



Infrastructure Economics

NEED ThinkTank Tuesday
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Who Are We?

- **Honorary Board: 54 members**

- 2 Fed Chairs: Janet Yellen, Ben Bernanke
- 6 Chairs Council of Economic Advisers
 - o Furman (D), Rosen (R), Bernanke (R), Yellen (D), Tyson (D), Goolsbee (D)
- 3 Nobel Prize Winners
 - o Akerlof, Smith, Maskin

- **Delegates: 600+ members**

- At all levels of academia and some in government service
- All have a Ph.D. in economics
- Crowdsource slide decks
- Give presentations

- **Global Partners: 45 Ph.D. Economists**

- Aid in slide deck development



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Credits and Disclaimer

- **This slide deck was authored by:**
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 - Jon Haveman, NEED
- **Disclaimer**
 - NEED presentations are designed to be nonpartisan.
 - It is, however, inevitable that the presenter will be asked for and will provide their own views.
 - Such views are those of the presenter and not necessarily those of the National Economic Education Delegation (NEED).



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Outline

- **What do we mean by infrastructure?**
- **Current state of infrastructure in the US**
- **Infrastructure in economic models**
- **Why should we invest in infrastructure?**
- **Public or private infrastructure investment**
- **Infrastructure investment in the US**



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What is a Useful Definition of Infrastructure?

- **Infra-** means "below;"
 - So the infrastructure is the "underlying structure" of a country and its economy.
- **Miriam-Webster definition of Infrastructure:**
 - the system of public works of a country, state, or region
 - *also* : the resources (such as personnel, buildings, or equipment) required for an activity
 - the underlying foundation or basic framework (as of a system or organization)
 - the permanent installations required for military purposes



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Different Kinds of Infrastructure (& Examples)

- **Provide basic services.**
 - Electricity, water, broadband (?).
- **Improve the performance of the economy.**
 - Roads, bridges, airports, seaports.....
 - General R&D?
 - Education
- **Make people's lives better.**
 - Roads, bridges, airports...
 - Protection from natural disaster
 - Child care, education.



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Infrastructure – Is it:

- **Traditional:**
 - Roads, bridges, tunnels, airports, seaports, dams, water, electrical, and telephone systems?
- **Additional:**
 - Broadband
- **What about:**
 - R&D? Human capital? Institutions?
- **What definition of “infrastructure” is the most useful today?**



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Categories of Infrastructure

- **Transportation**
 - Highways, roads, bridges
 - Mass transit
 - Airports, seaports
- **Water**
 - Supply
 - Distribution
- **Waste management**
 - Trash, recycling, and wastewater
- **Energy**
 - Generation
 - Transmission
- **Communications**
 - Telephone
 - Internet



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Current State of Infrastructure in the US

2021 Infrastructure Grades

| | | | |
|----------------------|------|-------------|------|
| AVIATION | ↑ D+ | PORTS | ↑ B- |
| BRIDGES | ↓ C | RAIL | B |
| DAMS | D | ROADS | D |
| DRINKING WATER | ↑ C- | SCHOOLS | D+ |
| ENERGY | ↑ C- | SOLID WASTE | C+ |
| HAZARDOUS WASTE | D+ | STORM WATER | D |
| INLAND WATERWAYS | ↑ D+ | TRANSIT | D- |
| LEVEES | D | WASTEWATER | D+ |
| PARKS AND RECREATION | D+ | | |

America's Cumulative Infrastructure Grade

- A EXCEPTIONAL
- B GOOD
- C MEDIOCRE
- D POOR
- F FAILING

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Current Infrastructure Package

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What is in it?

• Transportation

| Roads, bridges, major projects | \$110 Billion |
|---|---------------|
| Passenger and freight rail | \$66 Billion |
| Public transit | \$39 Billion |
| Airports | \$25 Billion |
| Port infrastructure | \$17 Billion |
| Transportation safety programs | \$11 Billion |
| Electric vehicles | \$7.5 Billion |
| Zero and low-emission buses and ferries | \$7.5 Billion |
| Revitalization of communities | \$1 Billion |

• Other

| Broadband | \$65 Billion |
|--|--------------|
| Power infrastructure | \$73 Billion |
| Clean drinking water | \$55 Billion |
| Resilience and waste water storage | \$50 Billion |
| Removal of pollution from water and soil | \$21 Billion |



What is missing?

- **Strategic thinking:**
 - Long term thinking, planning, prioritizing.
- **Meaningful climate resilience planning.**
- **Education & R&D.**
- **Expanding/insuring water supplies.**
- **Hazardous waste.**
- **A meaningful magnitude of spending?**



Funding – According to the White House

- Unspent emergency relief funds
- Targeted corporate user fees.
- Strengthening tax enforcement – crypto currencies.
- Revenue generated from higher economic growth.



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Infrastructure Benefits



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Infrastructure in economic models

- **Vast macroeconomic literature on relation between infrastructure and economic growth**
- **Wide variation in the magnitude of economic effects of infrastructure spending on growth or productivity**



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Econometric issues that make the task difficult

- **Direction of causality**
 - Between infrastructure investment and productivity
 - Between infrastructure investment and output
- **Spurious correlation**
 - Non stationary data
 - Ignoring unobserved factors that might affect both infrastructure investment and output
- **Heterogenous Effects**



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Why Should we Invest in Infrastructure?

- **Vital ingredient to economic growth**

- Facilitates economies of scale, raises productivity
A 10% rise in infrastructure assets directly increases Real GDP per capita by 0.7 – 1%.
 - o Assuming increases in spending translate 1-1 to the stock of assets:
 - ~\$50 billion will raise GDP per capita in the US by ~\$300 - \$450.
 - o Productivity growth raises standards of living

Why Should we Invest in Infrastructure?

- **Vital ingredient to economic growth**

- Facilitates economies of scale, raises productivity
- Reduces trade costs by improving access to markets
 - o Port capacity improvement
 - o Reducing traffic congestion
- Reduces effective distances, facilitates trade and agglomeration
- Advances public health by providing clean water and effective sewage systems

Case for Spending More on Infrastructure Maintenance

- **Rundown infrastructure increases costs**

- Longer travel time → higher costs for businesses
- Wear on cars → more spending on car repairs → faster car depreciation
- Vehicle deterioration → Additional fuel consumption

“The average motorist in the U.S. is losing \$523 annually -- \$112 billion nationally -- in additional vehicle operating costs as a result of driving on roads in need of repair.”

-- November 2016 Urban roads TRIP report

- **Deferred maintenance is a debt burden on the future generations.**



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Public or Private Infrastructure Investment?

- **Nonrival consumption**

- **Non-excludable use**

→ Social benefits might exceed expected financial return.

→ Private sector likely to underprovide key types of infrastructure.

→ Economic case for public provision of infrastructure assets.



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Public or Private Infrastructure Investment?

- **A few arguments for public provision:**

- Provision of public infrastructure increases productivity of private infrastructure
 - o Incentivizes private capital investment,
 - o Increases labor productivity,
 - o Indirectly increases employment and wages.



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Public or Private Infrastructure Investment?

- **A few more arguments for public provision:**

- Provides short-term stimulus to the economy by creating jobs
- Promotes trade and commerce
- Promotes equity
 - o Pays prevailing wages
 - o More demographically inclusive
 - o Encompasses all congressional districts
- Promotes public health and well-being
- Improves public safety
- Affects not just the present but the future generations also

- **Some of these are more debatable than others**



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Empirical Evidence on Effect of Gov't Spending

- **In studies from 80s, early 90s:**
 - A 1% increase in the stock of public capital raised GDP by 0.39%
- **In more recent studies**
 - by only 0.08% in the short run, 0.12% long run
- **In terms of multiplier, most short-term estimates are less than 1**
 - Due to negative effects of tax/interest rate increases on private C and I
- **Longer term multiplier**
 - OECD panel data – 1.6
 - US interstate highway system – 1.8



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Empirical Evidence on Effect of Gov't Spending

- **Estimates from the 2009 American Recovery and Reinvestment Act**
 - Each \$100,000 spent led to 0.8 job-years created
 - Highway construction employment unaffected in 2009-10
 - o fell sharply afterwards
 - Significant “crowd-in” of state and local highway spending
 - o For each \$1 of federal grant and additional \$2.30 in state spending



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Infrastructure Investment in the US

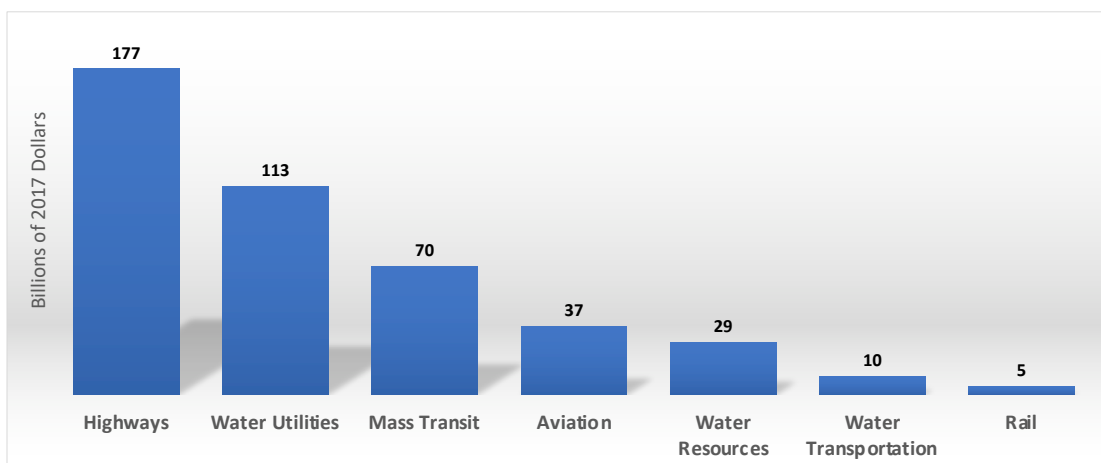
- **Transportation, drinking water, and wastewater infrastructure**
 - mainly funded by the public sector
- **Publicly owned transportation infrastructure**
 - Highways
 - Mass transit
 - Aviation
 - Water transportation
 - Rail
- **Publicly owned water infrastructure**
 - Water utilities
 - Water resources
- **In 2017, Federal, State and Local governments spent**
 - \$441 billion on infrastructure
 - 2.3% of gross domestic product



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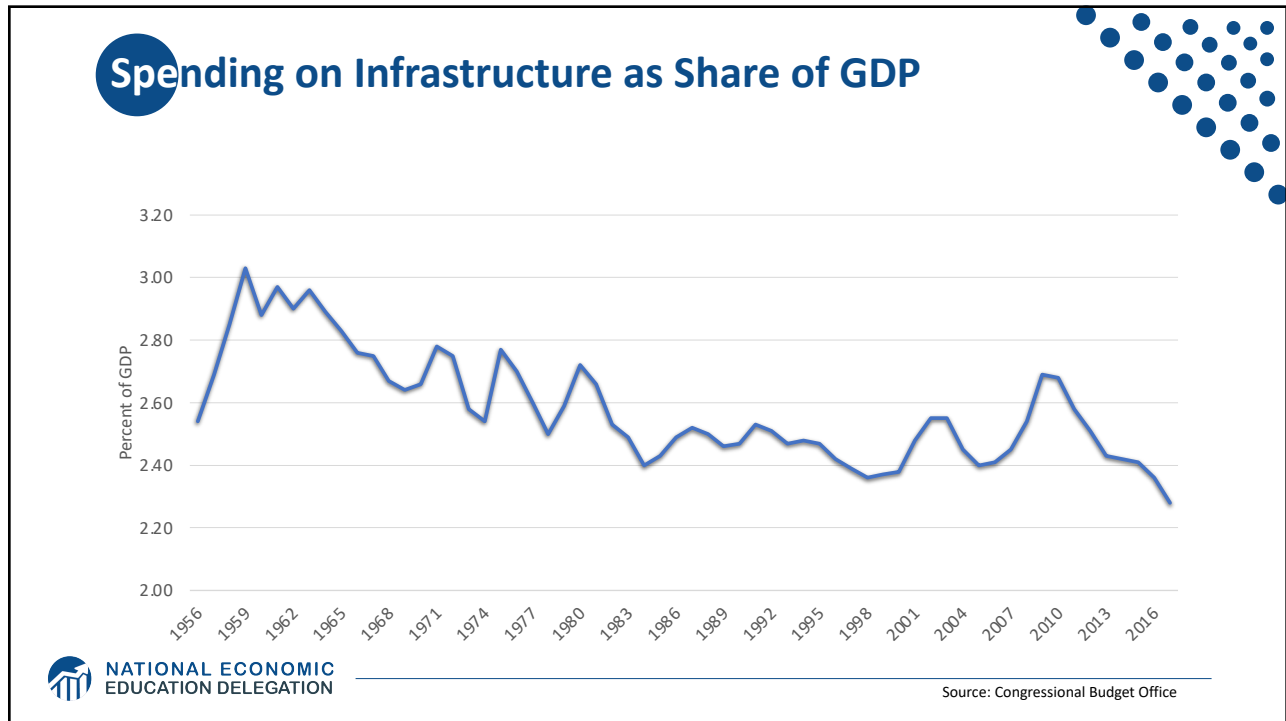
Government Spending on Infrastructure, 2017



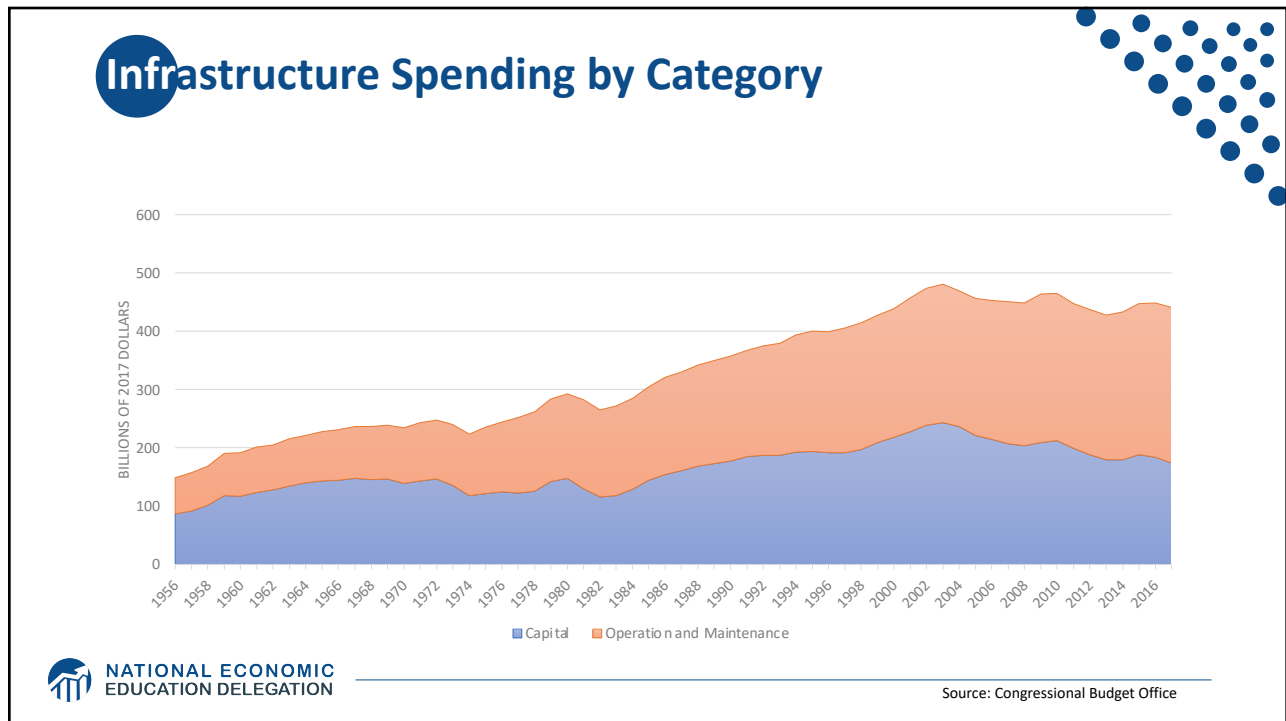
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Source: Congressional Budget Office

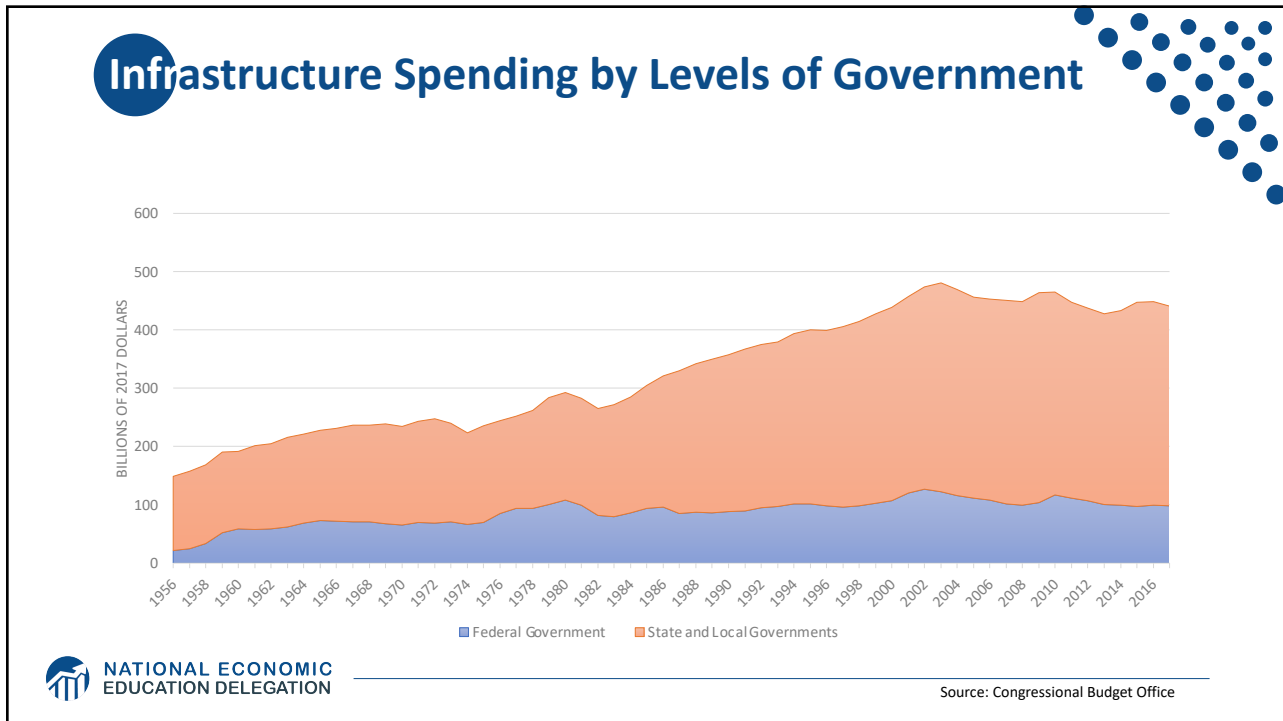
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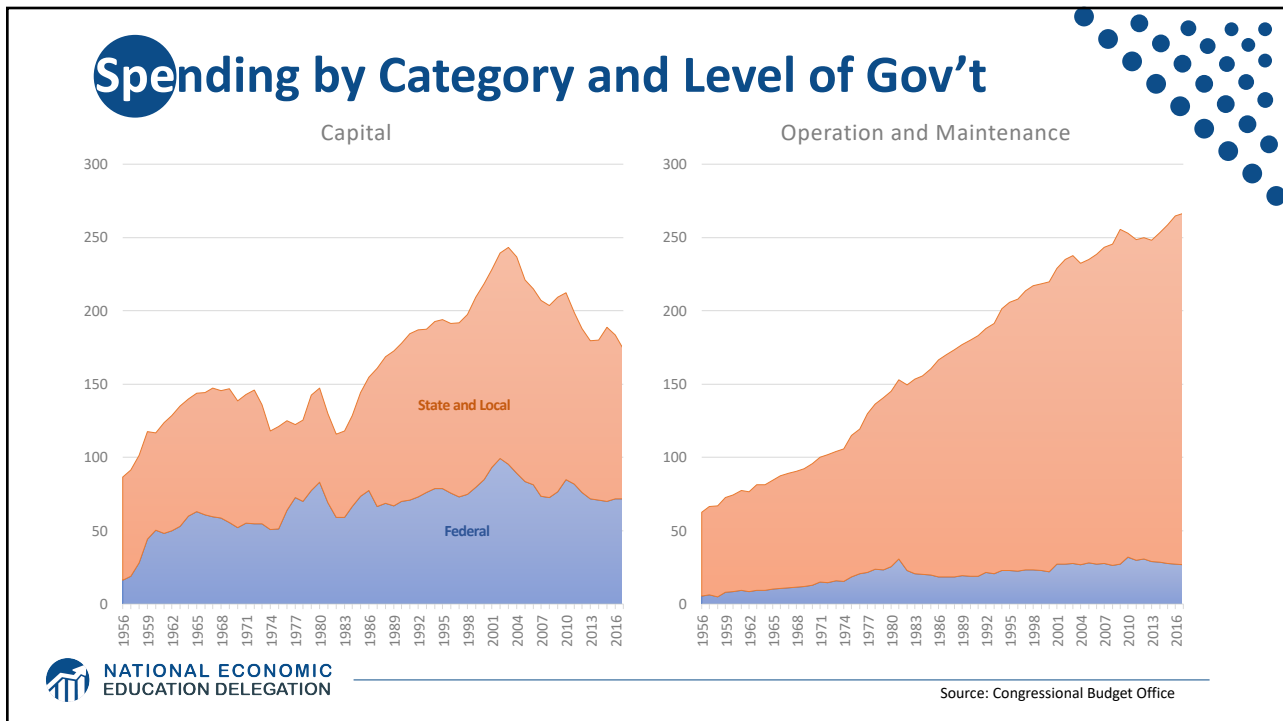
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What About Private Sector Investment?

- State and local governments own almost all of the nation's transportation and water infrastructure.
- Most of the private-sector investment in these occurs through public-private partnerships for publicly owned infrastructure.

What Is a Public-Private Partnership?

- **Per Engel et al. (2011)**

“an agreement by which the government contracts a private company to build or improve infrastructure works and to subsequently maintain and operate them for an extended period (for example, 30 years) in exchange for a stream of revenues during the life of the contract”

- New federal investment tends to favor new construction
- Traditional procurement separates design, construction and maintenance aspects
- Contractors involved in new construction not incentivized to build to minimize long term maintenance costs
- PPP helps correct this incentive problem.

Types of PPP contracts

- **PPP contracts differ based on the amount of risk transferred from the public to the private sector:**
 - Design-Build (DB)
 - Design-Build-Operate-Maintain (DBOM)
 - Design-Build-Finance-Operate-Maintain (DBFOM)
 - Similarly, we can have DBF, DBFM, etc.



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Few Public-Private Partnerships in the US

- Colorado I-70 Project
- Denver FasTracks commuter and light rail project in Colorado,
- Goethals Bridge reconstruction project linking New York City and New Jersey
- Bayonne Water Joint Venture LLC project, a water and wastewater PPP in New Jersey
- Automated People Mover (APM) project at Los Angeles International Airport (LAX)
- LaGuardia Airport Terminal B P3 project



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Few Public-Private Partnerships in the US

- A few P3s in California
 - Route 91 toll lanes in Orange County
 - Route 125 toll road in San Diego County
 - Presidio Parkway project connecting the City of San Francisco to the Golden Gate Bridge



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An Alternative Financing Tool – User Fees

- **Make those who use infrastructure more heavily, pay for it.**
 - User fees help in appropriately rationing assets to the space.
 - Help in demand management where congestion is an issue



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An Alternative Financing Tool – User Fees

• Singapore's congestion pricing model

- Singapore -- an island nation with land area of 250 sq. miles
- Limited street capacity in the central business area
- Heavy congestion
- Electronic Road Pricing (ERP) System launched in 1998
 - o variable pricing designed to respond to congestion in real-time
- Complementary policies to ERP
 - o Parking fees inside the restriction zone doubled
 - o Buses and bus frequency increased
 - o HOV+4 lanes established
 - o 15,000 park-and-ride spaces were established outside the restriction zone

Another Aspect of Infrastructure – Broadband

- Talk of a digital divide ubiquitous
 - especially in light of the current pandemic
- 21 million+ Americans lack meaningful access to the internet
 - Meaningful access: 25 Mbps download and 3 Mbps upload
 - 14.5 million have no access at all
- Lack of access more common among the less educated, low income, living in rural or suburban areas
- 9 million+ school children lacked internet access for online schoolwork

Broadband Access

- Modern-day equivalent of the interstate highway system
- Lack of access not just a rural problem
 - In 2016, 57% of households in Detroit, MI;
 - 49% in Memphis, TN and
 - 48% in Cleveland, OH without fixed broadband
- Digital redlining within cities
- Where available, service is often limited to a single service provider – natural monopolies
 - Due to high up-front fixed costs of laying fiber optic lines



Solutions to the Access Problem

- FCC Launched a \$20 billion Rural Digital Opportunity Fund in February 2020
 - \$6 million budget
 - Target census blocks that without 25/3 Mbps broadband
- Taking matters into their own hands, cities and communities:
 - Building municipal infrastructure and cooperatives providing broadband
 - Despite legal barriers or bans on publicly owned networks in 19 states
 - 850+ communities served by a municipal network or cooperative
 - Community-owned networks are less expensive and have more transparent pricing than private ISPs – Harvard Study



Enormous Economic Benefits to Access

- **Individual benefits:**

- Better health and life outcomes.
 - o Access to health and education online.
 - o Job search and development of digital skills.
- Higher property values.
- Increased population and job growth.
 - o Higher rates of business formation.

- **Broader economic benefits:**

- World Bank
 - o 10% increase in access yields a 1.2% jump in real incomes.
- Indiana
 - o ROI = 300-400%.

Technological Advancements of the Future to the Rescue?

- **Low Earth Orbit (LEO) satellite internet**

- On June 13, 2020 Elon Musk's SpaceX launched 58 satellites into low earth orbit as part of the Starlink program.
- Aims to provide low-latency (less lag) satellite internet.
- Better internet coverage than traditional communications satellites.
- Could potentially provide high quality internet to homes and businesses without access to cable, fiber, or reliable cellular internet.

Pace of Investment



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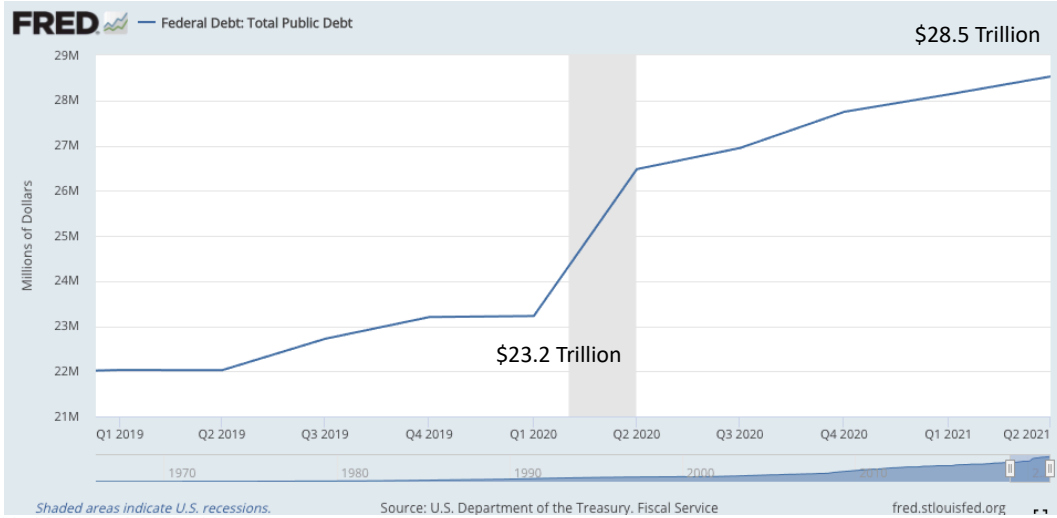
Too Much, Too Soon? Too Little, Too Late?

- **Is the current infrastructure package appropriate?**
- **The United States has enormous needs.**
 - Basic infrastructure – bridges, roads, etc.
 - Other:
 - General R&D: 2% of GDP in the 1950s, currently 0.75%.
- **Is now the time to borrow extensively?**
 - Have just borrowed > \$4 Trillion.
 - Interest rates are very low.
- **Given the state of our infrastructure, the ROI can be very high.**



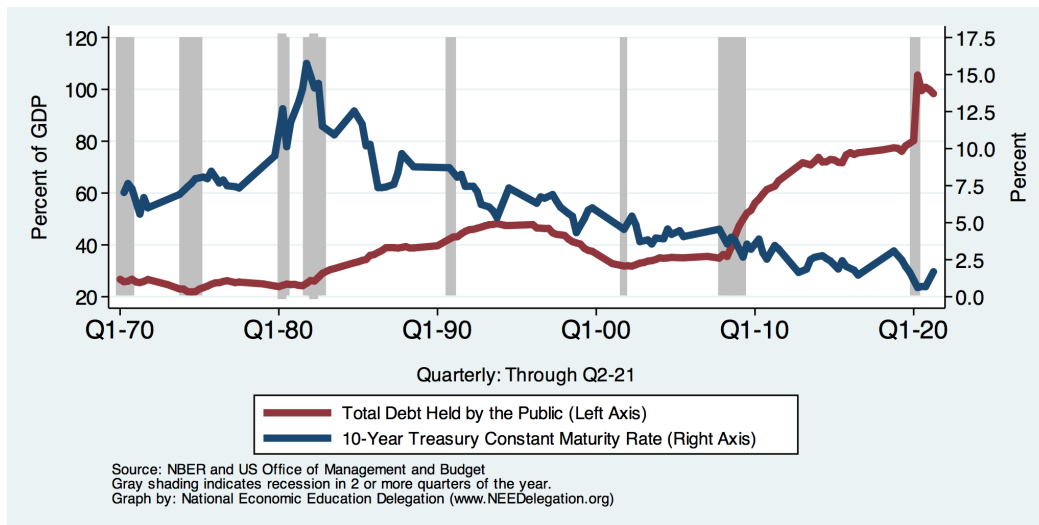
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COVID Borrowing



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Rising Debt and Low Interest Rates



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Debt Outlook is Troublesome

Federal Debt Held by the Public, 1900 to 2050

Percentage of Gross Domestic Product



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Summary

- **Infrastructure investment is important.**
- **Current state of US infrastructure – leaves a lot to be desired for.**
- **Public infrastructure investment can play a vital role in long run growth.**
 - Improve mobility
 - Raise private capital productivity
 - Improve health
- **May not be ideal as short-term stimulus.**
- **Arguments for and against going big.**
 - ROI arguments likely carry the day in today's interest rate environment.
 - Risk is always the impact on the debt.



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Thank you!

Any Questions?

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Current State of Transportation Infrastructure

- **Roads**

- Over 4 million miles of roads.
- In 2018: 3.3 trillion VMT (Vehicle Miles Traveled).
- 40%+ of America's urban interstates are congested.
- In 2017, 8.8 billion hours of traffic delay.
 - o Costing the country \$166 billion in wasted time and fuel.

"The average auto commuter spends 54 hours in congestion and wastes 21 gallons of fuel due to congestion at a cost of \$1,080 in wasted time and fuel."

-- 2019 Urban Mobility Report, Texas A&M Transportation Institute

- 42,060 motor vehicle fatalities in 2020 (8% increase over 2019).



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Current State of Transportation Infrastructure

• Mass Transit

- ~2,500 separate transit agencies.
- Transit ridership: peaked at 10.7 billion in 2014.
- 50% of passenger trips by bus.
 - o 10% of fleets NOT in “state of good repair”.
- 33+% by heavy rail (subway/metro)
 - o 3% of fleets NOT in “state of good repair”.
- Transit’s physical infrastructure fairs considerably worse (% NOT in “state of good repair”):
 - o 15% of facilities (e.g., maintenance facilities),
 - o 17% of systems (e.g., power, signal, communications, fare collecting)
 - o 35% of guideway elements (e.g., tracks), and
 - o 37% of stations.



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Current State of Transportation Infrastructure

• Aviation

- In 2018, 10 million+ commercial flights
 - o Flying ~3 million passengers daily
- National Plan of Integrated Airport Systems (NPIAS)
 - o identifies over 3,300 airports in the U.S. aviation network
- Contributed 5.1% to US GDP
 - o Generated 10.6 million jobs
- In 2017, 80% of flights were on-time. Delays were caused by
 - o late-arriving aircrafts (6.8%),
 - o air carriers (5%),
 - o weather (3.1%), and
 - o diverted flights (0.2%).



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Current State of Transportation Infrastructure

• Ports

- 99% of US overseas trade pass through ports
- Los Angeles and Long Beach – busiest ports in the US
 - o Top 10 U.S. ports account for 3/4th of U.S. trade
- Congestion decreased port productivity by over 25% over the past decade
- Port infrastructure upgrades needed to accommodate new, larger ships with deeper navigation channels

• Waterways

- More than 600 million tons of cargo
 - o 14% of annual domestic freight
- Beyond their 50-year design life
- 50% vessels experience delays due to maintenance shut downs



Current State of Water Infrastructure

• Drinking Water

- 150,000+ public drinking water systems
- 1 billion+ glasses of drinking water consumed daily
 - o 80% from surface waters such as rivers, lakes, oceans, reservoirs
 - o 20% from groundwater aquifers
- Delivered via 1 million miles of pipes
 - o Majority laid in mid-20th century and are aging
 - o estimated 240,000 water main breaks occur each year
 - o 6 billion gallons of treated drinking water lost daily due to leaking pipes
 - could support 15 million households



Current State of Water Infrastructure

• Wastewater

- 14,748 wastewater treatment plants
 - 1.3 million miles of public and private lateral sewers
- Used by 76% of Americans
 - Likely to serve 56 million more people by 2032
- Structural failure, blockages, and overflows cause at least 23,000 to 75,000 sanitary sewer overflow events each year



Current State of Water Infrastructure

• Dams

- There are over 90,000 dams in the US providing:
 - drinking water,
 - irrigation,
 - hydropower,
 - flood control, and
 - recreation
- Average age – 56 years
- By 2025, 7 out of every 10 dams will be over 50 years old
- In 2015, there were 15,500 high-hazard potential dams
 - up 52% since 2005



Current State of Water Infrastructure

• Levees

- A network of 30,000 miles of levees
- Levees in the U.S. Army Corps of Engineers Levee Safety Program protect
 - o over 300 colleges and universities,
 - o 30 professional sports venues,
 - o 100 breweries, and
 - o an estimated \$1.3 trillion in property
- Built in the mid-20th century with an average age of 50 years, aging fast
- Levees are crucial with majority of the U.S. population living within 50 miles of a coast



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Available NEED Topics Include:

- US Economy
- Climate Change
- Economic Inequality
- Economic Mobility
- US Social Policy
- Trade and Globalization
- Trade Wars
- Immigration Economics
- Housing Policy
- Federal Budgets
- Federal Debt
- 2017 Tax Law
- Autonomous Vehicles



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