Session 7: Infrastructure Markets

1.463 Globalization of the E&C Industry
Fall 2009

Fred Moavenzadeh & Kyle Frazier
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What is Infrastructure?

- Generic (dictionary) definitions:
  - “the underlying foundation or basic framework (as of a system or organization)”
  - “the permanent installations required for military purposes”
  - “the system of public works of a country, state, or region”

- Public works: “works (as schools, highways, docks) constructed for public use or enjoyment, especially when financed and owned by the government”

- Do these definitions seem adequate/accurate?

Economic Attributes of Infrastructure

- Capital goods (not consumed directly)
  - Derived demand
- “Lumpy” investment
- Long life-spans/design-service lives
- Location-specific (not mobile)
- Prone to market failures
  - Public goods
  - Externalities
- Consumed by households and enterprises

# Infrastructure Services & Systems

<table>
<thead>
<tr>
<th>Service</th>
<th>Associated Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>Roads, bridges, tunnels, rail tracks, harbors, etc.</td>
</tr>
<tr>
<td>Water Supply</td>
<td>Dams, reservoirs, pipes, treatment plants, etc.</td>
</tr>
<tr>
<td>Water Disposal</td>
<td>Sewers, used water treatment plants, etc.</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Dams, canals</td>
</tr>
<tr>
<td>Garbage Disposal</td>
<td>Dumps, incinerators, compost units</td>
</tr>
<tr>
<td>District Heating</td>
<td>Plant, network</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>Telephone exchanges, telephone lines, etc.</td>
</tr>
<tr>
<td>Power</td>
<td>Power plants, transmission &amp; distribution lines</td>
</tr>
</tbody>
</table>

Categorizing Infrastructure

- Because “infrastructure” is a broad term encompassing a wide variety of facilities and systems, it may be useful to seek an organizational framework or typology.

- ...but, categorization is no straightforward task, either, as utility of a given framework depends on one’s perspective.
### ASCE Infrastructure Categories

<table>
<thead>
<tr>
<th>Types of Infrastructure “Graded” by ASCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation</td>
</tr>
<tr>
<td>Drinking Water</td>
</tr>
<tr>
<td>Inland Waterways</td>
</tr>
<tr>
<td>Rail</td>
</tr>
<tr>
<td>Solid Waste</td>
</tr>
</tbody>
</table>

- ASCE publishes a periodic “report card” on America’s infrastructure. The fifteen categories of infrastructure assessed in the most recent report card are listed in the table above.

# Infrastructure Investment Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Example Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>Bridges, roads, tunnels, airports, rail, ports, urban &amp; regional transport systems</td>
</tr>
<tr>
<td>Energy &amp; Utilities</td>
<td>Electricity generation and distribution, water supply and waste water treatment, renewable energy</td>
</tr>
<tr>
<td>Social</td>
<td>Universities, schools, student accommodation, prisons, hospitals and health care, public and mixed large-scale housing development, sports facilities and community facilities</td>
</tr>
<tr>
<td>Communications</td>
<td>Cable networks, WiFi networks, mobile phones and broadcast towers, etc.</td>
</tr>
</tbody>
</table>

- Infrastructure has emerged as an investment “asset class.” The table above is adapted from a publication by Ernst & Young, an investment/financial advisory firm active in infrastructure.

Infrastructure Typology

- **Economic infrastructure**
  - Transportation, communications, information, energy

- **Social infrastructure**
  - Educational, health care, water supply, waste management, recreation, environmental protection

- **National security infrastructure**
  - Defense installations, border security systems
Two Types of Infrastructure

- **Network structure**
  - Many parts, each functioning independently and requiring small-to-medium budget
  - Complexity emerges from density & interactions
  - Examples: transport systems, sewage systems, power distribution networks, communications networks

- **Stand-alone facilities**
  - Often large, complex, and costly; require all components to be in place for facility to deliver intended service
  - Examples: power plants, petrochemical plants, skyscrapers, environmental remediation
Infrastructure at the Intersection of Systems

Large-scale infrastructure systems occur at the intersection of three systems:

1) Social system – generates demand for services; establishes regulatory framework; includes economic systems

2) Natural system – “source and sink”; supplies resources for infrastructure systems and absorbs waste from their construction & operation

3) Technological system – enables realization of needs given constraints of (1) & (2)
Interdependencies in Infrastructure Systems

- Growing focus on interdependencies among various infrastructure systems
  - Motivated, in part, by increased profile of homeland security and disaster resilience
  - Emphasis on risk management/mitigation

- Lifeline systems: electric power, gas and liquid fuels, telecommunications, transportation, waste disposal, and water supply
Key Facets of Infrastructure Development

- Sustainable development
- Multiple stakeholders approach (inclusive)
- Lifecycle view
- Consideration of interdependencies
- Value stream perspective
Key Dimensions of an Infrastructure Systems Architecture
Development and Competitiveness

As the “underlying foundation,” infrastructure creates value in multiple ways:
- It is important to socioeconomic development, and
- It contributes to productivity and economic competitiveness.

These dual effects keep infrastructure on the policy agenda of developed and developing nations alike.
Infrastructure: A Global Market

- Although the location-specific nature (immobility) of infrastructure systems makes the specific context of a project important, the market for infrastructure has "globalized" in key ways:
  
  - Many E&C firms, the “suppliers” of infrastructure, compete for projects on a global basis, and
  
  - Financing of large-scale infrastructure projects taps the global capital markets.
Current Challenge(s)

- At a global level, there exists a need to upgrade or enhance infrastructure systems if infrastructure capacity is to be sufficient for supporting world economic growth.

- ...but, there are major differences between the needs of emerging economies and developed economies.
A Distinction in Needs

Emerging economies
- Economic growth often constrained by physical infrastructure capacity
- Implies demand for construction to relieve this constraint
  - With high projected growth rates in some emerging economies, mobilizing the resources to meet this demand is likely to be a central E&C challenge

Developed economies
- Need for physical expansion of infrastructure stock relatively small compared to base already in place (“legacy systems/assets”)
  - Pressing challenges concern extracting more capacity from existing networks and facilities
  - Rehabilitation/renewal
  - Integration of systems as density/interdependency/complexity increases?
The Infrastructure challenge
Percentages of total projected cumulative infrastructure investment needed during the next 25 years to modernize obsolescent systems and meet expanding demand broken down by region (rows) and sector (columns).

How are these needs to be met?

- Although generalizations should be made with caution, many infrastructure systems have “traditionally” been financed and owned by the public sector.
  - In the U.S. case, this is especially true for surface transportation and water infrastructure.

- Over past several decades, the private sector role has increased and evolved.
  - PPPs, privatization, etc.
  - Infrastructure as an asset class (see slides 8 & 19)
Infrastructure development/operation

- Arms-length investment funds are but one type of private involvement in infrastructure development and operation.

- Some E&C firms have moved into roles as infrastructure operators and managers, not just planners and builders.
  - Cintra
    - Spanish spin-off from Ferrovial; focuses on transport infrastructure development; international presence
    - Early U.S. investments through MIG-Cintra consortium (e.g., Chicago Skyway, Indiana Toll Road)
Infrastructure & Economic Stimulus

Go forth and multiply
Estimated impact on GDP of the fiscal stimulus package

<table>
<thead>
<tr>
<th>Types of stimulus</th>
<th>Examples</th>
<th>Multiplier*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct federal spending, federal funding of state and local infrastructure</td>
<td>$165 billion on infrastructure improvements and science</td>
<td>1.0 to 2.5</td>
</tr>
<tr>
<td>Non-infrastructure transfers to states</td>
<td>$87 billion on Medicaid; $79 billion for fiscal stabilisation</td>
<td>0.7 to 1.9</td>
</tr>
<tr>
<td>Payments to individuals</td>
<td>$47 billion in unemployment insurance; $26 billion in health-insurance subsidies;</td>
<td>0.8 to 2.2</td>
</tr>
<tr>
<td>Temporary individual tax cuts</td>
<td>$142 billion Making Work Pay credits</td>
<td>0.5 to 1.7</td>
</tr>
<tr>
<td>Tax loss carry-back</td>
<td>$15 billion</td>
<td>0.0 to 0.4</td>
</tr>
</tbody>
</table>

Sources: Congressional Budget Office; congressional committees
*Dollar increase in GDP per dollar of stimulus

Figure by MIT OpenCourseWare.

- Infrastructure investment embraced as a strategy for creating jobs and jump-starting economy.
- What trade-offs and/or limitations might be important to thinking about this strategy?

Infrastructure in the U.S.

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Available at: http://politicalhumor.about.com/od/politicalcartoons/ig/Political-Cartoons/Infrastructure-Bridge.htm
Historical Development of Infrastructure

- Roles of public and private sectors
- Overarching goals/objectives: economic development, social equity, public health, environmental protection, etc.
- Economic and political drivers
- Overall vision or decentralized development?
### Table 2-1 Highway Mileage and Expenditures Classified by Administrative Responsibility

<table>
<thead>
<tr>
<th>Administration</th>
<th>Number of agencies</th>
<th>Highway miles (% of total) for which responsible</th>
<th>1999 Revenues (% of total) used for highways by collecting agency ($ millions)</th>
<th>1999 Expenditures for highways (% of total) by Expending agency ($ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal agency</td>
<td>5</td>
<td>118,391 (3)</td>
<td>26,016 (22)</td>
<td>1,424 (1)</td>
</tr>
<tr>
<td>State agency</td>
<td>52</td>
<td>773,903 (20)</td>
<td>62,097 (53)</td>
<td>71,414 (61)</td>
</tr>
<tr>
<td>County agency</td>
<td>2,815</td>
<td>1,766,394 (45)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Town and township</td>
<td>14,051</td>
<td>1,206,917 (31)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Municipality</td>
<td>18,100</td>
<td>—</td>
<td>29,765 (25)</td>
<td>44,595 (38)</td>
</tr>
<tr>
<td>Other jurisdictions</td>
<td>—</td>
<td>66,399 (2)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>35,023</td>
<td>3,932,004</td>
<td>117,878</td>
<td>117,433</td>
</tr>
</tbody>
</table>

Figure by MIT OpenCourseWare.
Dimensions of the Problem

The challenges to provision of infrastructure in the U.S. are multidimensional and (may) include:

- Underinvestment in infrastructure
- Deteriorating condition of infrastructure systems
- Inadequate funding approaches and financing mechanisms
- Fragmented governmental framework & institutional structure
- Deficiencies in new technology development, transfer, and utilization
Lack of leadership or a compelling vision
- Multiple sources identify this as one of the most important problems in the U.S. infrastructure sector
- Leadership role typically suggested for the federal government

What are the implications of this “leadership deficit” for the U.S. infrastructure market, from an A/E/C perspective?
Useful References & Further Reading

- **Sustainable Critical Infrastructure Systems: A Framework for Meeting 21st Century Imperatives** (NRC, 2009)

- **Public Works, Public Wealth: New Directions for America’s Infrastructure, A Report of the CSIS Public Infrastructure Project** (Ehrlich & Landy, CSIS, 2005)

- Also several sources which have already been cited.
Concluding Thoughts

What are the major issues in infrastructure?
- Refining the government role (or, both public and private roles)
- Accommodating future needs while utilizing legacy systems and institutions
- Improving incentive mechanisms
- Reducing the overall costs of infrastructure systems?

What are the opportunities and risks from an E&C perspective?
- What skills are needed?
- How would you approach different global markets?
1.463J The Impact of Globalization on the Built Environment
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