Infrastructure investment and growth

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How important is infrastructure for economic growth?

• Old question – even in Adam Smith’s *Wealth of Nations*
• Empirically revived after Aschauer (1989) – who found huge rates of return on public capital in the U.S.

For policy-making, the key link is that between infrastructure *spending* and growth.

What do we know about it empirically?
Two distinct logical steps involved:
(1) From spending to infrastructure services – the cost of acquiring (and operating) infrastructure assets
(2) From infrastructure assets to growth – the productivity of infrastructure assets (or their services)
The bulk of empirical macro research has focused on (2). But for optimal spending / provision decisions we need to know more about (1) too.
Infrastructure and growth

Start with (2): from assets to output / growth

Two common empirical approaches:
- Growth regressions augmented with infrastructure measures
- Infrastructure as another input in aggregate production function (or its dual, the cost function)

On balance, majority of studies – especially recent ones on developing economies – find significant positive effects

Some methodological caveats with many studies – reverse causality, heterogeneity, non-stationarity...

A key issue is the measurement of infrastructure assets
- Physical indicators (e.g., road km)
- Monetary indicators (investment flows or their cumulative totals)
Infrastructure and growth

Measures of infrastructure spending can be very poor proxies for the quantity / quality of assets

- Poor project selection; procurement; corruption (Tanzi-Davoodi 1997; Pritchett 2000; Keefer-Knack 2007) – more on this later

### Empirical studies, by reported finding (Straub 2007)

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Negative</th>
<th>None</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Capital (65)</td>
<td>10.8%</td>
<td>40.0%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Physical Indicator (75)</td>
<td>1.3%</td>
<td>24.0%</td>
<td>74.7%</td>
</tr>
</tbody>
</table>
4.1.1 Infrastructure Stock and Economic Growth

\[ y = 0.4812x + 1.6724 \]
\[ R^2 = 0.1701 \]
4.1.2 Infrastructure Quality and Economic Growth

\[ y = 0.6312x + 1.8891 \]

\[ R^2 = 0.2054 \]
Infrastructure and growth

Example of growth approach: Calderón-Servén 2009
Empirical growth framework with physical measures of infrastructure
  Synthetic index of telecom, transport and power assets – plus (noisy!) measures of quality of assets
Large panel dataset
Results:
  – Infrastructure quantity and quality have robust growth effect – and economically significant.
  – Not much evidence of heterogeneity (in log-log terms)
    • Across developing regions
    • Landlocked vs other countries
    • Related to infrastructure endowment (i.e., non-linearities)
Hence the marginal contribution of infrastructure development to growth is higher wherever quantity / quality are lower.
Figure 2
Growth changes across regions due to infrastructure development (2001-5 vs. 1991-5 averages)
Infrastructure and growth

How does the growth contribution of infrastructure development vary across countries? Closer look

Calderón, Moral and Servén (2010): Cobb-Douglas production function approach -- physical and human capital; infrastructure

- Focus on the contribution of infrastructure to labor productivity (GDP per worker)
- Synthetic infrastructure index (as before)
- 88 industrial and developing countries, 1960-2000 (> 3,500 obs)
- Allow for heterogeneity of infrastructure contribution – both generic and along specific dimensions
  - Empirical framework allows intercepts, error variances and short-run dynamics to differ freely across countries.
  - Imposes (testable) cross-country homogeneity of long-run coefficients.
Infrastructure and growth

Main results

• Infrastructure elasticity in range .07 to .10 – and robust.
• Elasticities of other inputs (physical and human capital) in line with literature (around 0.35, 0.10 respectively)
• No evidence of (general) cross-country parameter heterogeneity
  – Accords with cross-country stability of factor shares (Gollin 2002)
• But country-specific estimates are noisy (especially in LICs), so tests may have low power. Test for specific forms of heterogeneity
  – By income level: infrastructure elasticity could differ in rich and poor countries
  – By level of infrastructure endowment: nonlinear effects of infrastructure (network effects?)
  – By population size: economies of scale / congestion effects.
  – By quality of policy framework: high / low distortions
Only this test comes close to 10% significance
Output elasticity of infrastructure vs. per capita GDP

Output elasticity of infrastructure vs. Infrastructure stock

Output elasticity of infrastructure vs. population

Output elasticity of infrastructure vs. distortion index
Further homogeneity tests
Break sample into high / low along the relevant dimension – and test for equality of mean infrastructure elasticity.

<table>
<thead>
<tr>
<th></th>
<th>Per Capita Income (A)</th>
<th>Per Capita Income (B)</th>
<th>Infrastructure Endowment</th>
<th>Total Population</th>
<th>Distortions</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>0.054</td>
<td>0.044</td>
<td>0.059</td>
<td>-0.016</td>
<td>-0.156</td>
</tr>
<tr>
<td>Low</td>
<td>0.059</td>
<td>0.062</td>
<td>0.055</td>
<td>0.131</td>
<td>0.271</td>
</tr>
<tr>
<td>p-value</td>
<td>0.985</td>
<td>0.94</td>
<td>0.988</td>
<td>0.576</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Overall, no strong evidence that the elasticity varies across countries. The implication is that the marginal product of infrastructure declines as the infrastructure / output ratio rises.
From spending to assets

• All this is only about the *benefit* side of infrastructure – what about the *cost*?
• Cost-benefit comparison is needed to assess the extent of under-provision of infrastructure – and whether it is greater than that of other inputs (e.g., human capital)
  – Limited evidence on this (e.g., Canning and Pedroni 2008: no generalized infrastructure shortage across countries / sectors)
  – Calderón and Servén (2010): big growth impact of infrastructure catch-up in Africa – but massive cost involved: 10% to 15% of GDP for (half) catching-up, even ignoring O&M.
  – Loayza (2010): big growth impact in Egypt – but only if much of the cost is financed by spending cuts elsewhere
Sub-Saharan Africa: cost of infrastructure catch-up

Investment required for halving the infrastructure quantity gap with other regions

![Bar chart showing percentage of GDP for different regions. The x-axis represents regions: West Africa LICs, East Africa LICs, South Africa LICs, Central Africa LICs, and Sub-Saharan Africa UMCs. The y-axis represents the percentage of GDP.]
From spending to assets

Is spending a good proxy for infrastructure development?

– Spending is often very inefficient: bad projects, waste…
– Weak link between spending and assets / services (Pritchett 2000): it is mediated by government technical capacity, fiscal institutions, budgetary practices, governance…
– Big scope for corruption and political clientelism
  • Tanzi and Davoodi 1997; Keefer-Knack 2007: weak governance and corruption raise measured ‘public investment’ – in reality, much is rent extraction rather than asset acquisition.
  • Incentives for investment over O&M: bigger room for corruption, political favors and photo-ops – so build new roads rather than maintain old ones.
Better understanding of costs of asset acquisition, and their determinants, is needed for policy decisions.

– Without it, a ‘big push’ to infrastructure may lead to massive waste

But this requires much more complete and detailed data on infrastructure spending and performance

– Often we cannot even establish the facts – especially on O&M, but in many countries also on sector-wise investment spending

– Bad data also hampers accountability / transparency

Poor data arguably is one of the biggest obstacles to better diagnostic of the problems and design of solutions

From spending to assets
From spending to assets

New database under construction – investment by infrastructure sector in developing countries

- Builds on earlier data collection for Latin America (Calderón and Servén 2004, 2010)
- Disaggregation into power, water/sanitation, roads, rail, telecom – when feasible
- Disaggregation into public and private investment
- Time coverage from 1980

Preview of work in progress.
Infrastructure investment and governance
(cumulative investment, percent of 1985 GDP)

Infrastructure investment vs quality of bureaucracy

- Weaker governance is associated with higher investment / GDP ratios (like in Tanzi-Davoodi 1997 and Keefer-Knack 2007)
From spending to assets

How big is the cost impact of governance?
Look at the average unit cost of infrastructure assets

\[ c \equiv \frac{\sum_{t=0}^{T} I_t}{K_T - K_0} \]

Note that \( c \) should be expected to vary across infrastructure sectors.

Construct sector-specific \( c \) – with \( K \) respectively given by

- road km
- power generation capacity (Gw)
- telephone lines
From spending to assets

Across countries, $c$ may vary with per capita GDP (wages, RER) and other factors

- Add also climatic / geographic / demographic controls in regressions

Some data limitations:

- No information on O&M spending
- No information on asset quality (except % roads paved)
- Small country sample (only 17 countries for the moment…)

No retrospective info on fiscal / budgetary institutions, so look instead at the correlation of unit cost with broader governance-related variables:

- (Control of) corruption [higher is better]
- Quality of bureaucracy [project selection, procurement…]
Unit cost of infrastructure assets and control of corruption (controlling for GDP per capita)
Unit cost of infrastructure assets and quality of bureaucracy (controlling for GDP per capita)
Weaker governance is associated with higher asset costs in all sectors examined. Corruption and low bureaucratic quality drive a wedge between investment spending and actual infrastructure development. Regression estimates suggest that the magnitude of the wedge is considerable:

- 1 sd improvement in corruption raises by 25% the volume of assets acquired with a given amount of investment.
- 1 sd improvement in bureaucratic quality raises it by 18%.
Conclusions

Extensive research on the growth benefits of infrastructure
- Overall, solid evidence that infrastructure quantity and quality help growth
- Also evidence of a positive impact on equity – hence scope for a double poverty-reducing effect
- Effects are bigger where infrastructure endowments are lower – so potentially a big payoff from infrastructure catchup for LICs

But much less attention has been paid to the costs
- More analysis of returns vs costs of infrastructure assets is needed – with more focus on specific sectors in specific countries
- Poor data on spending (especially O&M) is one of the biggest obstacles to better understanding of costs
Conclusions

Poor governance drives a wedge between infrastructure spending and actual infrastructure development
– Low government capacity, weak fiscal governance and corruption inflate asset costs, discourage O&M, and reduce the efficiency of spending
– This has big effects on the cost of infrastructure development

Raising the efficiency of spending is a key priority
– Research needs to identify institutional mechanisms and incentives that favor sound spending decisions
  Developing stronger project selection and evaluation capacity
  Assessing if / how different budgetary institutions, checks and balances can help
– Otherwise, more spending may yield a lot of waste and not much more infrastructure development.