0.8	1.1
Durables Manufacturing	0.3	1.3	2.2	2.5	2.4	2.2	1.9	1.9	1.6	1.6	1.7	1.9	2.3
Durable Materials and Products	0.4	1.8	2.8	2.8	2.7	2.4	2.1	2.0	1.6	1.6	1.8	1.8	2.3
Non-Electrical Machinery	0.2	1.2	2.3	2.8	2.6	2.3	1.9	1.7	1.6	1.4	1.7	1.8	2.2
Electrical Machinery	0.2	1.3	2.1	2.4	2.4	2.6	2.7	2.8	2.8	2.8	3.0	3.3	3.7
Transportation Equipment	0.3	1.3	2.3	2.7	2.5	2.1	1.8	1.6	1.3	1.1	1.3	1.3	1.6
Miscellaneous manufacturing	0.2	0.4	1.0	0.8	0.8	0.5	0.5	0.7	0.7	0.9	1.0	1.3	1.7
Wholesale and Retail Trade	0.2	0.4	1.0	1.1	1.2	1.0	0.9	0.9	0.8	1.0	1.1	1.2	1.3
Transportation	**0.2**	**0.5**	**1.4**	**1.5**	**1.6**	**1.5**	**1.6**	**1.6**	**1.5**	**1.7**	**1.8**	**1.8**	**2.1**
Finance, Insurance, and Real Estate	0.1	0.2	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.2
Other Services	0.1	0.3	0.7	0.8	0.9	0.8	0.7	0.7	0.6	0.6	0.6	0.7	0.8

Source: Inforum estimates using the LIFT model

Enhanced Infrastructure Impacts: Employment

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total Employment	**166.2**	**564.9**	**1,345.4**	**1,504.9**	**1,538.1**	**1,205.0**	**989.0**	**824.1**	**518.3**	**653.2**	**613.5**	**659.6**	**785.5**
Farms, Forestry, fishing	-0.7	2.4	6.0	6.4	4.2	-0.5	-4.6	-6.2	-10.7	-9.6	-11.2	-11.8	-11.2
Mining	0.5	5.2	8.9	9.4	8.6	6.9	5.2	4.6	2.8	3.8	4.1	5.5	8.7
Utilities	0.0	0.3	1.6	2.4	2.8	2.4	2.5	2.8	2.8	4.1	4.2	4.8	5.1
Construction	64.1	315.6	548.4	642.5	626.8	566.7	425.0	332.5	175.4	114.8	84.4	37.1	71.0
Nondurables Manufacturing	6.2	26.3	60.0	53.2	56.3	43.2	38.9	30.5	19.6	29.8	17.2	28.8	31.8
Durables Manufacturing	9.0	67.0	124.3	132.7	127.1	100.2	79.9	74.0	51.5	53.5	56.0	56.0	73.6
Durable Materials and Products	5.3	27.8	45.5	46.4	43.4	37.6	29.9	28.5	19.8	21.2	22.1	22.7	29.3
Non-Electrical Machinery	0.5	8.1	19.3	25.7	24.1	19.7	14.6	13.0	11.0	11.1	14.7	14.6	17.0
Electrical Machinery	0.3	11.5	22.6	29.8	29.1	27.3	28.0	29.3	26.6	28.3	29.3	29.8	33.5
Transportation Equipment	2.0	17.7	30.1	27.5	32.7	25.8	19.4	17.8	12.1	11.2	13.1	12.5	17.7
Miscellaneous manufacturing	0.9	1.8	6.9	3.4	-2.2	-10.0	-12.1	-14.6	-18.0	-18.3	-23.3	-23.7	-23.8
Wholesale and Retail Trade	28.1	35.2	152.1	167.2	179.7	108.8	106.7	89.6	55.9	128.8	121.8	145.7	146.8
Transportation	**9.1**	**20.8**	**55.0**	**46.9**	**24.7**	**-28.4**	**-74.0**	**-129.9**	**-192.2**	**-220.0**	**-269.5**	**-306.0**	**-338.2**
Finance, Insurance, and Real Estate	6.1	5.4	44.6	47.4	49.4	21.9	25.3	20.8	15.7	45.8	41.7	57.6	61.6
Other Services	43.3	89.3	346.5	398.6	458.1	381.4	378.9	398.4	388.5	493.1	554.0	630.5	723.7

Source: Inforum estimates using the LIFT model

Many Possibilities for Extensions

- Extend national analysis to state/region effects
- Further data and modeling development of PPP mechanisms
- Extend modeling of infrastructure funding mechanisms (Taxes, tolls, fees, PPP, repatriation, infrastructure bank, etc.)
- Complete alignment of detailed categories (CBO) with NIPA/Fixed Assets data
- Project detailed public spending (CBO) with Lift model (BEA concepts) projections
- Extend data development for Operations and Maintenance

Additional Resources I

- See Research, Models, and Policy Analysis pages on www.Inforum.umd.edu
- Horst (2017). Great Again: Improving U.S. Infrastructure. www.inforum.umd.edu/organization/conferences/outlook2017/outlook2017.html
- Horst, Werling (2014). Catching Up: Greater Focus Needed to Achieve A More Competitive Infrastructure. www.inforum.umd.edu/organization/news.html#naminf
- Werling, Horst, Meade, et al. (2012). Failure to Act: The Economic Impact Of Current Investment Trends in Airports, Inland Waterways, and Marine Ports Infrastructure. www.inforum.umd.edu/organization/news.html#edrasce2012

Additional Resources II

- Werling, Horst, Meade, et al. (2011). Failure to Act: The Economic Impact of Current Investment Trends on Surface Transportation Infrastructure.
  www.inforum.umd.edu/organization/news.html#edrasce
- Horst (2018). Working papers on data and modeling
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