# Infrastructure investment and growth

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# Background

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?

# Background

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

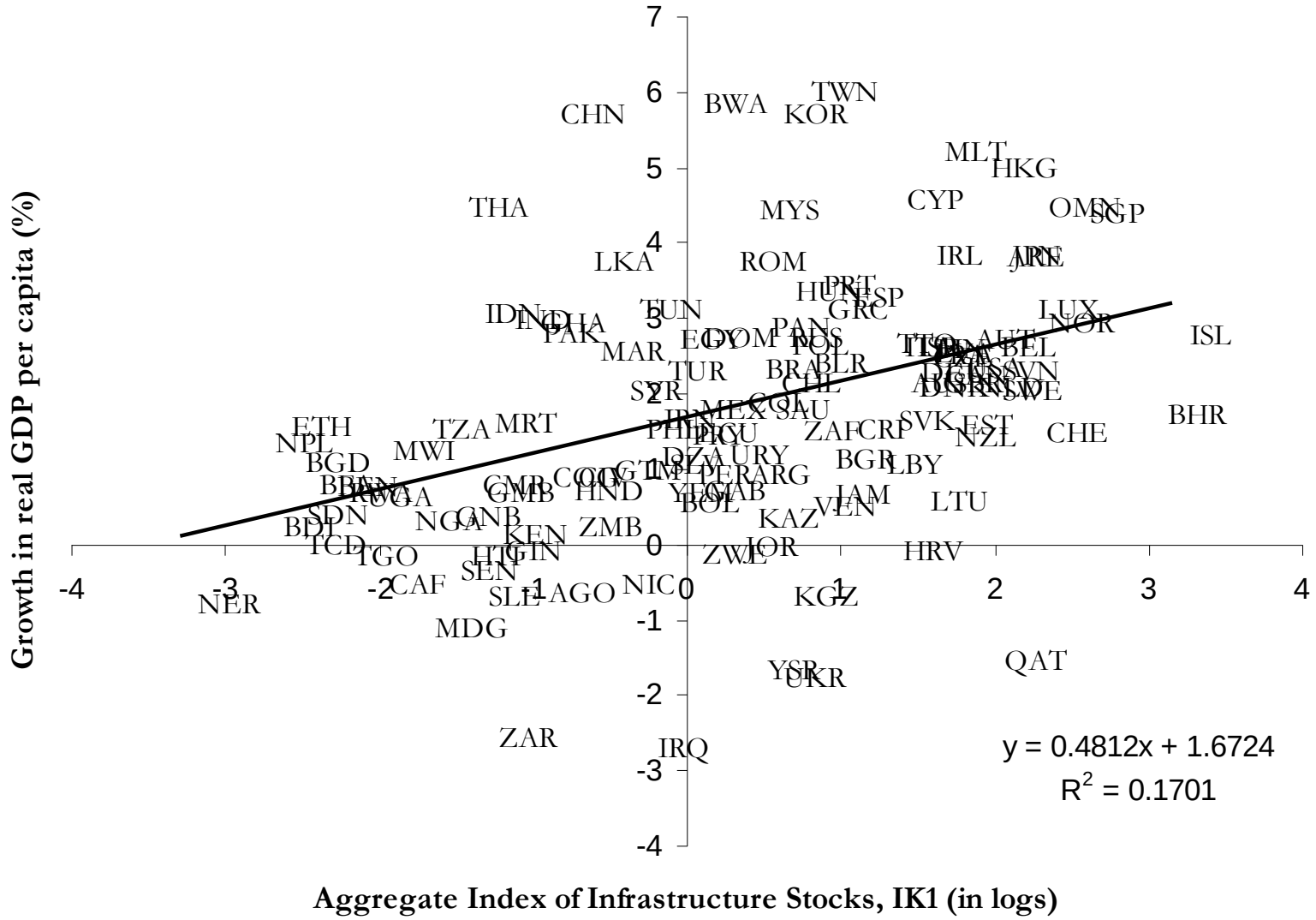
Measures of infrastructure spending can be very poor proxies for the quantity / quality of assets

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

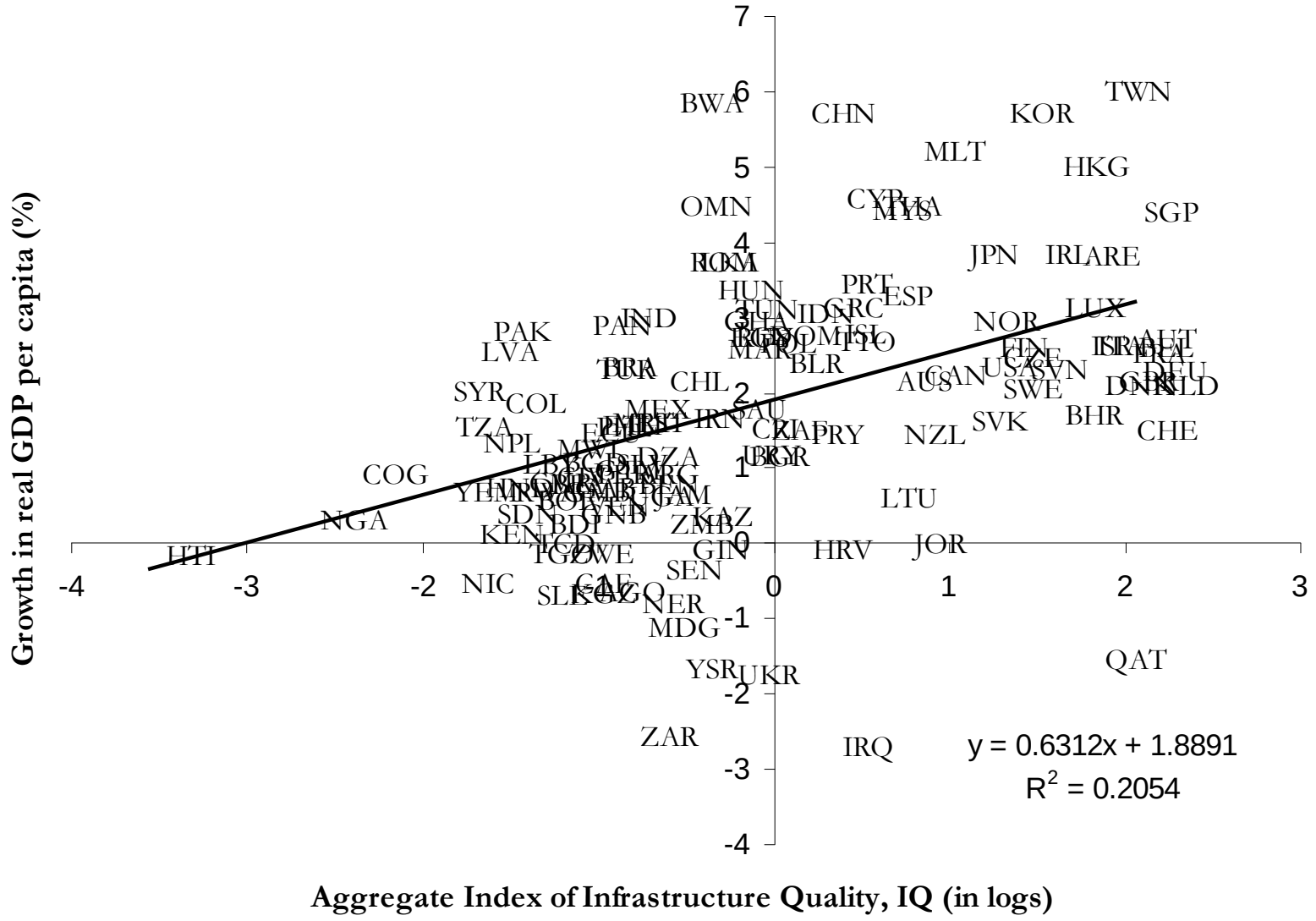
## Empirical studies, by reported finding (Straub 2007)

| Independent variable | Negative | None | Positive |
|---|---|---|---|
| Public Capital (65) | 10.8% | 40.0% | 49.2% |
| Physical Indicator (75) | 1.3% | 24.0% | 74.7% |

# 4.1.1 Infrastructure Stock and Economic Growth



# 4.1.2 Infrastructure Quality and Economic Growth



# 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:

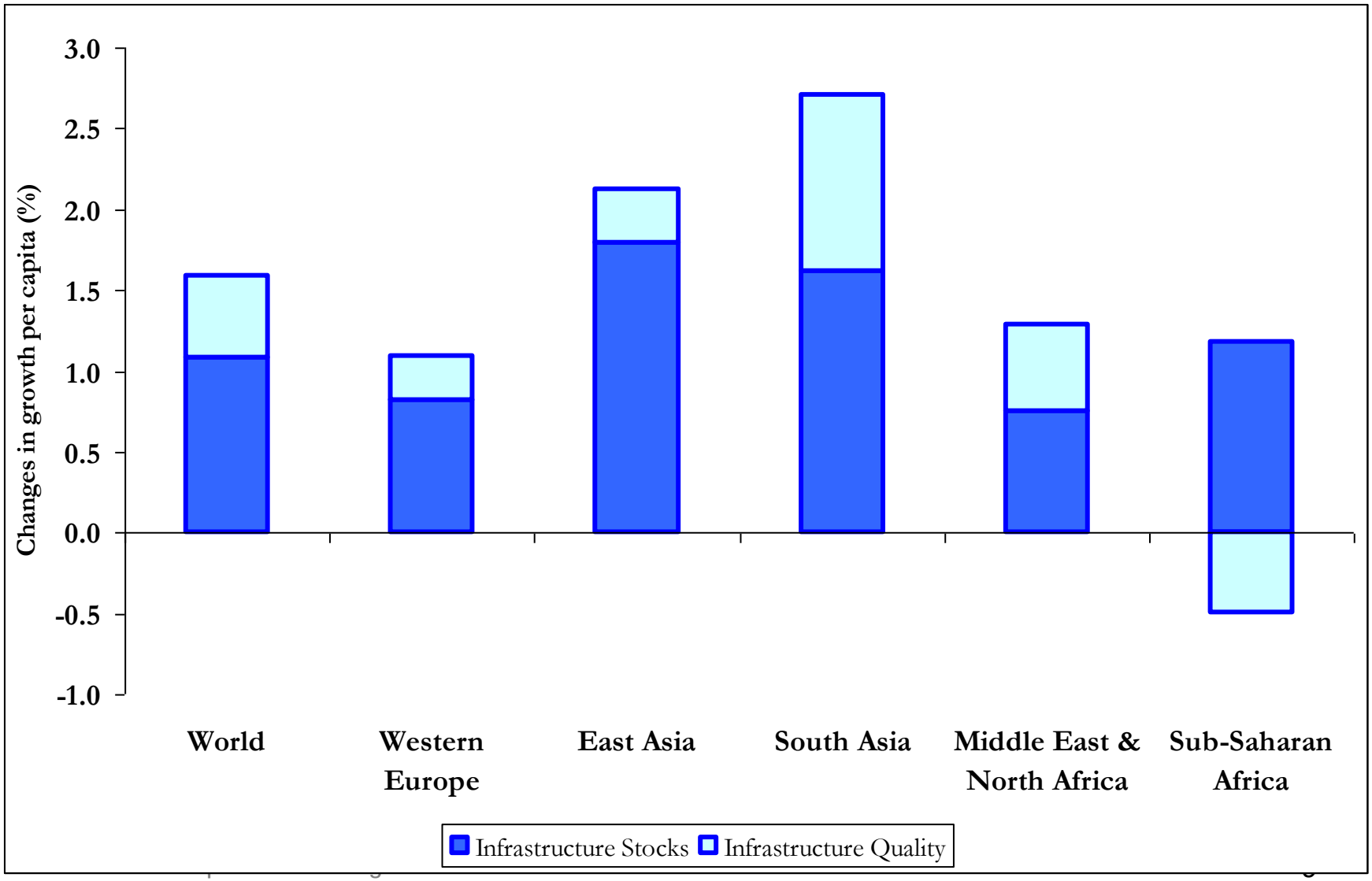
– Infrastructure quantity and quality have robust growth effect – and economically significant.

– 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

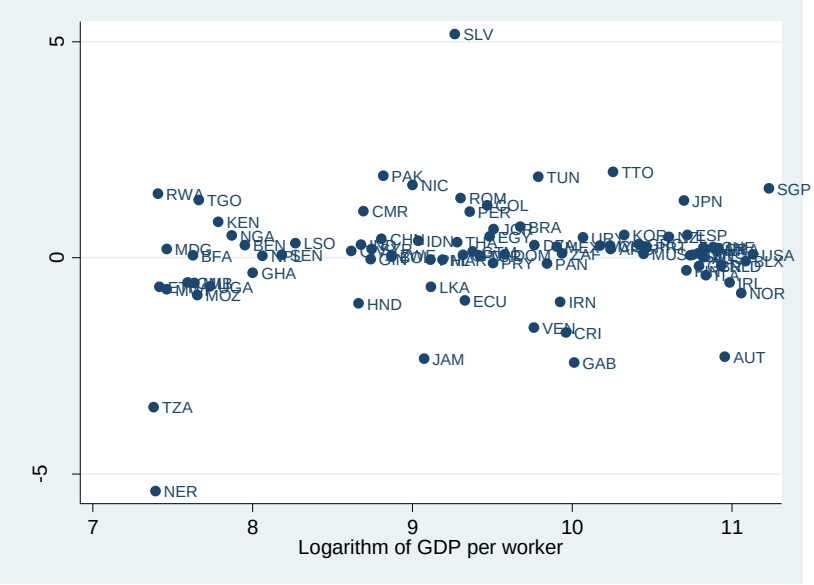
- Focus on the contribution of infrastructure to labor productivity (GDP per worker)
- synthetic infrastructure index (as before)
- 88 industrial and developing countries,1960-2000 (> 3,500 obs)
- Allow for heterogeneity of infrastructure contribution – both generic and along specific dimensions
  - 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

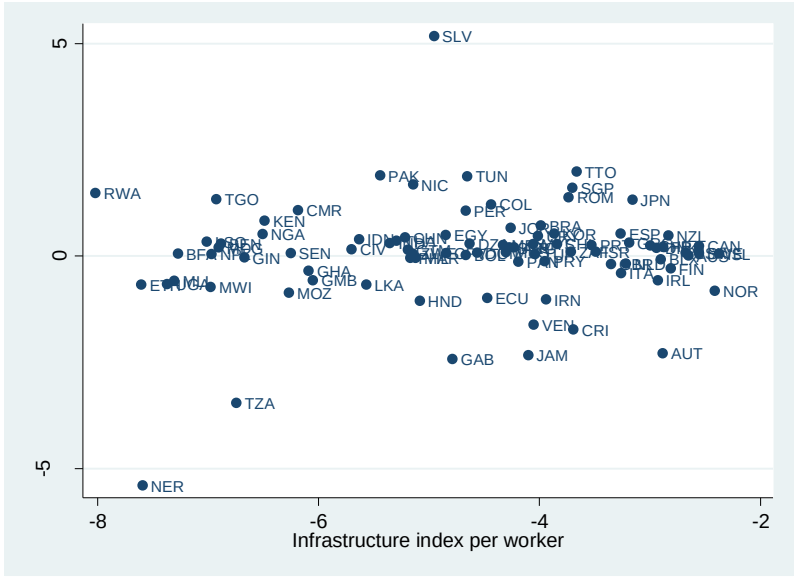
Main results

- 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

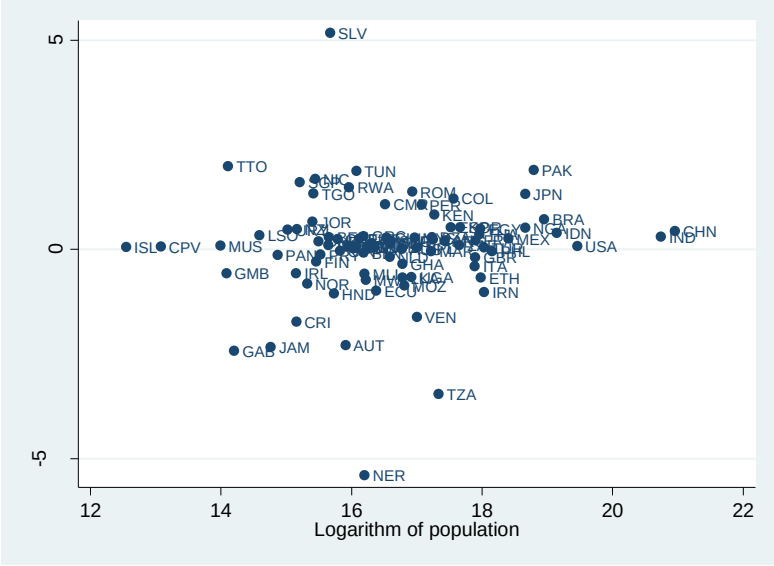
    Only this test comes close to 10% significance



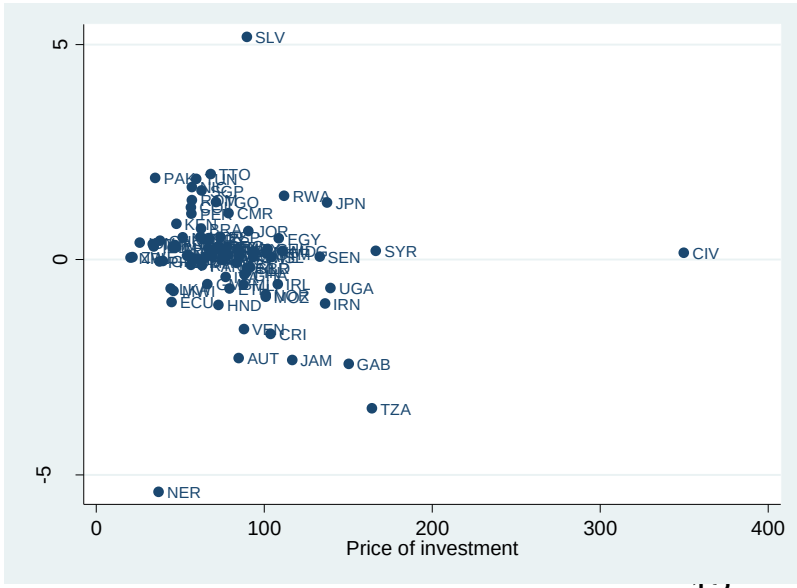

**Output elasticity of infrastructure vs. per capita GDP**




**Output elasticity of infrastructure vs. Infrastructure stock**




**Output elasticity of infrastructure vs. population**




**Output elasticity of infrastructure vs. distortion index**

# Infrastructure and growth

Further homogeneity tests

Break sample into high / low along the relevant dimension – and test for equality of mean infrastructure elasticity.

| | Per Capita Income (A) | Per Capita Income (B) | Infrastructure Endowment | Total Population | Distortions |
|---|---|---|---|---|---|
| High | 0.054 | 0.044 | 0.059 | -0.016 | -0.156 |
| Low | 0.059 | 0.062 | 0.055 | 0.131 | 0.271 |
| p-value | 0.985 | 0.94 | 0.988 | 0.576 | 0.102 |

Overall, no strong evidence that the elasticity varies across countries.

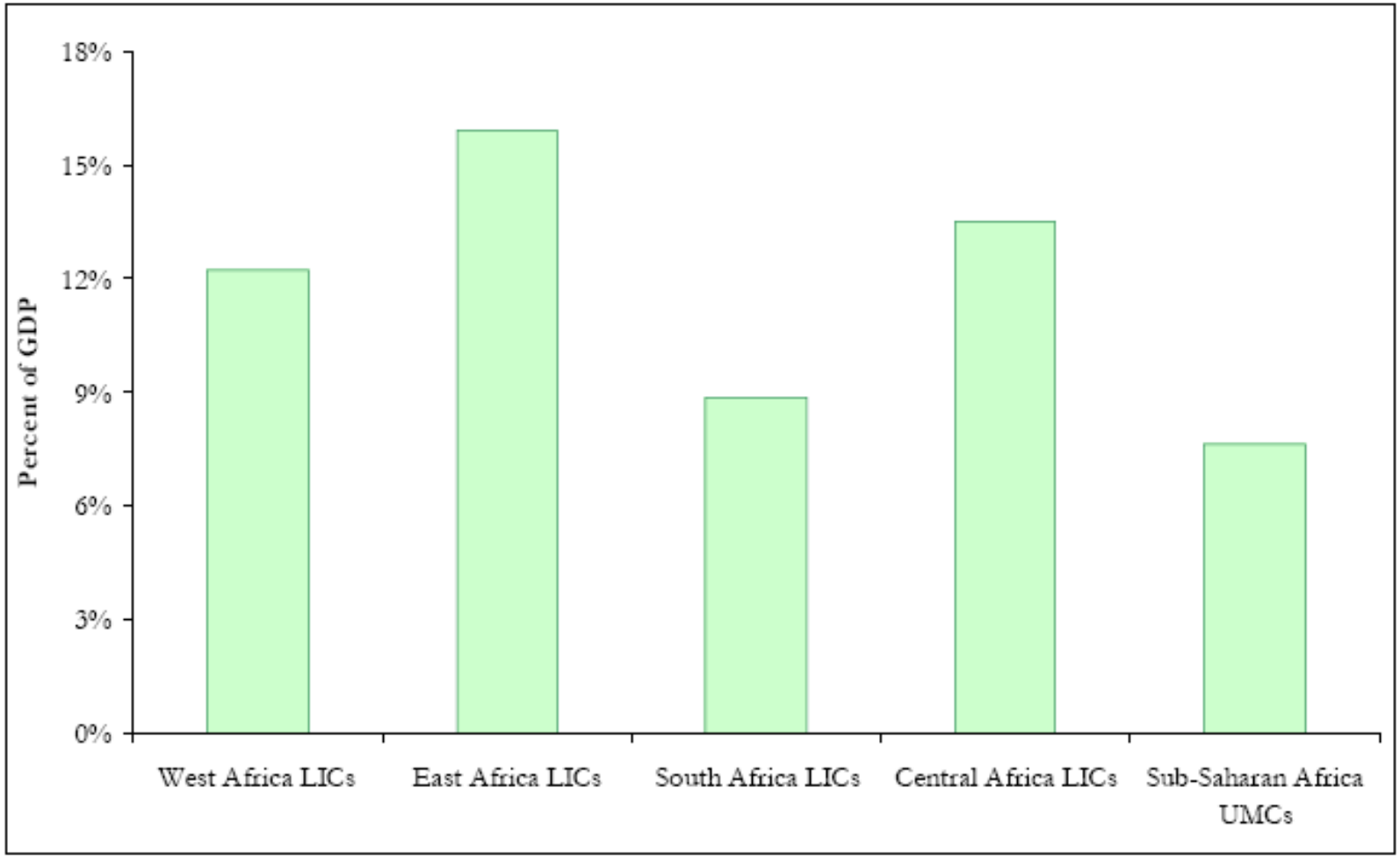
The implication is that the marginal product of infrastructure declines as the infrastructure / output ratio rises.

# 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



# 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.

# From spending to assets

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

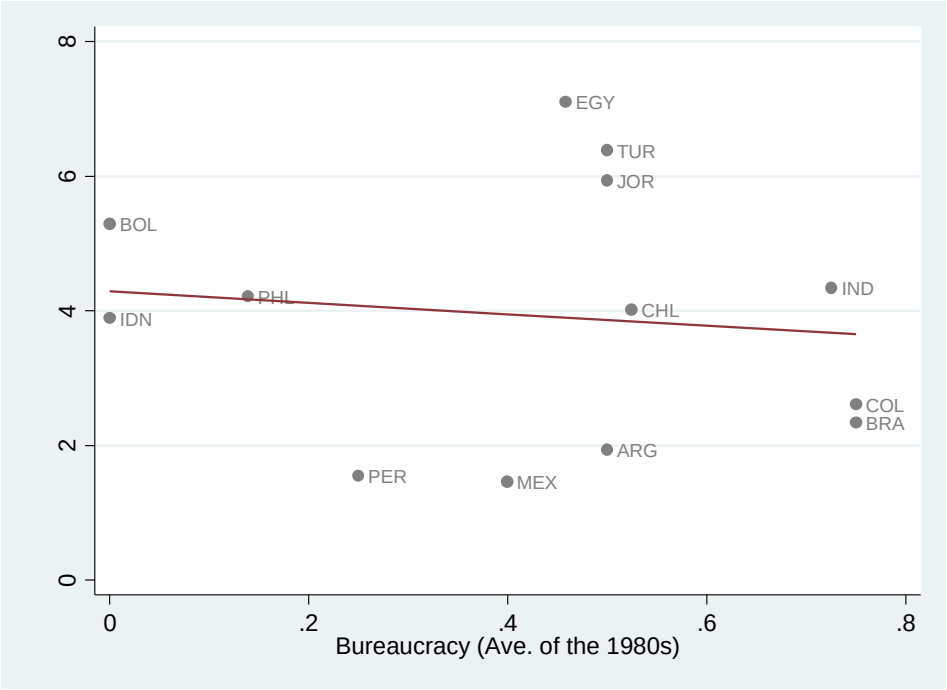
# From spending to assets

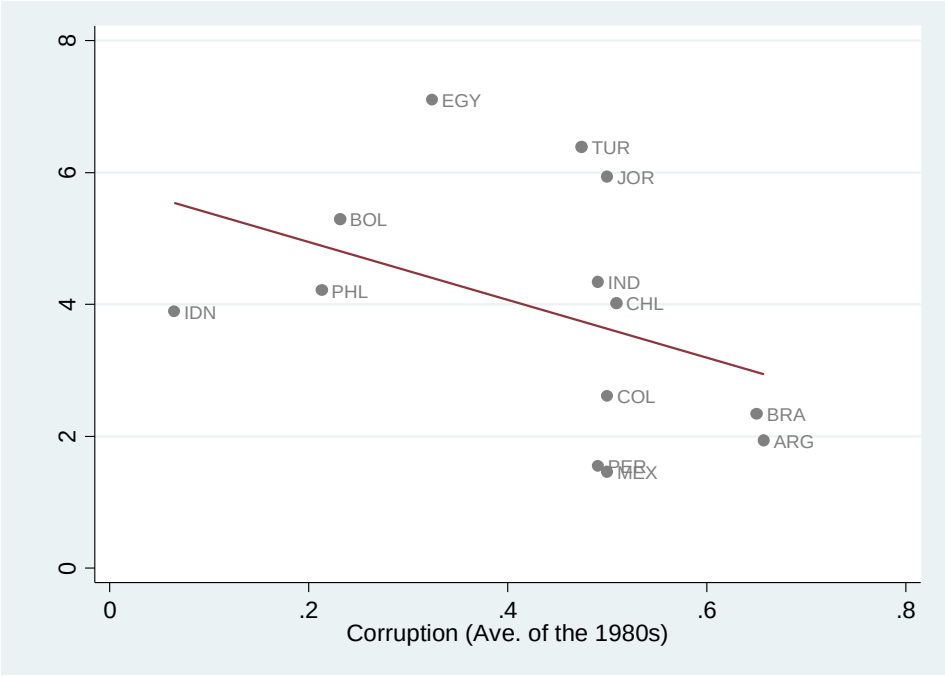
New database under construction – investment by infrastructure sector in developing countries

- 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

Infrastructure investment vs control of corruption

- 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:

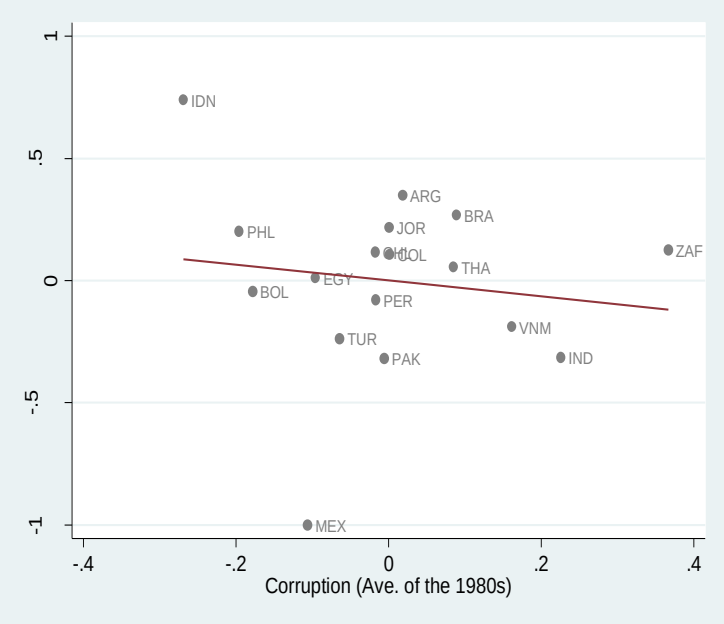
- No information on O&M spending
- No information on asset quality (except % roads paved)
- Small country sample (only 17 countries for the moment…)

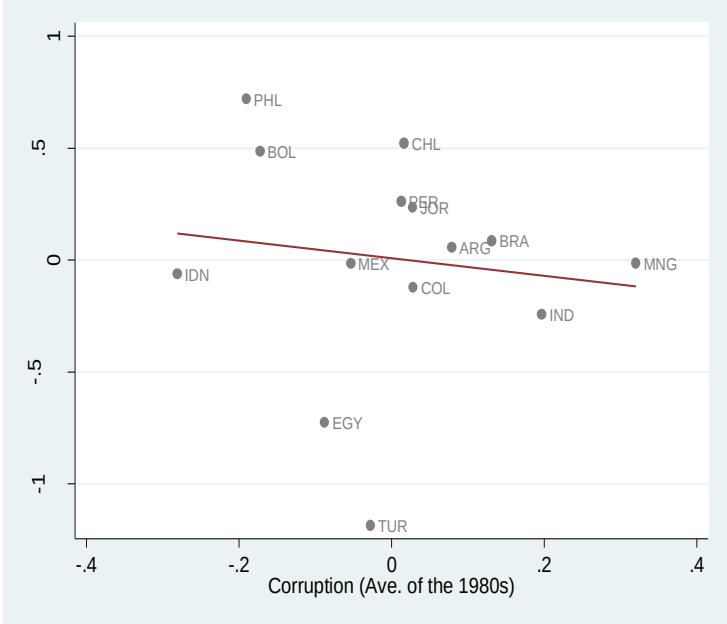
No retrospective info on fiscal / budgetary institutions, so look instead at the correlation of unit cost with broader governance-related variables:

- (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)

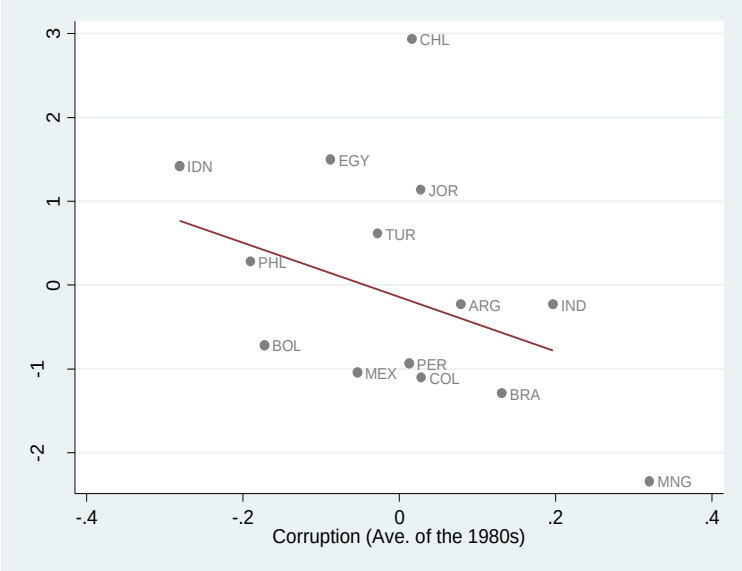
Power



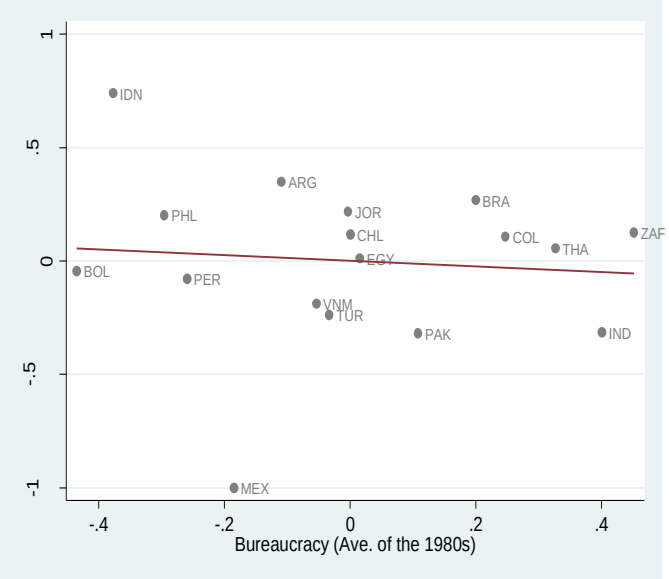

Phone lines

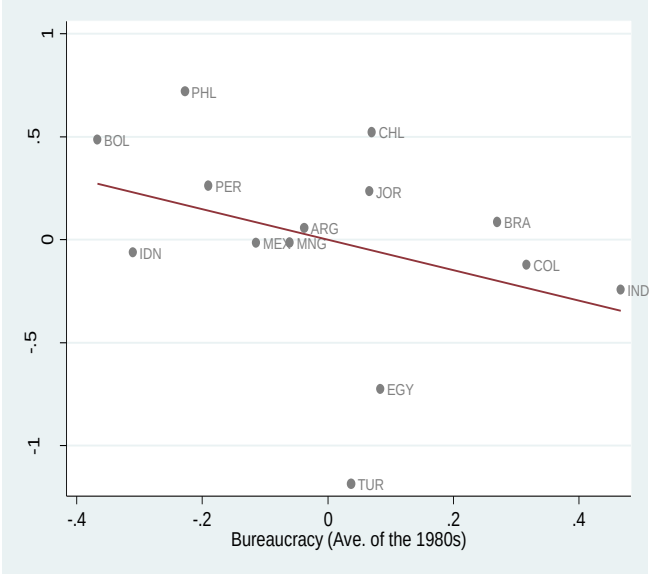
Roads



# Unit cost of infrastructure assets and quality of bureaucracy (controlling for GDP per capita)

Power

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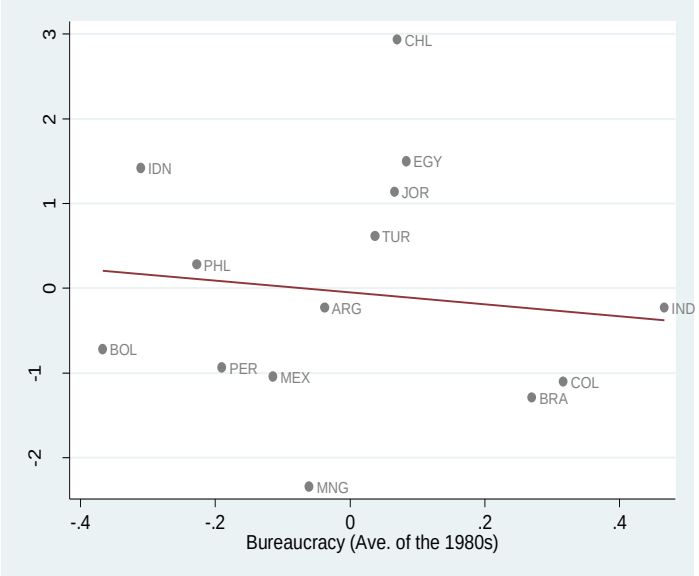

# From spending to assets

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.

End