

Assessing the Quality of Infrastructure through the Lens of Nighttime Lights – A Showcase

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The views expressed in this presentation are those of the authors and do not necessarily reflect the views and policies of the Asian Infrastructure Investment Bank.

Outline

- Introduction to AIIB;
- Data needed to measure Infrastructures;
- A showcase using historical nighttime light data assess the quality of infrastructure.

Introduction to AIIB



ABOUT AIIB

Asian Infrastructure Investment Bank

Who we are

Multilateral Development Bank (MDB) established by international treaty and headquartered in Beijing, founded to bring countries together to address **Asia's infrastructure funding gap, estimated at USD26 trillion through 2030.**¹ Our core principles are openness, transparency, independence and accountability.

Our mission

To improve economic and social development in Asia, through a focus on **sustainable infrastructure, cross-border connectivity and private capital mobilization.** Projects are supported via sovereign and nonsovereign loans, equity participations and guarantees.

Credit strength

Strong support from diversified global shareholder base. **USD100 billion capital stock** with 20% assigned to paid-in capital. Conservative risk management and financial policies. Experienced management team. **AAA/Aaa/AAA credit rating** with stable outlook. **0% risk weighting** from the BIS.

The bank's foundation is built on the lessons and experience of existing Multilateral Development Banks (MDB) and the private sector. Its *modus operandi* is to be:

Lean, with a small efficient management team and highly skilled staff.

Clean, an ethical organization with zero tolerance for corruption.

Green, an institution built on respect for the environment.



¹Source: "Meeting Asia's Infrastructure Needs", ADB 2017

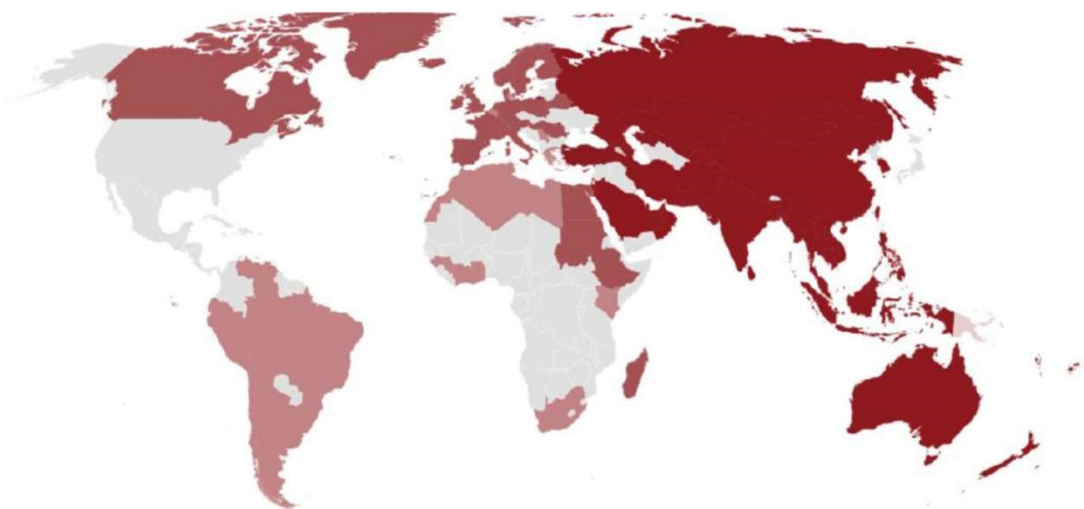
OVERVIEW OF SHAREHOLDING STRUCTURE

97 approved members



The Bank...will help to mobilize much needed additional resources from inside and outside Asia... and will complement the existing multilateral development banks.

Articles of Agreement



* Prospective founding member: These are prospective members who were original signatories to the Articles of Agreement in June 2015. Countries or territories who sought membership after that date are simply called prospective members. All prospective members have been approved by the Board of Governors but have not yet met the full requirements of membership.



Members Regional

- | | | |
|------------------|-----------------|----------------------|
| Afghanistan | Iran | Qatar |
| Australia | Israel | Russia |
| Azerbaijan | Jordan | Samoa |
| Bahrain | Kazakhstan | Saudi Arabia |
| Bangladesh | Korea | Singapore |
| Brunei | Kyrgyz Republic | Sri Lanka |
| Darussalam | Lao PDR | Tajikistan |
| Cambodia | Malaysia | Thailand |
| China | Maldives | Timor-Leste |
| Cyprus | Mongolia | Turkey |
| Fiji | Myanmar | United Arab Emirates |
| Georgia | Nepal | Uzbekistan |
| Hong Kong, China | New Zealand | Vanuatu |
| India | Oman | Vietnam |
| Indonesia | Pakistan | |
| | Philippines | |

Members Non-Regional

- | | |
|------------|----------------|
| Austria | Malta |
| Belarus | Netherlands |
| Canada | Norway |
| Denmark | Poland |
| Egypt | Portugal |
| Ethiopia | Romania |
| Finland | Spain |
| France | Sudan |
| Germany | Sweden |
| Hungary | Switzerland |
| Iceland | United Kingdom |
| Ireland | |
| Italy | |
| Luxembourg | |
| Madagascar | |

Prospective Regional

- Armenia
- Cook Islands
- Kuwait*
- Lebanon
- Papua New Guinea
- Tonga

Prospective Non-Regional

- | | |
|---------------|---------------|
| Algeria | Peru |
| Argentina | Serbia |
| Belgium | South Africa* |
| Bolivia | Togo |
| Brazil* | Tunisia |
| Chile | Uruguay |
| Cote d'Ivoire | Venezuela |
| Ecuador | |
| Ghana | |
| Greece | |
| Guinea | |
| Kenya | |
| Libya | |
| Morocco | |

HIGH-QUALITY SHAREHOLDER BACKING

Diversified International Shareholder Base

Regional vs Non-Regional Shareholding Split

Regional Members	Current Shareholding
China	30.9%
India	8.7%
Russia	6.8%
Korea	3.9%
Australia	3.8%
Indonesia	3.5%
Turkey	2.7%
Saudi Arabia	2.6%
Iran	1.6%
Thailand	1.5%
Other 34 Members	10.6%
Total: 44 Members	76.6%

Non-Regional Members	Current Shareholding
Germany	4.7%
France	3.5%
UK	3.2%
Italy	2.7%
Spain	1.8%
Netherlands	1.1%
Canada	1.0%
Poland	0.9%
Switzerland	0.7%
Egypt	0.7%
Other 16 Members	3.1%
Total: 26 Members	23.4%

Ratings Status of AIIB Shareholders¹

AAA:	13%
AA- or better:	28%
A- or better:	65%
BBB- or better:	90%

Preferred Creditor Treatment – In line with other MDBs, AIIB expects to benefit from preferred creditor treatment such as:

In its members it will not be required to participate in any rescheduling of national debt, Member liabilities to the AIIB, such as sovereign loans or sovereign guarantees on private sector projects, rank on par with their obligations to the IMF and other MDBs.



Note: 1. Based on ratings from S&P, Moody's and Fitch using the Basel 2/3 methodology – if three ratings available take median, if only two ratings available take lower rating. Ratings are then weighted by shareholding.

AIIB'S THEMATIC PRIORITIES

We approach lending, developing our business lines and selecting our projects based on three thematic priorities



Sustainable Infrastructure

Promoting green infrastructure and supporting members to meet their environmental and development goals, especially their commitments under the Paris Agreement and the United Nations' Sustainable Development Goals.



Cross-border Connectivity

Prioritizing cross-border infrastructure, ranging from roads and rail to ports, airports, energy pipelines and telecoms.



Private Capital Mobilization

Devising innovative solutions that mobilize private capital, in partnership with other MDBs, governments, private financiers and other partners. AIIB's presence on cofinancings helps spread risk across the MDB and private sector communities, and can help to crowd in private sector capital.

Data needed to measure Infrastructures

- Limited statistics available for infrastructure investments:
 - Money Metric Measurement;
 - Physical measurement.
- Limited data on cross-border connectivity:
 - Cross-border roads, railways, grid, air-routes, etc.
- New areas:
 - Geographical locations at the project level;
 - Statistics/measurements on ESG;
 - Statistics/measurements on the impact of Climate Change;
 - Nighttime lights.

A showcase using nighttime light data assess the quality of infrastructure

“

“Quantity is important...but quality is the most important thing.”

“I want to move forward on the basis of prudence and the basis of meticulous study.”

Liqun Jin, President of AIIB
Interview by Reuters on February 12, 2019

”

Why use the nighttime lights?

- An unbiased source;
- Flexible with the geographic scope.

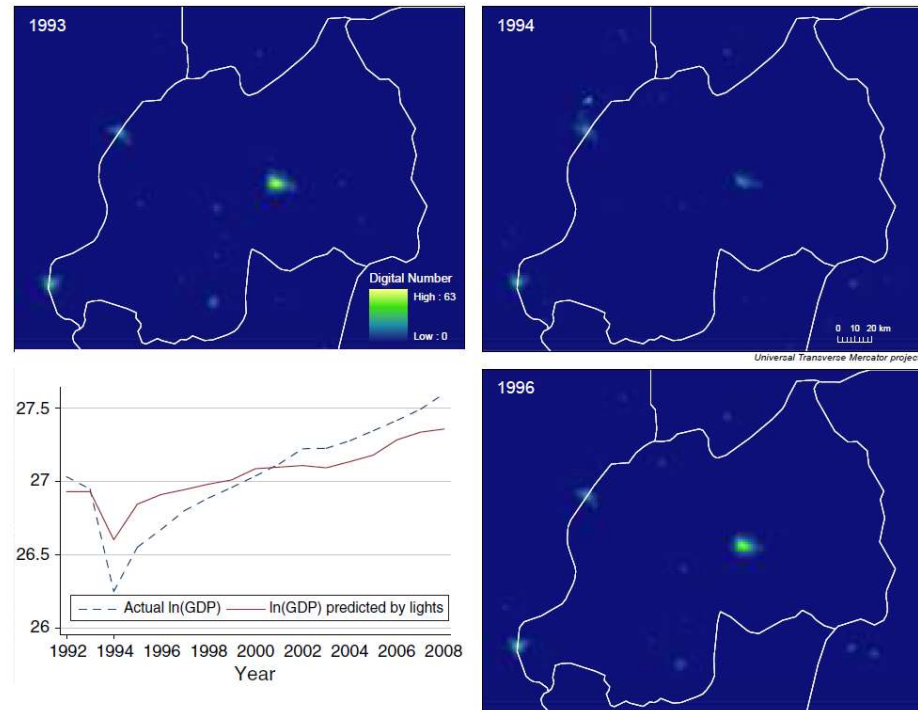
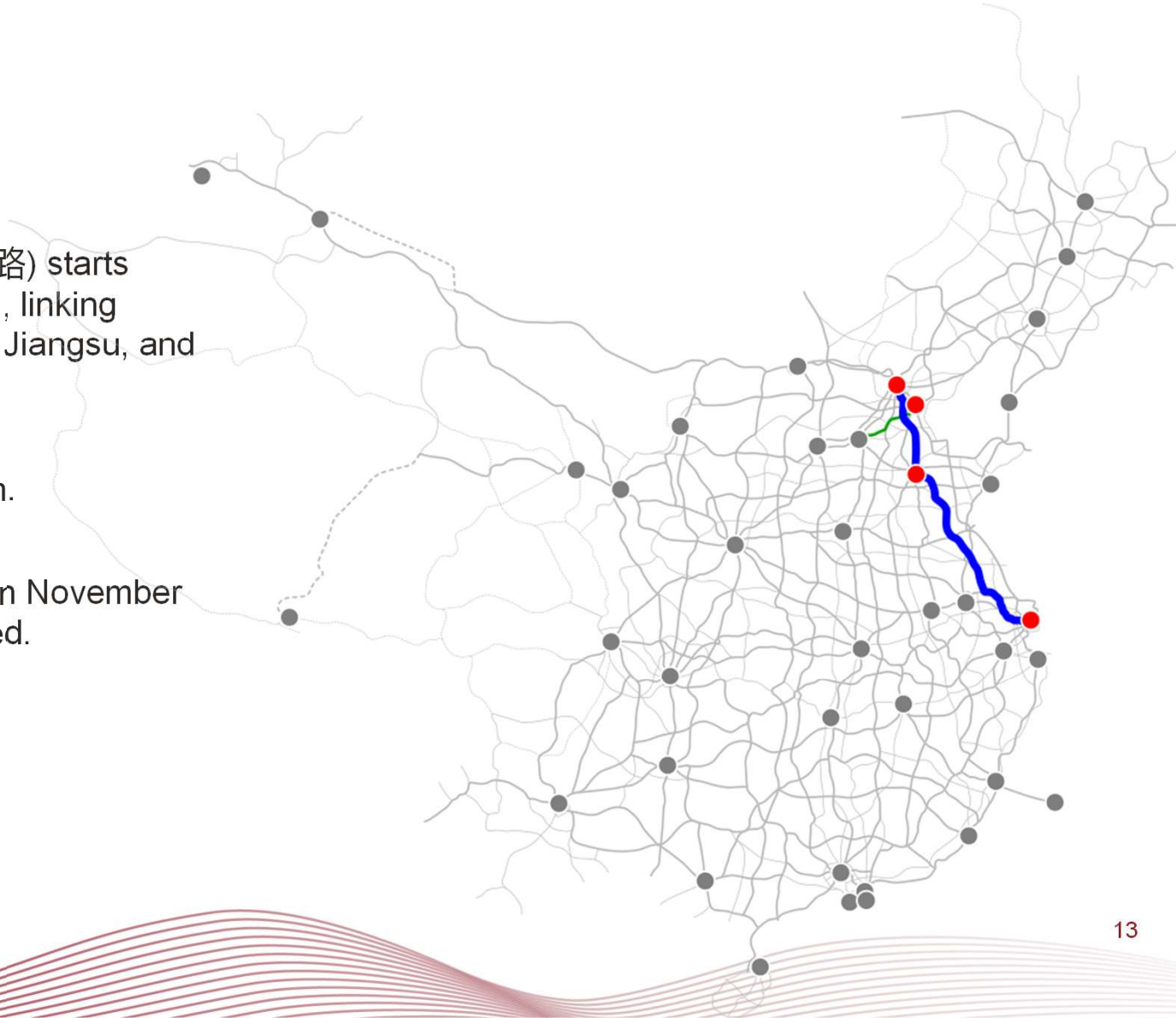


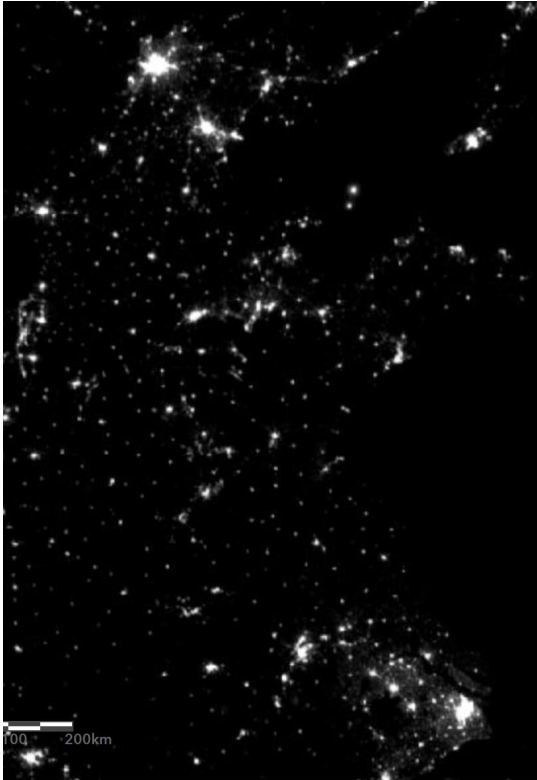
FIGURE 4. GENOCIDE EVENT: RWANDA

- Source: Henderson, Storeygard, and Weil (AER, 2012)

- **Jinghu Expressway (京沪高速公路)** starts from Beijing and ends in Shanghai, linking Beijing, Tianjin, Hebei, Shandong, Jiangsu, and Shanghai.
- The total length is around 1262 km.
- The construction started in 1987. In November 2000, the whole line was completed.



1992 vs. 2000



http://www.arcgis.com/home/webmap/viewer.html?url=https%3A%2F%2Fgis.ngdc.noaa.gov%2Farcgis%2Frest%2Fservices%2Fdmisp%2Favg_lights_x_pct%2FImageServer&source=sd

Questions:

- (1) Whether are the nighttime lights getting brighter;
- (2) How long does it take for the nighttime lights to become brighter;
- (3) What are the rankings of economies in terms of the effectiveness of the infrastructure investments;
- (4) What are the relationships between debt and effectiveness?

Literatures review

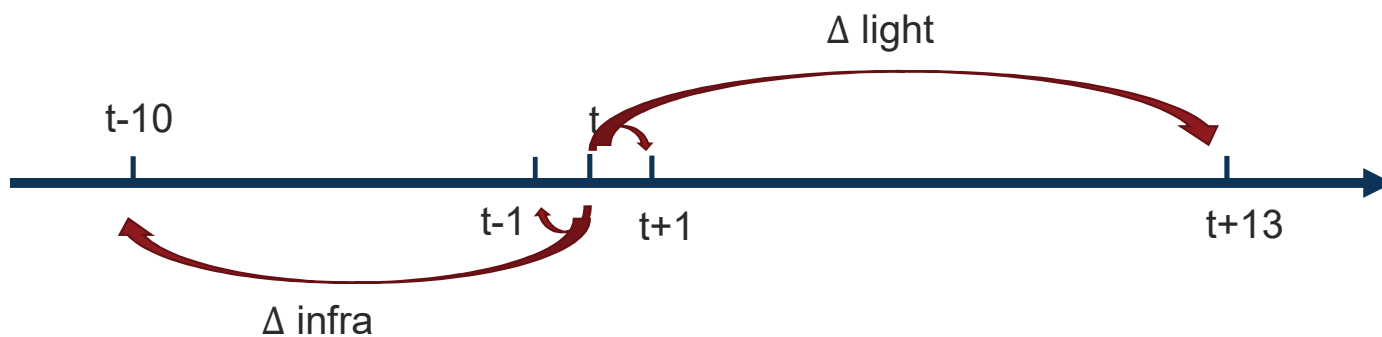
- Henderson, Storeygard, and Weil (AER, 2012) use aggregate brightness during nighttime, as seen from outer space, as an indicator of economic activity.
- Pinkovskiy and Sala-i-Martin (QJE, 2016) use nighttime light as an instrument to realign the economic development based on the national account and based on household surveys.
- Strong correlations between nighttime light and electricity consumption were also found by Proville, Zavala-Araiza, and Wagner (PLOS ONE, 2017).
- AidData (2018) matched the nighttime lights with the location of China-financed infrastructure in developing countries to assess the latter's impact on economic growth and inequality.
- The Intensity of light in nighttime satellite images is used as a proxy for power infrastructures by Ghai, Ismail, and Pakala (Stony Brook University, 2018).

Data

- **Nighttime lights data:** Version 4 DMSP-OLS Nighttime Lights Time Series from **1992 to 2013** provided by the US National Oceanic and Atmospheric Administration (NOAA) at <http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html>;
- **Infrastructure Data:**
- Calderón, C., E. Moral-Benito and L. Servén (2014) "Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach", Journal of Applied Econometrics:
 - **Paved roads:** total length of paved roads in kilometers per thousand workers;
 - **Electricity:** electricity generating capacity in gigawatts per thousand workers;
 - **Rails:** total length of rail in kilometers per thousand workers.

Methodology

- Rolling window approach:
 - Based on the data availability, we choose the lags of infrastructures such as paved roads as $l = 1, 2, \dots, 10$ and the heads of nighttime light as $h = 1, 2, \dots, 13$.



Correlations between the infrastructure investments and the brightness of lights

- Calculate correlations between the changes in infrastructures from $t - l$ to t and the changes in brightness of lights from t and $t + h$ with $t \in [1992, 2000]$ for each combination of l and h .
- Selection criteria:
 - 1. The correlations are positive;
 - 2. The correlation estimates are significant at least at 10%.

On paved roads ...

Table 1. Number of countries with significant positive correlations between changes in the paved road and changes in brightness of lights with $N \in [90, 95]$

Heads of Light Brightness h	1	2	3	4	5	6	7	8	9	10	11	12	13	
Lags of changes in Paved Roads l	1	3	8	5	4	13	9	5	4	7	3	9	9	6
	2	3	10	8	9	11	12	12	10	11	5	8	9	7
	3	2	5	11	11	20	13	17	14	14	3	7	10	7
	4	0	5	4	12	17	12	12	12	9	2	6	7	6
	5	1	3	3	12	13	14	11	7	6	2	5	9	6
	6	1	4	6	10	14	13	6	8	7	5	5	9	6
	7	0	7	6	9	14	11	8	8	7	3	5	5	4
	8	0	5	6	11	15	9	10	9	11	2	3	7	5
	9	0	3	5	10	12	11	8	7	6	2	2	6	4
	10	1	1	4	8	9	10	8	6	8	2	3	6	7

On electricity...

Table 2. Number of countries with significant positive correlations between changes in electricity generated and changes in brightness of lights with $N \in [90, 95]$

Heads of Light Brightness h	1	2	3	4	5	6	7	8	9	10	11	12	13
1	5	4	0	3	6	7	5	3	4	3	4	8	0
2	3	6	5	8	5	11	6	6	8	6	7	9	7
3	2	8	7	5	4	8	7	6	7	6	9	9	8
4	3	7	5	4	5	8	5	8	8	4	8	7	4
5	1	4	2	2	4	8	9	7	6	8	10	8	7
6	1	3	2	4	5	15	7	11	9	7	9	9	7
7	1	5	4	5	9	14	12	10	10	11	7	9	3
8	1	5	6	4	6	11	14	13	11	9	6	7	4
9	2	3	6	3	4	13	14	14	9	7	5	6	6
10	3	5	4	2	7	12	13	11	11	8	3	7	1

On rails ...

Table 3. Number of countries with significant positive correlations between changes in rails and changes in brightness of lights with $N \in [90, 95]$

Heads of Light Brightness h	1	2	3	4	5	6	7	8	9	10	11	12	13
1	5	2	1	1	4	3	3	2	1	2	2	1	1
2	2	4	4	4	5	4	2	5	5	4	2	5	7
3	1	6	4	8	7	9	5	8	7	4	4	7	5
4	1	4	0	9	7	8	6	8	6	6	7	8	6
5	1	4	3	4	4	11	10	7	9	7	5	9	6
6	2	2	0	7	5	11	9	7	5	6	4	5	5
7	1	2	0	6	3	11	7	3	5	4	5	6	5
8	0	4	3	6	5	12	7	3	7	6	6	5	8
9	2	2	2	7	8	12	7	4	5	9	7	5	6
10	0	2	2	7	9	11	9	6	11	4	7	4	3

Observations

- The frequency of significance: paved roads (953), electricity generated (842), and rails (661).
- Different combinations of $[l, h]$ to have the most number of countries with significant correlations:
 - $[3, 5]$ for paved roads (with a number of obs. as 20);
 - $[6, 6]$ for electricity generated (with a number of obs. as 15);
 - $[8/9, 6]$ for rails (with a number of obs. as 12).

Measure the effectiveness of infra investment using differences between the changes in light brightness and the changes in infrastructure investment

Measure the effectiveness of infra investment using the difference between the changes in brightness and the changes in infrastructure investment

$$\bullet R_{i,t}^{lh} = \left(\frac{Light_{i,t+h}}{Light_{i,t}} - 1 \right) / h - \left(\frac{Infra_{i,t}}{Infra_{i,t-l}} - 1 \right) / l,$$

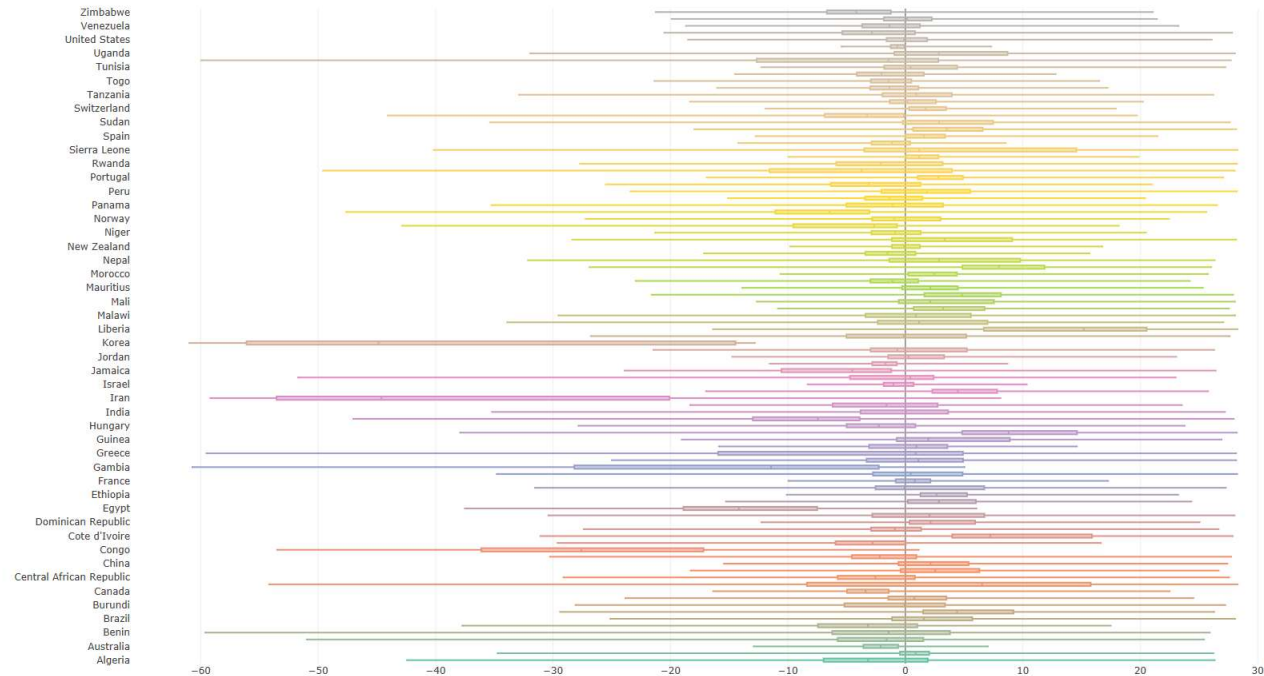
where $t \in [1992, 2000]$, the lags of infrastructure investment $l = 1, 2, \dots, 10$, and the heads of nighttime light $h = 1, 2, \dots, 13$.

- $R_{i,t}^{lh}$ is the difference between the annualized growth rate of light brightness and the annualized growth rate of infrastructure investment.
- Higher $R_{i,t}^{lh}$ indicates that the infrastructure investment is more effective in terms of bringing higher economic growth (measured by lights).

Growth Rate Difference between Light and Paved Roads (annualized %)

- Countries with a high value of median $R_{i,t}^{lh}$ (%):

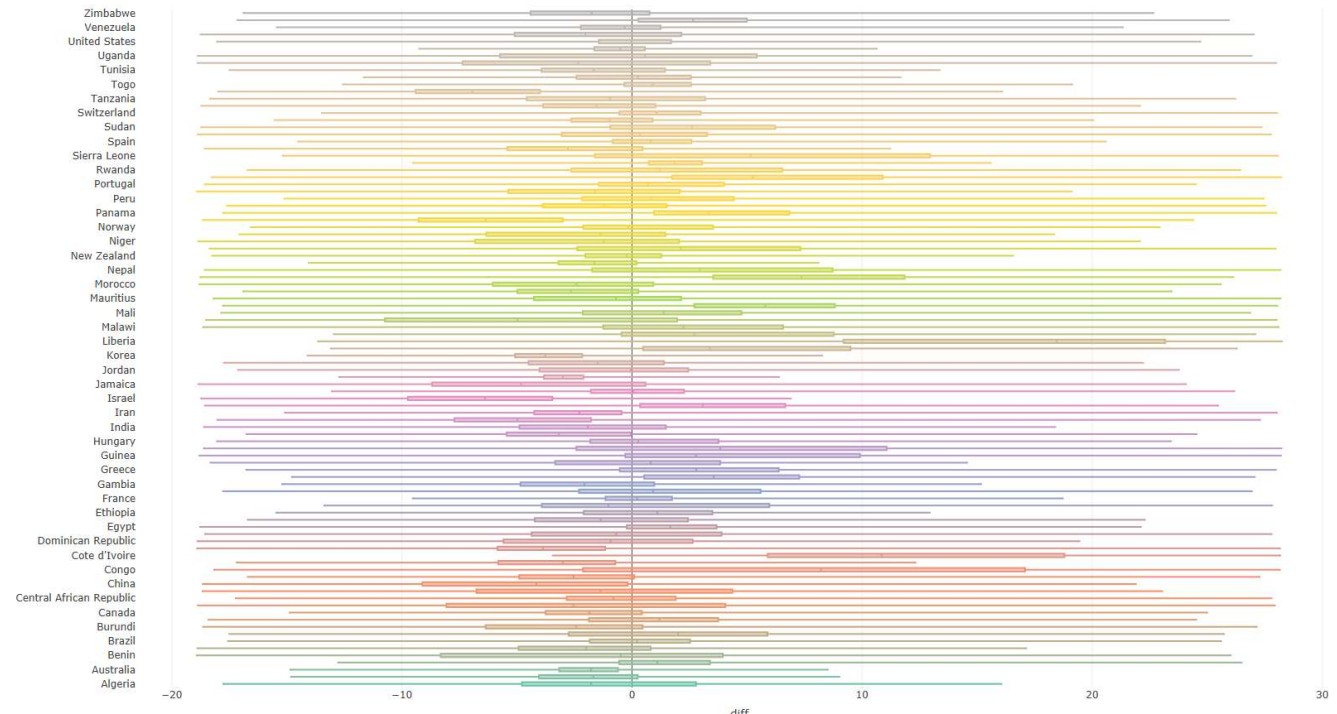
Liberia (15.19),
Honduras (8.79),
Mozambique (7.96),
and Cote d 'vote (7.25).



Growth Rate Difference between Light and Electricity (annualized %)

- Countries with a high value of median $R_{i,t}^{lh}$ (%):

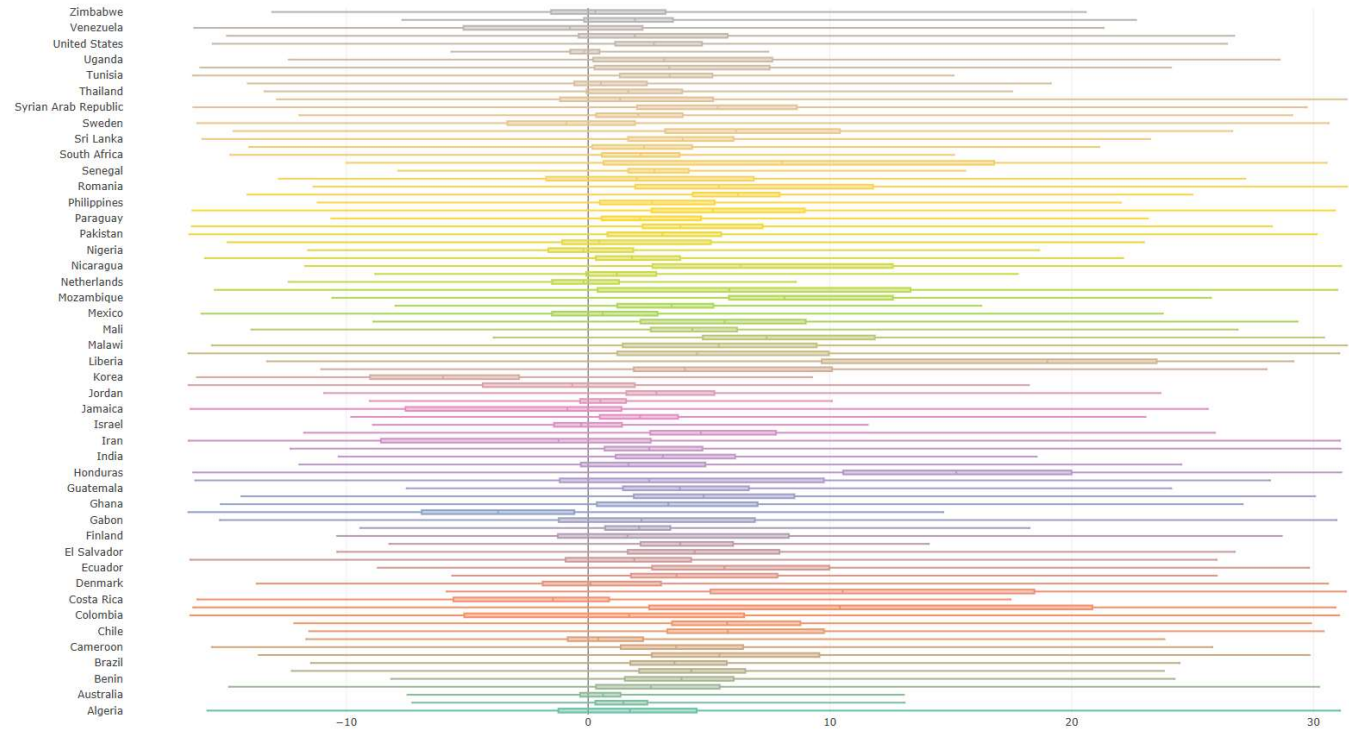
Liberia (18.47),
Cote d 'voto (10.85),
Congo (8.22),
Mozambique (7.36),
and Sierra Leone (5.16).



Growth Rate Difference between Light and Rails (annualized %)

- Countries with a high value of median $R_{i,t}^{lh}$ (%):

Liberia (18.99),
Honduras (15.22),
Cote d 'vote (10.53),
Congo (10.41),
and Mozambique (8.12).



Observations

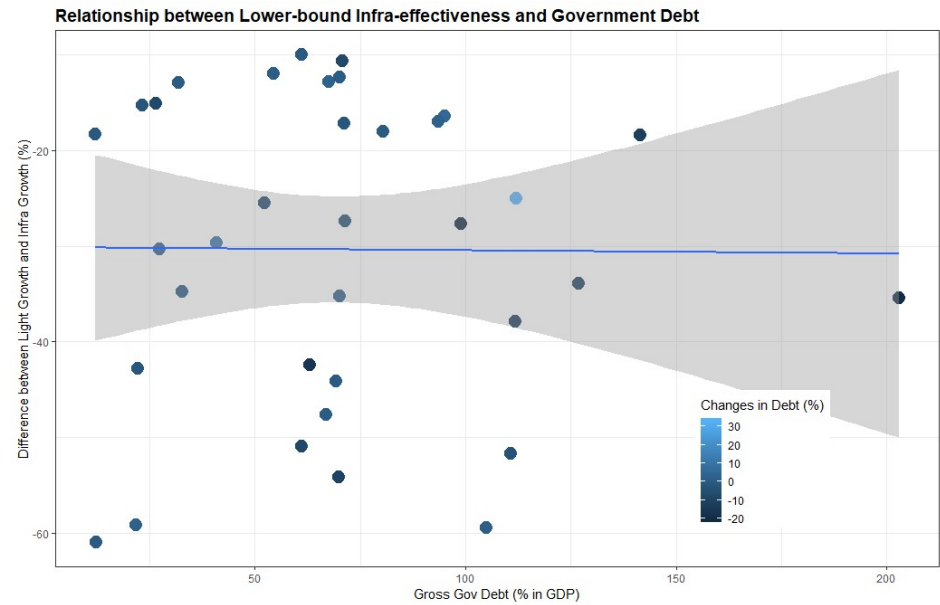
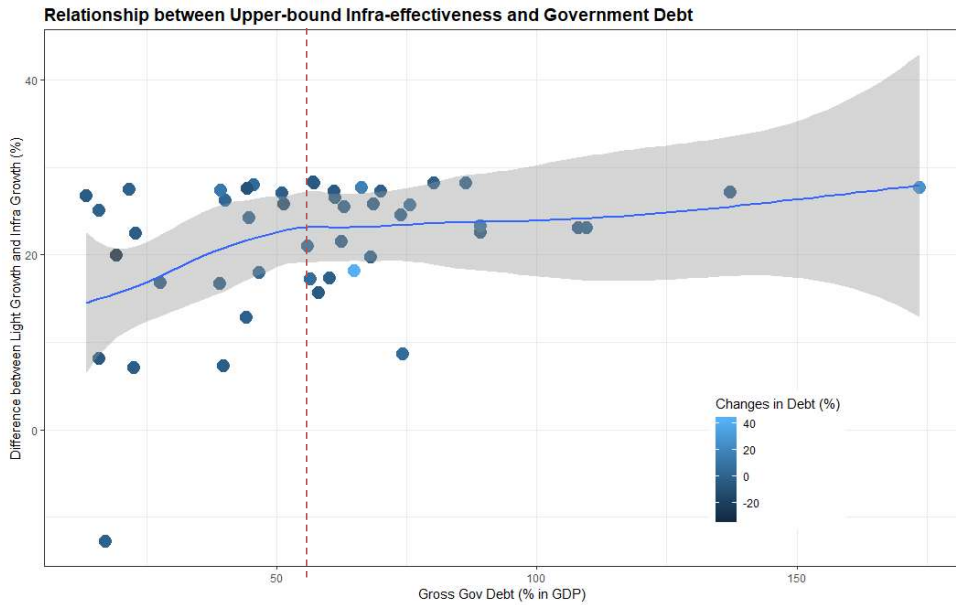
- Rails are the most effective infrastructure investments, followed by electricity:
 - Most of the countries in the sample have positive median $R_{i,t}^{lh}$.
- Paved roads show large heterogeneities in terms of effectiveness:
 - Large negative $R_{i,t}^{lh}$ for countries such as Iran, Korea, Congo, and the Gambia.

Debt and Effectiveness of Infrastructure

Debt and Effectiveness of Infra - Paved Road

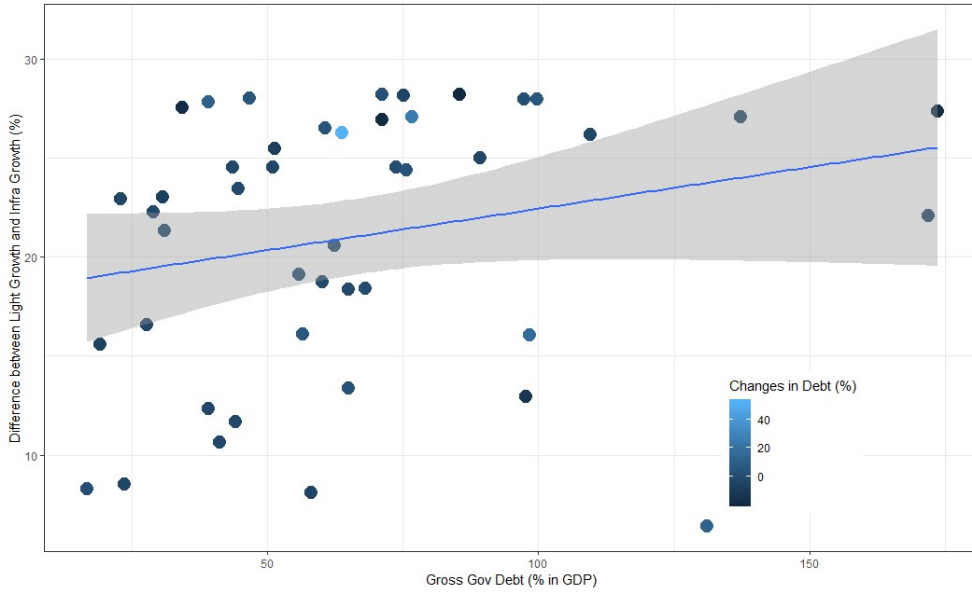
- **Upper-bound:** the maximum R_t^{lh} for each country i .

- **Lower-bound:** the minimum R_t^{lh} for each country i .

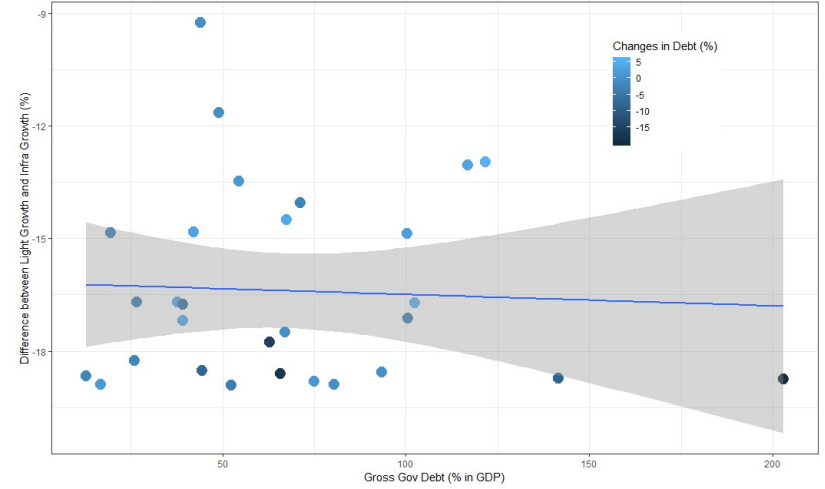


Debt and Effectiveness of Infra - Electricity

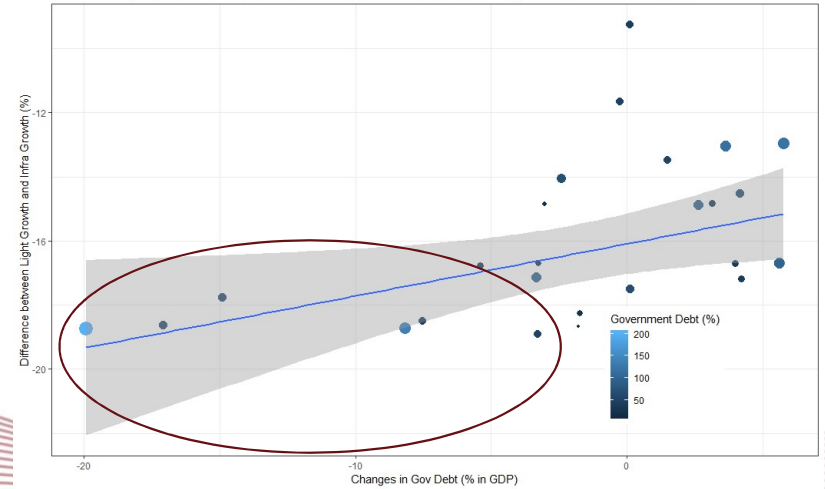
Relationship between Upper-bound Infra-effectiveness and Government Debt



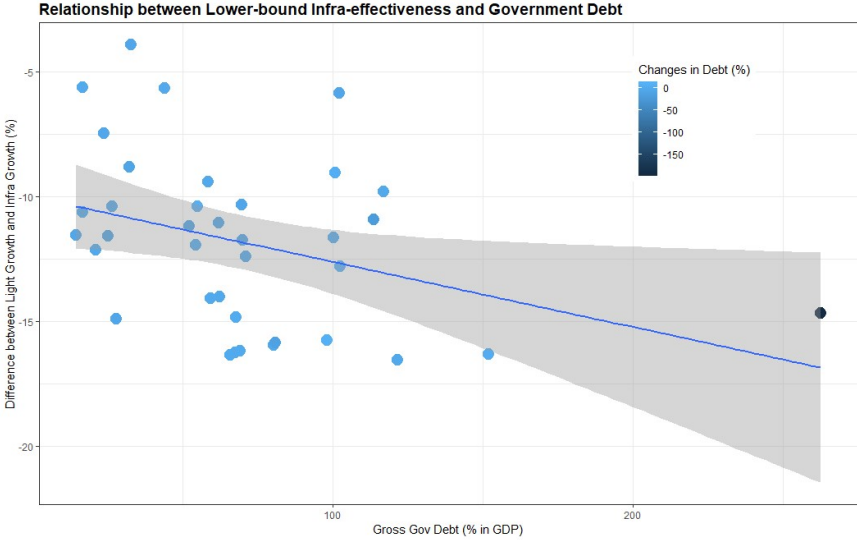
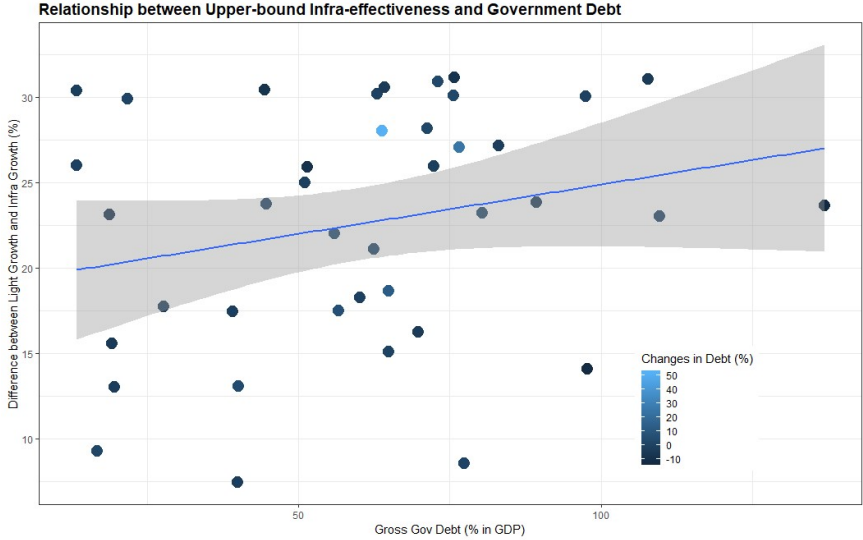
Relationship between Lower-bound Infra-effectiveness and Government Debt



Relationship between Lower-bound Infra-effectiveness and Changes in Government Debt



Debt and Effectiveness of Infra - Rails



Observations for Infra-induced Brightness of Lights and Debt

- Paved roads:
 - Upper-bound (best performing country-episodes):
 - Effectiveness of the investments increases along with government debt till a certain level;
 - Lower-bound (worse performing country-episodes):
 - No clear relationship.
- Electricity generated:
 - Upper-bound:
 - Effectiveness of the investments increases along with the government debt;
 - Lower-bound:
 - No clear relationship between the effectiveness of the investments and debt;
 - But sharp contractionary measure by reducing debt might worsen the worst.
- Rails:
 - Upper-bound:
 - Effectiveness of the investments increase along with the government debt;
 - Lower-bound:
 - High debt levels do associate with worse effectiveness of investment.

Caveats

- The economic benefits were not assessed based on the geographical locations of each project but at an aggregated level;
- The time coverage of the analysis is limited (1992-2013), which might not reflect the on-going dynamics;
- No causal relationship was examined;
- This is a check of one-to-one association between economic return and infrastructure investments, which is not based on a comprehensive multivariate analysis.

Next Steps...

- Acquire more up-to-date data and the project level data (AidData, Fitch, etc.);
- Examine the impacts at project level;
- Investigate the causal relationship;
- Introduce the multivariate framework to examine what the factors are behind the upper-bound episodes.

THANK YOU.

