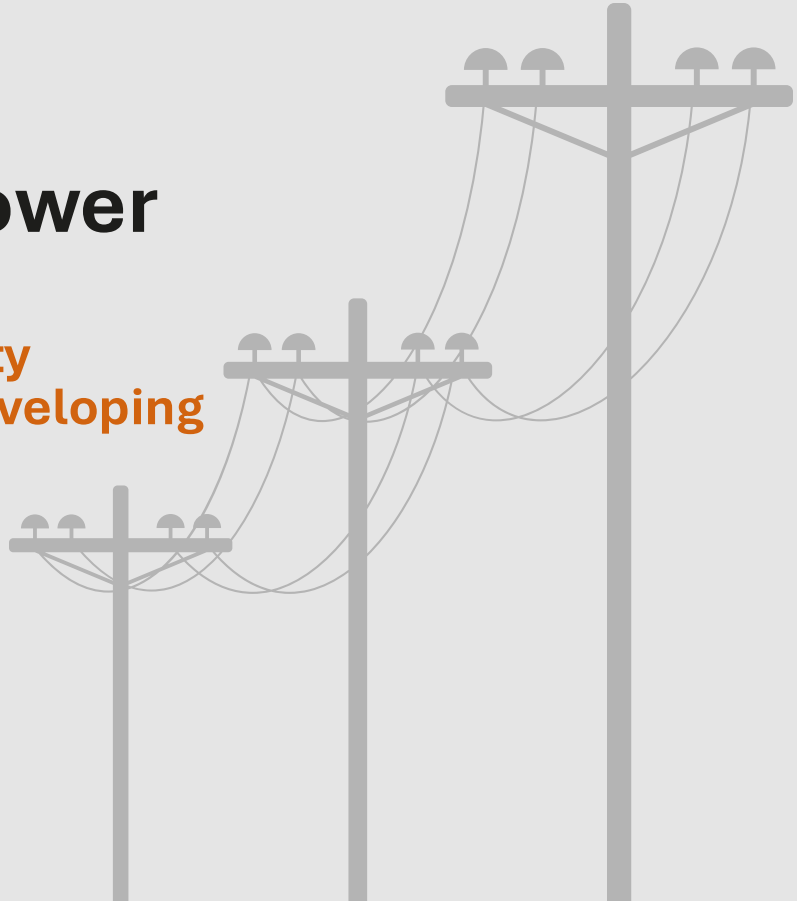
Utilities in Competitive Markets Deliver More Power with Less

How Market Structures Influence Utility Efficiency and Electricity Access in Developing Countries



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Substantial Research Paper Preliminary Presentation
April 2025

Overview

- 685 million people still lack electricity — inefficient utilities are a key barrier.
- Study benchmarks 49 utilities across 37 countries
- Combines DEA and regression analysis
- Finds links between markets, efficiency, and access

Motivation

1. Many utilities in developing countries underperform
2. In Honduras, national company’s debt is 9% of GDP and still struggles
3. Weak utility performance hinders service quality and expansion
4. Benchmarking can guide reforms and share best practices

Research Question and Data: How do market structures affect utility efficiency and electricity access?

Data:

49 utilities across 37 countries (utility performance + market structure variables + access data)

Sources:

UPBEAT dataset, Global Power Market Structures, WDI, – all World Bank

What Do We Mean by Market Structure?

Type:

Vertically Integrated Utility (VIU)

One company controls generation, transmission, and distribution.

Single Buyer Model (SBM)

Power is generated by multiple producers but bought and distributed by one central utility.

Wholesale-Retail Competition (WRC):

Multiple buyers and sellers compete to sell electricity to consumers.

Characteristics:

Unbundling:

Generation, transmission, and distribution are operated by separate entities.

Regulation:

Independent oversight of tariffs, investments, and performance standards.

Private IPPs:

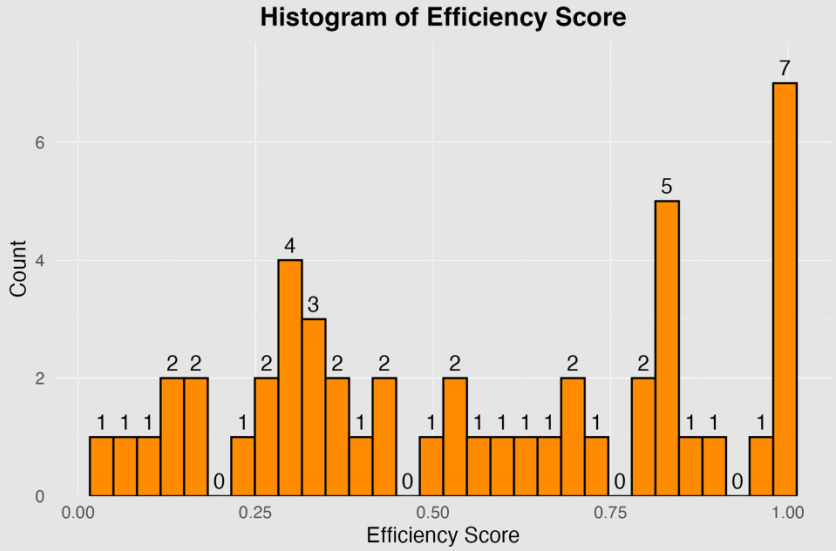
Independent power producers operate alongside or instead of state-owned utilities.

DEA Method in Brief

- DEA measures efficiency: inputs vs. outputs
- Each utility is compared to a custom benchmark
- Benchmark is built from a weighted mix of top performers
- Input-oriented model: shrink inputs, hold outputs constant
- Calculates an efficiency score (θ): 1 = efficient, <1 = room to improve
- My inputs: employees, assets
- My outputs: profit margin, customers, low losses
- DEA uses real data (non-parametric) — no assumptions or equations needed
- Method comes from Charnes, Cooper & Rhodes (1978)

Distribution of DEA Efficiency Scores

Looking at utilities with distribution operations in the data set that had complete input and output data (average 2012-2022).



- **Efficiency ranges from 0.04 to 1.0**
- **Average score = 0.56 and most utilities cluster below 0.7**
- **7 completely efficient utilities**

What do efficient utilities have in common?

Utility (Country)	Efficiency Score	Net Profit Margin (%)	Distribution Loss (%)	Customers per Employee
CPFL PAULISTA (Brazil)	1.000	4.3%	8.9%	13,754
CESSA (Bolivia)	1.000	4.8%	7.7%	848
ELECTROCENTRO (Peru)	1.000	15.6%	10.7%	1,883
ELFEC S.A. (Bolivia)	1.000	10.0%	9.2%	677
MEPCO (Pakistan)	1.000	-8.0%	15.8%	348
MEC (Marshall Islands)	1.000	13.5%	34.0%	21
PUC_M (Fed. States of Micronesia)	1.000	-12.1%	27.0%	46

- Positive profit margins
- Low distribution losses (<15%)
- High customer-to-employee ratios
- Some high scores due to scale or context

Interpreting DEA Results Carefully

Context

Geography and customer base shape costs

Model

Bounded by chosen inputs and outputs

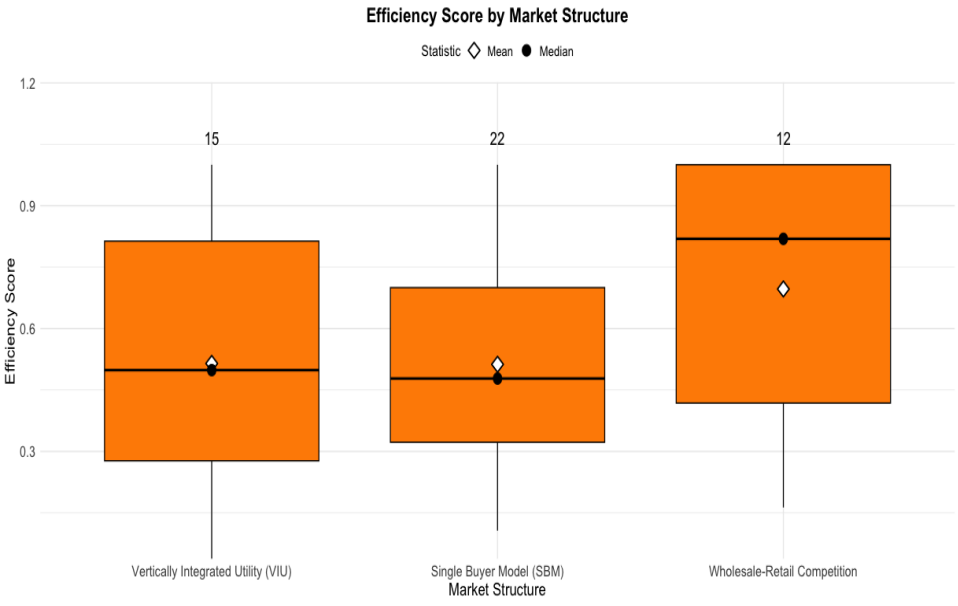
Mandate

Some utilities do not pursue commercial goals

Type

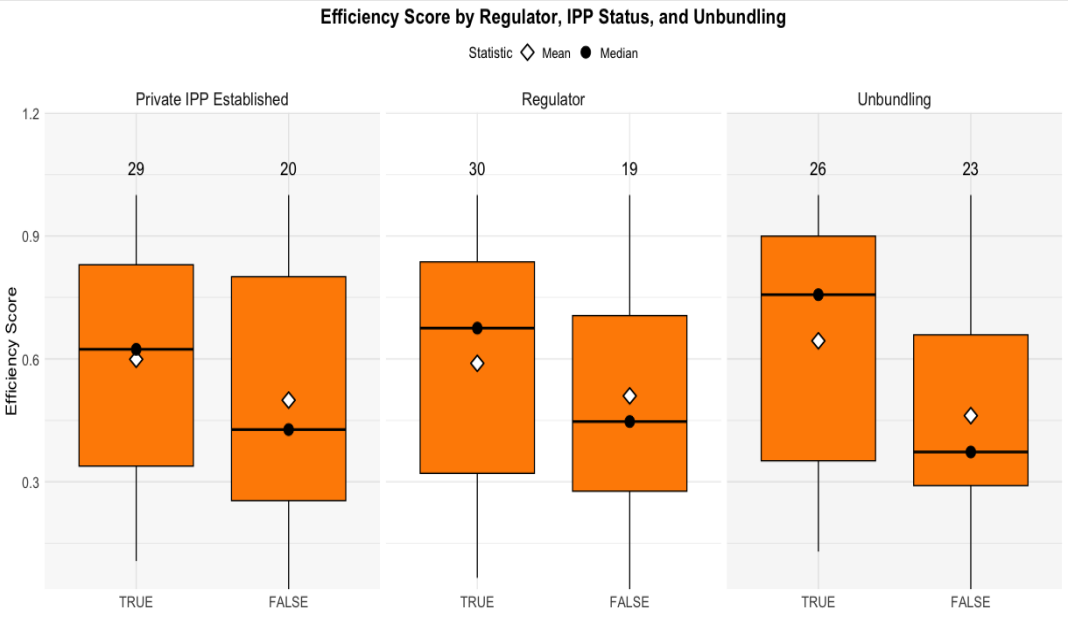
VIU utilities may appear inefficient due to unmatched outputs

Market Structures and Efficiency



- **Utilities in wholesale-retail markets are most efficient**
- **Utilities in VIU markets outperform those in SBM on average**

Governance and Efficiency



- **Private IPP presence linked to stronger outcomes**
- **Regulated utilities perform better**
- **Unbundling aligns with higher efficiency across categories**

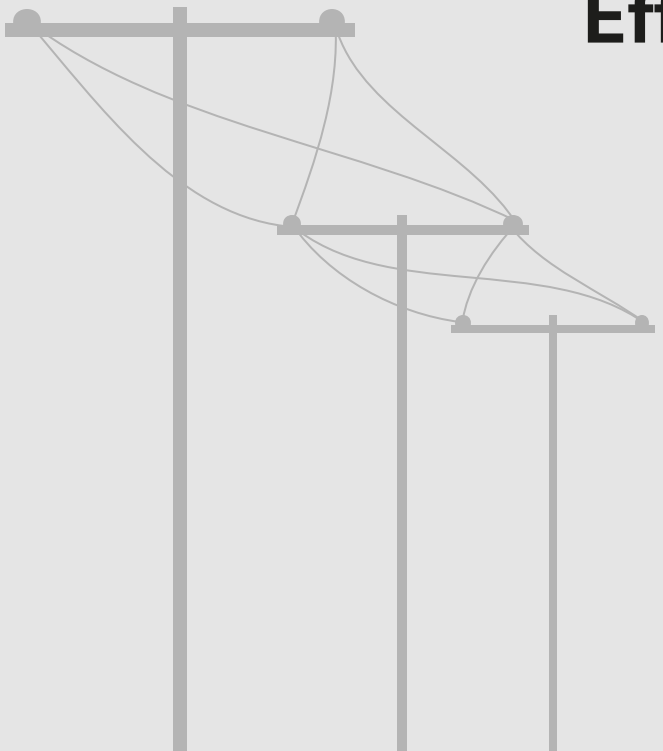
What Drives Efficiency?

Competitive pressure improves performance

Unbundling improves focus and accountability

Independent regulation enforces discipline

But structure alone isn't enough—context still matters



Efficiency is not just a technical metric. It’s essential for expanding electricity and supporting development

Regression Analysis Model

$$\text{Access}_{(2022)} = \beta_0 + \beta_1 \cdot \text{Efficiency} + \beta_2 \cdot \log(\text{GDP per capita}) + \beta_3 \cdot \text{Population density}_{(2022)} + \varepsilon$$

- Dependent variable: Electricity access rate in 2022 (% of population)
- Key predictor: Efficiency score (DEA-based, averaged over 2012–2022)
- Control variables: log(GDP per capita), based on 2012–2022 average, Population density in 2022 (people per km)

This model helps isolate whether more efficient utilities are associated with higher access, beyond what income or geography would explain

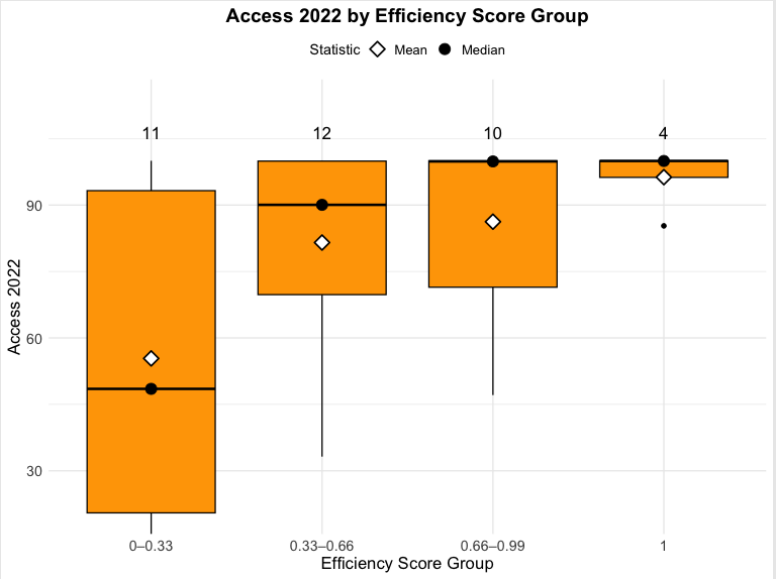
Efficiency and Access

1-point rise in DEA score = +24.6 percentage point gain in electricity access

Regression Summary: Access to Electricity (2022)				
Variable	**Coefficient**	**St. Error**	**P-value**	**95% CI (Lower-Higher)**
Efficiency	24.64	19.74	0.001	10.384 - 38.901
Log GDP per capita	24.37	7.01	0.000	19.683-29.064
Population density	0.02	2.31	0.000	0.006 – 0.046

Model Fit Metrics	
R-squared	.830
Adjusted R-squared	.814
Observations	37

Fully efficient utilities found in countries with near-universal access



Reform Pathways for Low Performers

Improve cost recovery (tariffs, collections)

Introduce performance incentives

Cut technical and commercial losses

Align social mandates with sustainable finance

Boost labor and asset productivity

Conclusions

- ✓ **Market structure and governance shape utility performance**
- ✓ **Utility efficiency associated with higher access**
- ✓ **Financial health is critical**
- ✓ **Context matters**
- ✓ **Reforms can close the gap**

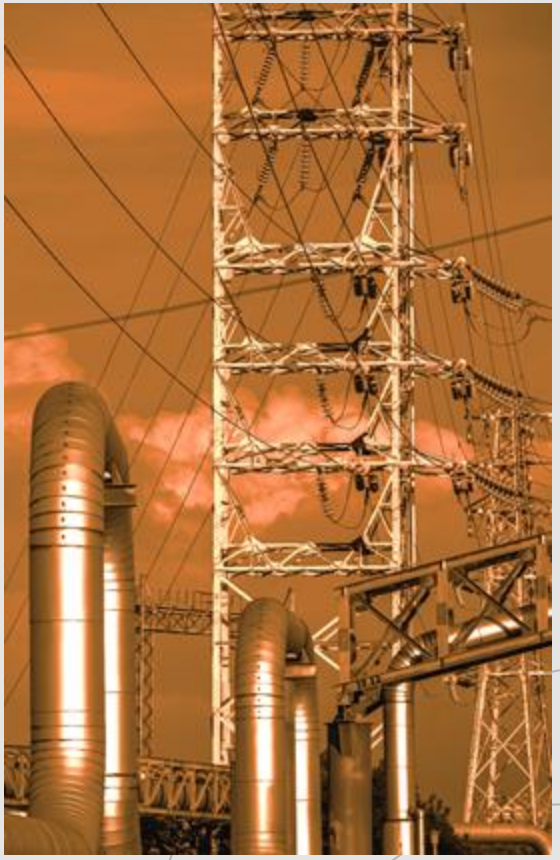
Reflection and Next Steps

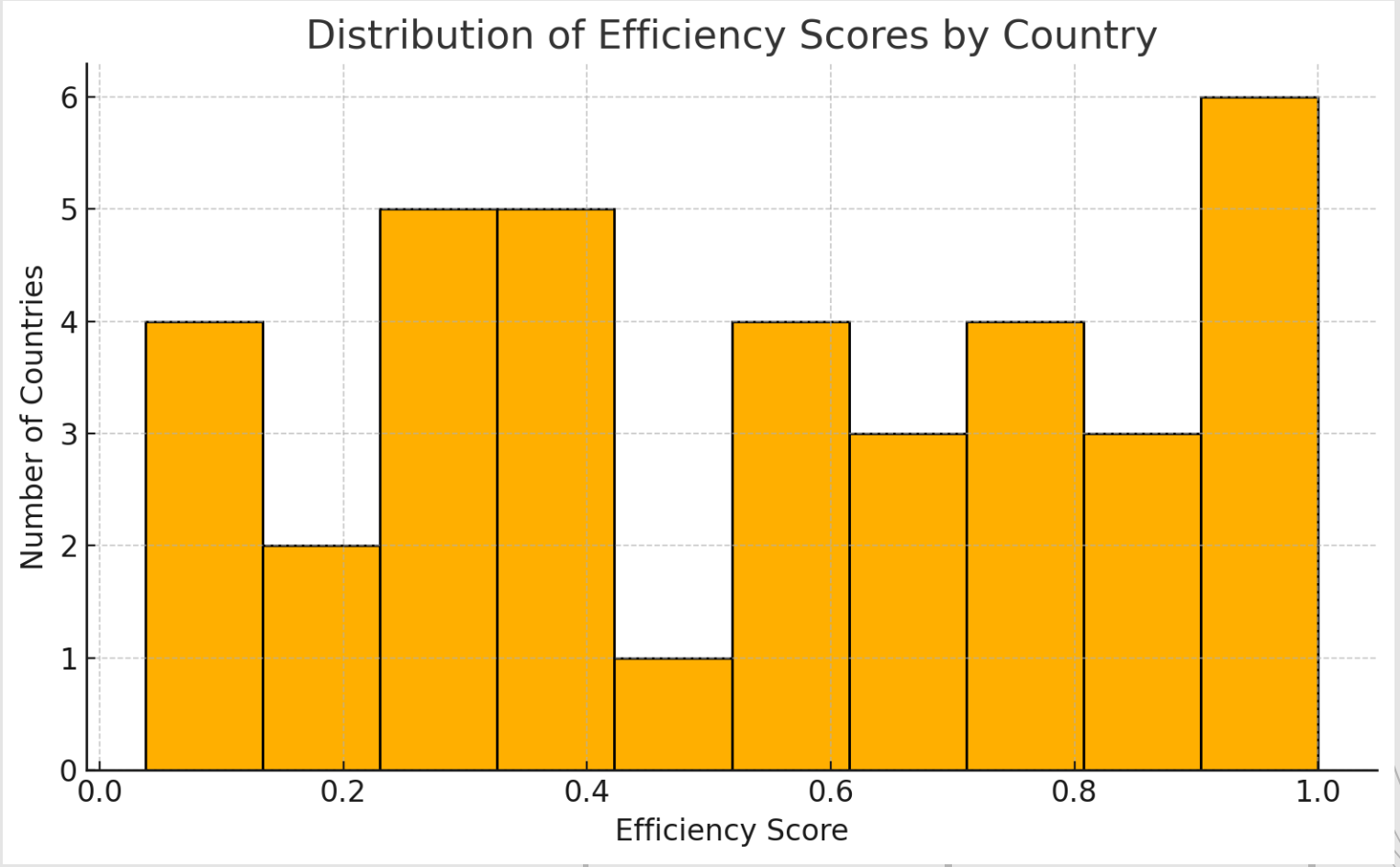
- Separate distribution-only from integrated utilities
- Focus on viable utilities (cost recovery, profit margins)
- Explore alternative input/output indicators
- Add case studies to explain variation

Feedback Questions

- Are DEA-based comparisons valid across diverse contexts?
- What other methods or data would strengthen this analysis?
- How can I better communicate these findings in final paper?

Thanks!




Distribution of Efficiency Scores by Country
Number of Countries
Efficiency Score
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0