Infrastructure Investment and Economic Growth in Developing Countries: An analysis of how investments in roads, electricity, and water systems impact GDP growth rates

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Abstract

This research examines how different forms of infrastructure investment affect the GDP development of developing countries. The magnitude and effectiveness of these impacts vary significantly across regions and are influenced by factors such as a nation's stage of economic development, institutional quality, and specific economic conditions, even though the study demonstrates a strong correlation with most of these variables. This research provides valuable information for international development organizations and politicians aiming to optimize infrastructure development plans that ultimately lead to stability and GDP growth.

1 Introduction

It is widely recognised that infrastructure investment is a conerstone for economic growth especially in countries that are in their developing stages. The improvement of key sectors such as electricity, transportation and water systems not only can diresctly facilitate productivity and increase revenue but also improve access in markets and resources. Despite these benefits, infrastructure gaps remain a persistent challenge, limiting the potential for sustained economic growth.

The paper is aiming to investigate the impact the infrastructure investments have on GDP growth in developing countries, using a dataset spanning in four decades. By using different types of infrastructure-such as electricity access, transportation investment, water withdrawals and urbanization-we explore the relative contributions toward economic development. The key questions that the papers seeks to answer are: 1. Which types of infrastructure investments have the most significant impact on GDP growth? 2. Are the impacts consistent across different regions and countries?

2 Literatur Review

Developing countries often face infrastructure gaps which prevents them from rapid growth, reducing productivity and economic activities. Even though infrastructure investment is very important for economic growth, {Esfahani and Ramírez (2003)} show that it is even more important for the

infrastructure to be effective, which highly depends on the quality of institutions governing the allocation and maintenance of such investments. The evolution of infrastructure will help economic growth in the short-term but the way these projects are financed, constructed, and maintained is critical for their long-term success, like {Straub (2008)} stated. We will be able to touch on that since the research will also look into the short term and long term impact on economic growth. This will provide us insight on which developing country is able to sustain long term growth through sustainability and maintenance of infrastructure. {Munnell (1992)} argues through his article on a historical perspective that investment in infrastructure directly boosts private sector productivity by reducing costs, improving market access, and enhancing the overall business environment. However, without the correct management and policies certain sectors fall into overcapacity. Given these approaches, this study is trying to take a closer look into the impact that this kind of investment has in economic growth, focusing on electricity, transportation and water systems in developing countries.

3 Data and Methodology

3.1 Dataset (Variables)

1. Year: Yearly data (1980-2023)
2. GDP: Gross Domestic Product
3. AccessToElectricity: Percentage of the population with access to electricity
4. AnnualFreshwaterWithdrawals: Total annual freshwater withdrawals (cubic kilometers)
5. SlumsPopulation: Population living in slums
6. UrbanPopulationPercentage: Percentage of population living in urban areas.
7. RailLines: Total length of rail lines (kilometers)
8. Invintrans_milions: Invenstment in transportation (milions)
9. Combined values: We have a couple values that are combined metrics.
10. GDPPC: GDP per capita Country_id: Identifier for each country
11. Logged variables: Log-transformed versions of the original variables to potentially address skewness and improve model fitting.

3.2 Data sources

All data was collected from the indicators of the World Bank Group.

3.3 Econometric Modeling (Methodology)

3.3.1 Panel Data Regression

A fixed-effects panel data regression model has been employed to analyze the effects of various infrastructural and demographic factors on GDP per capita. The model's specification is as follows:

GDPPCit= 0 + 1AccessToElectricityit + 2AnnualFreshwaterWithdrawalsit + 3SlumsPopulationit + 4UrbanPopulationPercentageit + 5RailLinesit + 6invintrans_millionsit + i+ t + it

- i indexes countries and t indexes time.
- i are country-specific effects, tare time effects, and it is the error term.

3.3.2 Log-Transformed Model

To address potential non-linearity and heteroscedasticity, log transformations of GDP per capita and other key variables are used in additional regression models. This allows for a multiplicative interpretation of the regression coefficients and potentially stabilizes variance across the data range.

log(GDPPCit) = 0 + 1log(AccessToElectricityit) + 2log(AnnualFreshwaterWithdrawalsit) + 3log(SlumsPopulationit) + 4log(UrbanPopulationPercentageit) + 5log(RailLinesit) + 6 log(invintrans_millionsit) + i + t + it

4 Results

4.1 Infrastructure and GDP

In this chapter, we ran regressions with GDP per capita and its logarithmic transformation so we can address the quantitative impact of infrastructure elements and demographic factors on economic output. Our first graph shows a strong positive correlation between GDP per capita and the variables that support our theories. One unit increase in the percentage of a population with access to electricity is associated with a 32.59 unit increase in GDP per capita. Similarly, an increase in urban population percentage and investment in transportation are associated with an increase in GDP per capita of approximately 90 and 1 unit, respectively. Conversely, the increase in rail line infrastructure is connected with a decrease in economic growth, likely caused by high maintenance costs, inefficiencies, or an over-investment compared to the demand. Moreover, not surprisingly, the relationship between the slum population and GDP per capita has a strong negative impact on each other. In the implimitation of the logarithmic value of the GDPPC we saw that the relationship with the variables remained similar towards their coefficient, showing small to no change.

```
.
. xtreg GDPPC AccessToElectricity AnnualFreshwaterWithdrawals SlumsPopulation U
> rbanPopulationPercentage RailLines invintrans_millions

Random-effects GLS regression                   Number of obs     =      5,280
Group variable: country_id                      Number of groups  =        120

R-squared:                                      Obs per group:
     Within  = 0.0223                                         min =         44
     Between = 0.2765                                         avg =       44.0
     Overall = 0.1072                                         max =         44

                                                Wald chi2(6)      =     167.39
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
```

GDPPC	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
AccessToEl~y	32.59258	6.035851	5.40	0.000	20.76253	44.42263
AnnualFres~s	-5.39162	8.079626	-0.67	0.505	-21.2274	10.44416
SlumsPopul~n	-50.93715	9.261613	-5.50	0.000	-69.08958	-32.78473
UrbanPopul~e	90.6192	14.56113	6.22	0.000	62.07991	119.1585
RailLines	-.1933346	.0739942	-2.61	0.009	-.3383606	-.0483087
invintrans~s	.8784552	.2415573	3.64	0.000	.4050116	1.351899
_cons	-35.42813	1076.036	-0.03	0.974	-2144.42	2073.564
sigma_u	5062.1125					
sigma_e	9140.6781					
rho	.2347105	(fraction of variance due to u_i)				

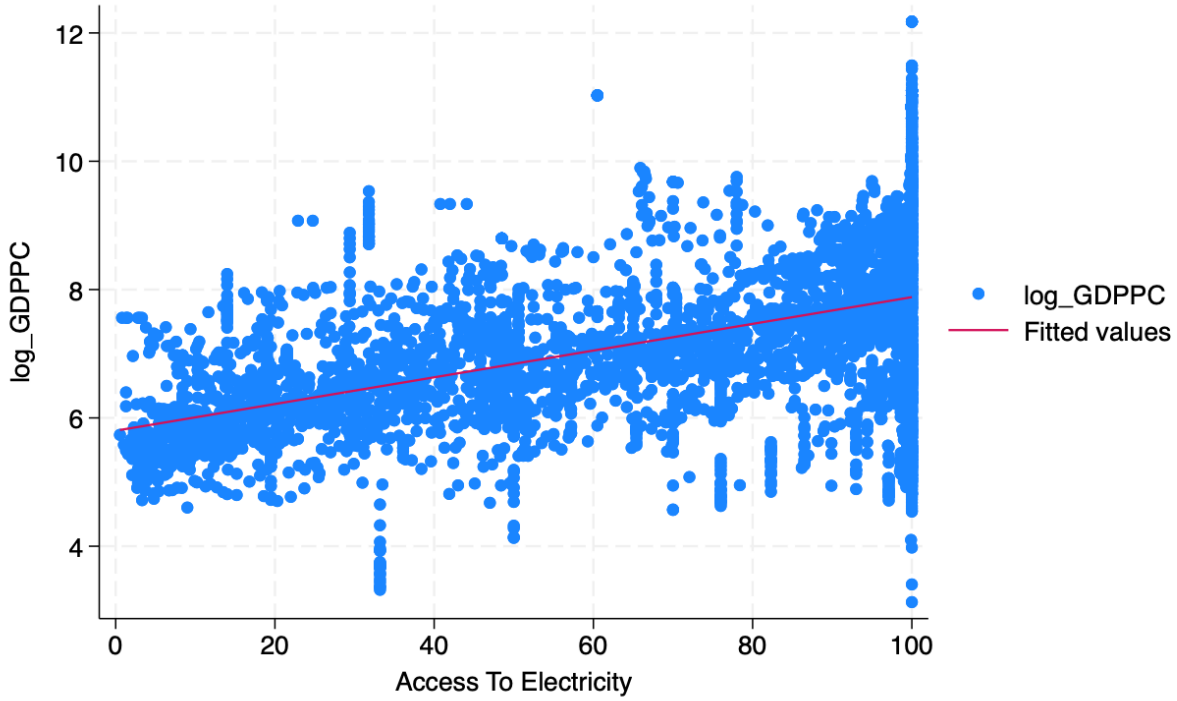
```
. xtreg log_GDPPC AccessToElectricity AnnualFreshwaterWithdrawals SlumsPopulati
> on UrbanPopulationPercentage RailLines invintrans_millions

Random-effects GLS regression                   Number of obs     =      5,280
Group variable: country_id                      Number of groups  =        120

R-squared:                                      Obs per group:
     Within  = 0.1996                                         min =         44
     Between = 0.6612                                         avg =       44.0
     Overall = 0.4892                                         max =         44

                                                Wald chi2(6)      =    1492.87
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =     0.0000
```

log_GDPPC	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
AccessToEl~y	.0068132	.0005105	13.35	0.000	.0058126	.0078138
AnnualFres~s	-.0000566	.0007231	-0.08	0.938	-.0014739	.0013606
SlumsPopul~n	-.0057085	.0007887	-7.24	0.000	-.0072544	-.0041627
UrbanPopul~e	.0459163	.0013865	33.12	0.000	.0431989	.0486337
RailLines	2.16e-06	6.36e-06	0.34	0.734	-.0000103	.0000146
invintrans~s	.0001341	.000022	6.10	0.000	.000091	.0001772
_cons	4.830825	.1057195	45.69	0.000	4.623619	5.038032
sigma_u	.63375502					
sigma_e	.76068851					
rho	.40972002	(fraction of variance due to u_i)				

4.2 Scatter Plot

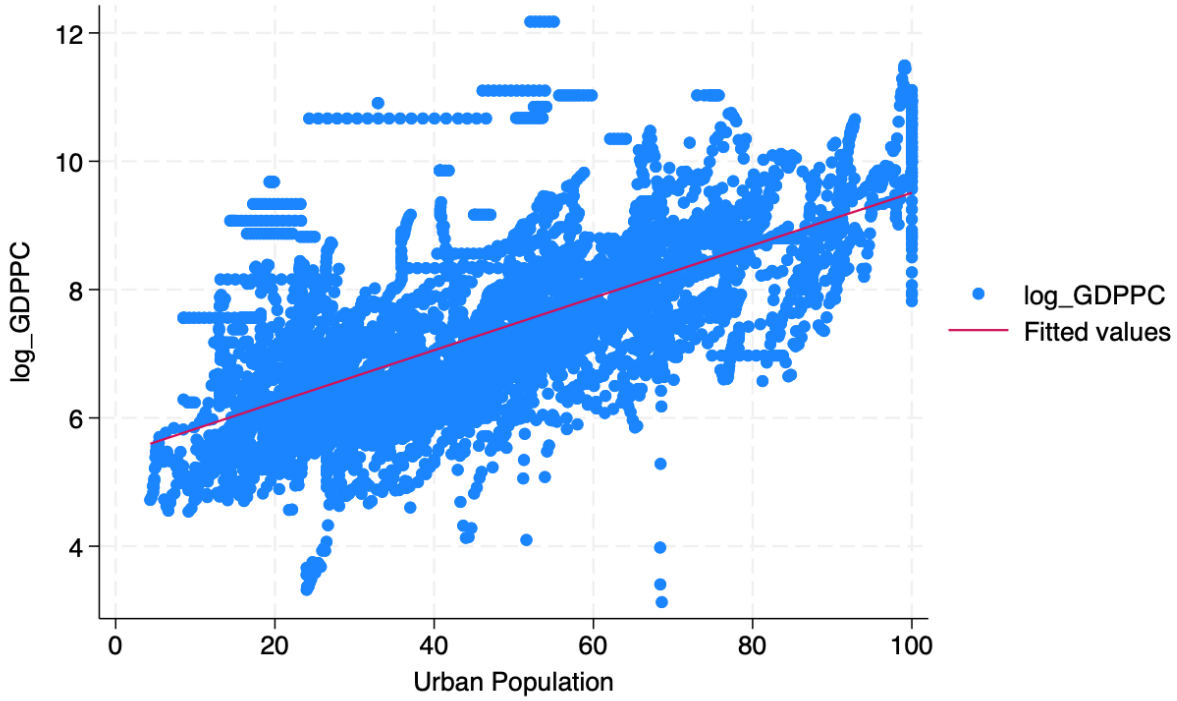
4.2.1 Log GDP per capita vs Access to Electricity

This graph shows a positive but insignificant relationship between the Access to electricity and the logarithm of GDPPC. The presence of outliers, particularly at higher levels of electricity access, suggests that its impact is not very significant because of other factors. Furthermore, the red line demonstrates a slight upward trend, suggesting this positive relationship but could be more assertive. As a result, Access to electricity is necessary for foundational economic activity, but it needs to be accompanied by other factors.



4.2.2 Log GDP per capita vs Urban Population

On the other hand, the graph of urban population and log_GDPPC is different, with a positive but significant relationship between the two. The fitted line shows an upward slope of the red line, which indicates urbanization has a more consistent and significant impact on GDP per capita. This reflects the benefits of concentrated economic activities and better infrastructure in urban areas. As a result, urbanization is a catalyst for facilitating more complex economic activities to improve economic growth.



4.3 Lasso regression

This table shows the output of the Lasso logistic regression model. After adjusting for overfitting and irrelevant predictors, some variables remained significant in their association with the outcome.

While Lasso regression provides a robust mechanism for variable selection, the results depend heavily on the choice of lambda. A smaller or a larger one can lead to over- or underfitting, respectively. However, this model demonstrated a good fit without overfitting but with a cross-validation mean deviance of 1.087, suggesting that the patterns were successfully captured.

```
Lasso logit model                          No. of obs        =      2,250
                                           No. of covariates =          7
Selection: Cross-validation                No. of CV folds   =         10
```

ID	Description	lambda	No. of nonzero coef.	Out-of-sample dev. ratio	CV mean deviance
* 1	selected lambda	.0129834	0	-0.0006	1.087236
2	lambda after	.01183	1	-0.0008	1.087423
12	last lambda	.004666	4	-0.0020	1.088705

* lambda selected by cross-validation.

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. ereturn display
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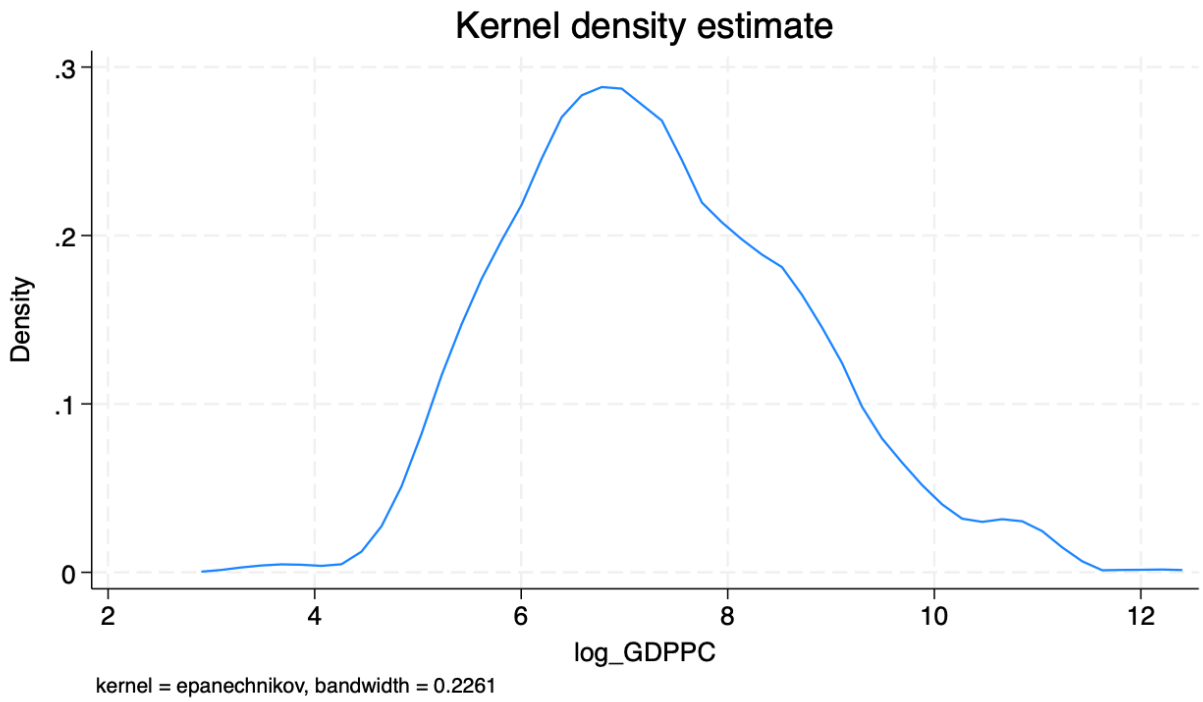
championsh~l	Coefficient
_cons	-1.189584

4.4 Kernel Density

Since we aim to work in developing countries, we expect the GDP per capita not to be very high. Through the Kernel density graph, we can understand that the distribution is slightly skewed to the right, suggesting that while most countries have a lower GDP per capita, a few are outliers and have significantly higher values. Investigating those outliers in future analysis is necessary, especially if significant skewness or outliers would be beneficial.



5 Conclusion

This paper examined how various economic and infrastructural variables influence GDP and GDP per capita across many years and countries. We utilized a robust statistical framework with regression analysis, scatter plots, Lasso regression, and kernel density estimates. Firstly, the random effect GLS model highlighted our variables' significant positive impact on log_GDP per capita but also revealed that some are not equally beneficial. We added visualizations through the scatter plots, revealing outliers and non-linear relationships. Through the lasso regression, we identified key predictors while eliminating redundant variables and providing a model focused on the most impactful factors. Lastly, we checked the density, highlighting many significant disparities. The density plots underscored the concentration of many countries at lower economic levels and revealed the skewness in transportation investment, with most countries investing minimally.

Based on our results, the study revealed that urban infrastructure is very significant and has a pronounced positive impact on GDP per capita, indicated by both the regressions and scatter plots. Investments in this sector enhance productivity by reducing transaction and transportation costs, improving access to markets, and facilitating information flow. However, even though infrastructure investment generally promotes GDP growth, it is essential for each country to require tailored strategies to maximize the economic benefits of such investments.

Future research could extend the analysis by exploring additional variables that may influence

economic development, such as technological advancement and educational attainment. It will also be important to apply different econometric methods and models, which could provide extended reports in this study.

6 References

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