Private Finance for Public Infrastructure In Emerging Markets

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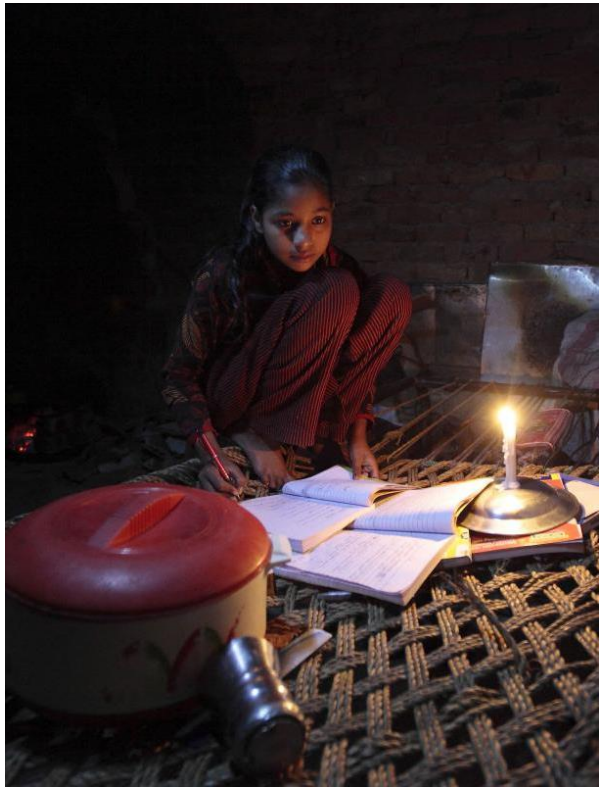
Two facts motivate our research program.

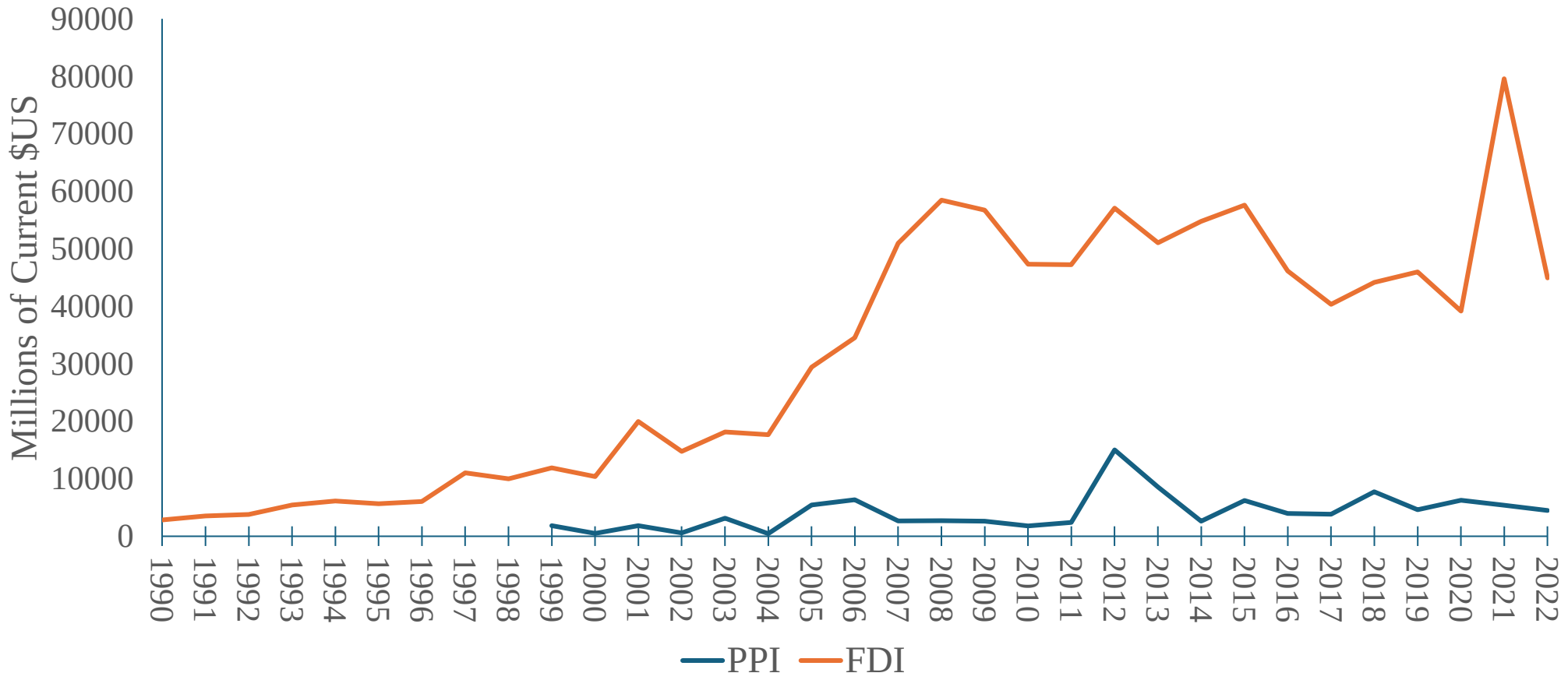





1) Poor countries: 1.2 billion people have no electricity, 1 billion live > 2 km from all-season road. 2.6 billion people do not have internet access.

(2) World Bank (2015) claims that by moving from “billions to trillions” of infrastructure investment in poor countries, rich-country private capital can: (i) close the infrastructure services gap, (ii) achieve the sustainable development goals, and (iii) make money.

Figure 1. “Billions to trillions” has not increased private participation in infrastructure.



PPI = Private Participation in Infrastructure
FDI = Foreign Direct Investment

Closing the Global Infrastructure Financing Gap via “informed risk taking” led by MDBs to catalyze private investment.

Furthermore, much past public investment in EMDE infrastructure has been unproductive.

- More than 33 percent of public investment in EMDEs is lost due to inefficiency (Schwartz, Fouag, Hansen, and Verdier 2020).

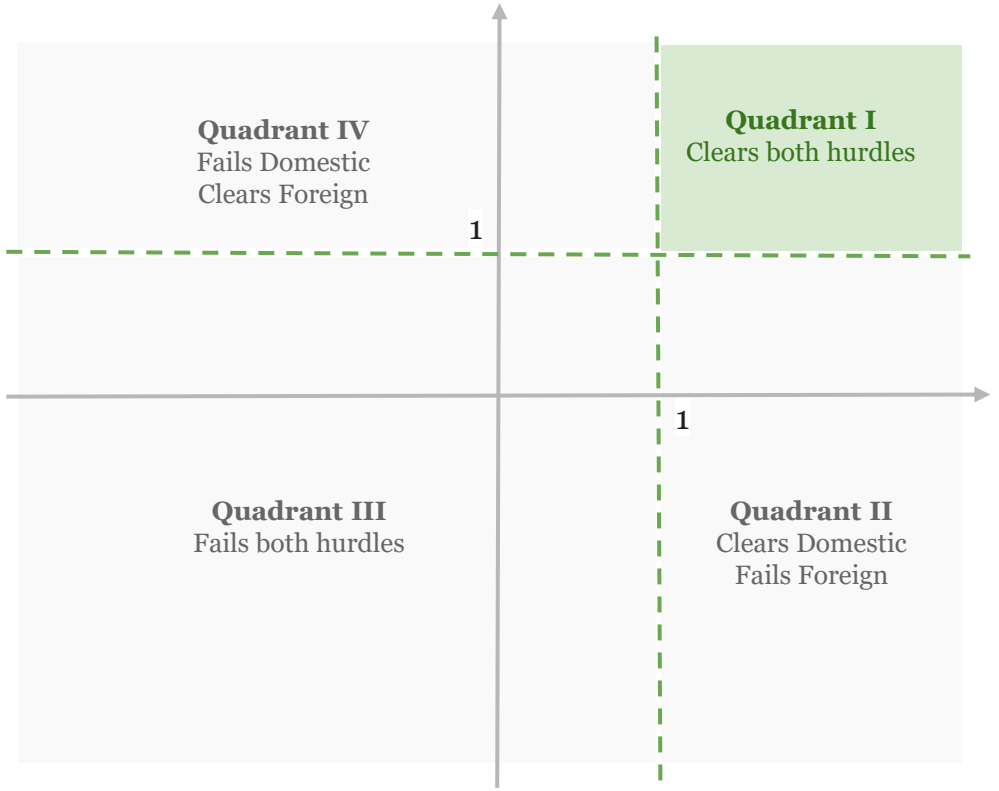
- Chinese BRI loans have a real return of 1.7% (Franz, Horn, Parks, Reinhart, and Trebisch 2024)

Question

Are there, in fact, EMDEs with infrastructure projects that are publicly efficient and privately profitable? To answer this question and drive better outcomes, we need a new approach…

For a given poor country and type of infrastructure, the Dual-Hurdle Framework sorts each country-infrastructure observation into one of four quadrants according to whether it clears the hurdle for: (a) Domestic efficiency, and (b) Foreign profitability.

$$\rho_{K^*}^{X} = \frac{r_X}{r_{K^*}}$$



$$\rho_{K}^{X} = \frac{r_X}{r_K}$$

Where r_X : rate of return on infrastructure
r_K : rate of return on domestic capital
r_{K^*}: rate of return on foreign capital

Problem: Antiquated Data on Infrastructure Returns

- Only systematic estimates of returns on infrastructure across EMDEs are from 1985!
- Governments and investors are flying blind → No data= no rational prioritization.
- Governments claim that suppliers of capital might overstate risks; investors make decisions based on subsidies rather economics.
- Information Needs:
  - Social/Economic rates of return (macro)
  - Financial rates of return (micro)
  - Risk-adjusted cost of capital estimates

Learning from Lending

= Hoover-WBG-IDB collaboration that seeks to fill the data gap in research and policymaking on EMDE Infrastructure.

Output: Produce and disseminate data to compute the social/economic and financial returns on investments in EMDE infrastructure today of the quality and availability that the IFC pioneered in 1981 for computing returns on emerging market portfolio equity.

Solution: Fill the Data Gap

Goal: Operationalize the Dual Hurdle Framework by producing and disseminating data to compute the social/economic and financial returns on investments in EMDE infrastructure today of the quality and availability that the IFC pioneered in 1981 for computing returns on emerging market portfolio equity.

Financial Returns: Use the IFC's universe of historical information on infrastructure project costs, cash flows, and other variables to create a publicly accessible database that will enable clients, the private sector, and researchers to compute expected (and actual) economic and financial returns by country, category of infrastructure, type of project (greenfield or brownfield), etc.

Social/Economic Returns: Use universe of historical information on IBRD, IDA, and IDB lending, project costs, project outcomes, project countries, and project types to create a publicly accessible database that will enable clients and potential donors, to compute expected (and actual) social rates of return.

Approaches to estimating prospective economic returns and/or applying the dual hurdle framework

- Macro (Chari, Henry, and Picardo 2024)
- Urban Spatial Network (Lebrand and Zarate 2024)
- Impact Evaluation (DIME 2023)
- Renewables (Lall and Vagliasindi 2024)
- Meta Analyses (Straub Et Al 2024)

Our approach shows:

- Social rates of returns on roads:
  - -High mean and median returns (MPX/ P_X).
  - -High variance in MPX across countries and projects.
  - -High variation in costs (P_X).

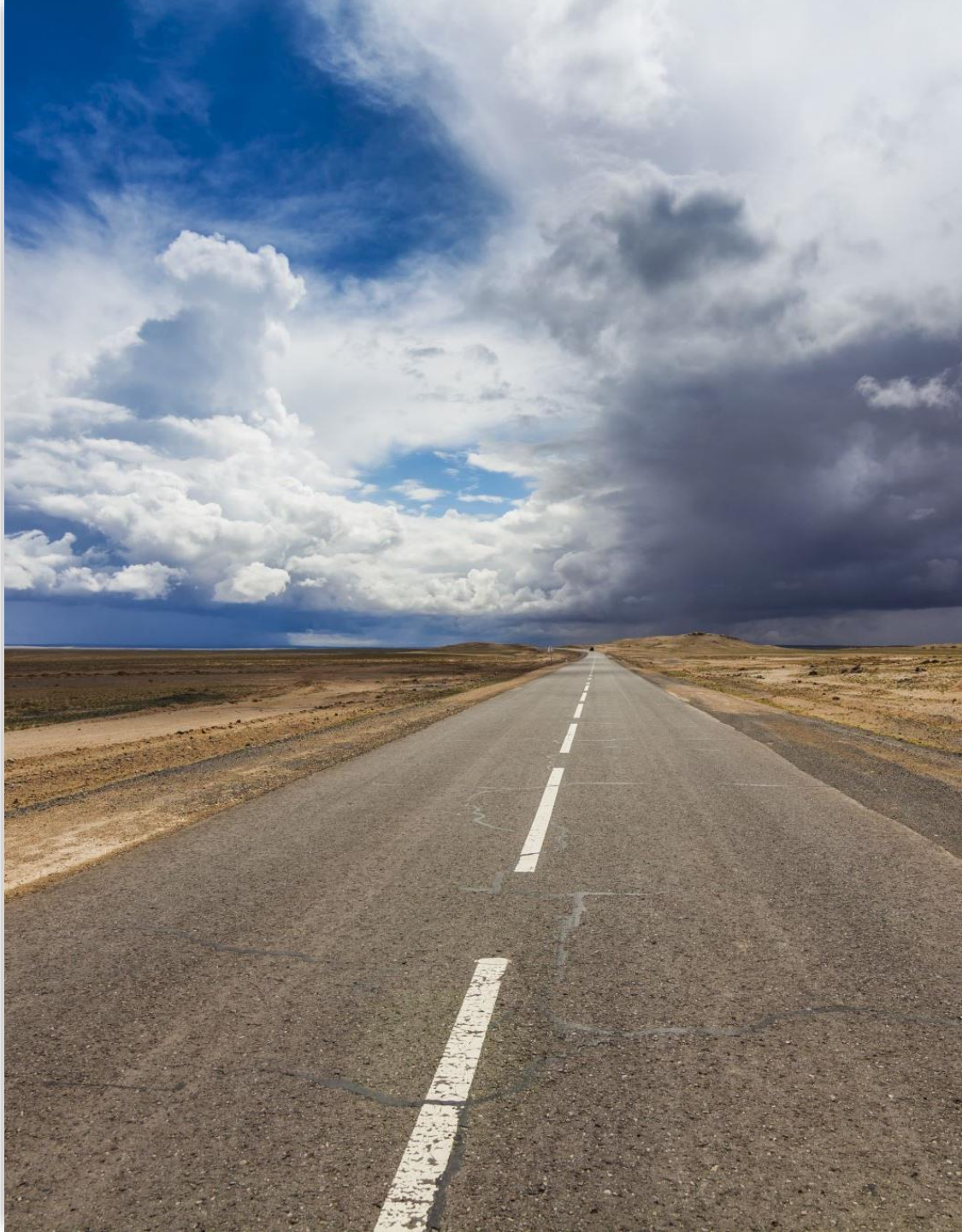
Excess return multiples on poor country roads so far…

With 2-lane Highways cost estimates (with 50+ countries and 2700 projects)

Mean: 8.9

Median: 6.0

Standard Deviation: 8.5



Caution: Aggregate Estimates Mask a LOT of Variation Across Countries and Road Project Types

- Estimated social returns, macro approach:

  Philippines: 400%

  Mexico: 130%

  Bolivia: 60%

  Turkey: 20%

  Estonia:10%

- What drives the variation? Marginal Products? Costs? Temporal? Cross-Sectional?
- E.g.. MPX can be high, but MPX/Px can be low if Px is very high.
- Granular analysis allows us to distinguish between countries and projects.

The ROCKS databases

- Original (2008) and update (2018).
- 2000 – 2017 sample period used.
- Around 2,800 records of road works.
- 98 countries.
- High heterogeneity of work types.
- Key: price/cost per Km of a road.

Source: World Bank ROCKS documentation

Work Category	Work Class	Work Type
Preservation	Routine	Routine Maintenance
	Periodic	Grading
		Gravel Resurfacing
		Concrete Pavement Preventive Treatment
		Bituminous Pavement Preventive Treatment
		Unsealed Preventive Treatment
		Surface Treatment Resurfacing
		Asphalt Mix Resurfacing
	Rehabilitation	**Strengthening**
		Concrete Pavement Restoration
		Reconstruction
Development	Improvement	Partial Widening
		Partial Widening and Reconstruction
		Widening
		Widening and Reconstruction
		Upgrading
	New	New 1L Road
		New 2L Highway
		New 4L Highway
		New 6L Highway
		New 4L Expressway
		New 6L Expressway

Summary of Rocks databases

Top WORKTYPES by number of countries	Avg Price per Km.	Median Price per Km.	Price Range		Std. Error (Price per km.)	No. of Projects	No. of Countries
			Min	Max			
Reconstruction	0.24	0.17	0.0002	3.25	0.0103	687	77
Strengthening	0.16	0.13	0.0191	1.16	0.0073	318	51
Asphalt Mix Resurf.	0.07	0.06	0.0065	0.82	0.0037	338	51
Upgrading	0.28	0.22	0.0036	3.85	0.0154	339	46
Surface Treatment Resurf.	0.03	0.02	0.0035	0.48	0.004	167	41
Routine Maintenance	0.01	0.00	0.0002	0.10	0.0016	107	33
Gravel Resurfacing	0.02	0.01	0.0019	0.11	0.0011	232	31
Widening	1.00	0.57	0.0097	5.79	0.0903	113	21
New 2L Highway	0.90	0.79	0.0420	1.99	0.0488	87	17
Widening and Reconstr.	0.95	0.80	0.1037	6.53	0.0746	125	16
Partial Widening + Reconstr.	0.28	0.25	0.0133	2.80	0.0353	79	13
Bituminous Pavement Prev.	0.02	0.01	0.0017	0.17	0.005	40	7
New 4L Expressway	4.04	3.25	0.4171	18.46	0.3599	70	6

Summary of Work Types, Costs from ROCKS databases. Projects after 2000 in Millions of 2000 USD.

Source: World Bank ROCKS databases

Hedonic approach to estimate the cost for New 2L Highways

WORKTYPES	Avg. Price per km.	Std. Error (Price per km)	No. of Projects	No. of Countries	Relative Price per km	Relative Std. Error (Price per km) %
New 6L Expressway	17.525	10.6001	2	1	19.525	61%
New 4L Expressway	4.037	0.3599	70	6	4.497	10%
New 4L Highway	2.561	0.2112	18	3	2.853	10%
New 6L Highway	1.990	0.7011	2	1	2.217	36%
Widening	1.003	0.0903	113	21	1.117	11%
Widening and Reconst.	0.950	0.0746	125	16	1.058	10%
New 2L Highway	0.898	0.0488	87	17	1.000	0%
Upgrading	0.283	0.0154	339	46	0.315	8%
Partial Widening and Reconst.	0.278	0.0353	79	13	0.309	14%
Reconstruction	0.241	0.0103	687	77	0.269	7%
Strengthening	0.162	0.0073	318	51	0.181	7%
New 1L Road	0.117	0.0113	12	3	0.130	11%
Asphalt Mix Resurfacing	0.073	0.0037	338	51	0.081	7%
Surface Treatment Resurfacing	0.031	0.0040	167	41	0.034	14%
Gravel Resurfacing	0.018	0.0011	232	31	0.020	8%
Routine Maintenance	0.008	0.0016	107	33	0.009	21%

Source: World Bank ROCKS databases

Hedonic approach to estimate the cost for New 2L Highways, examples:

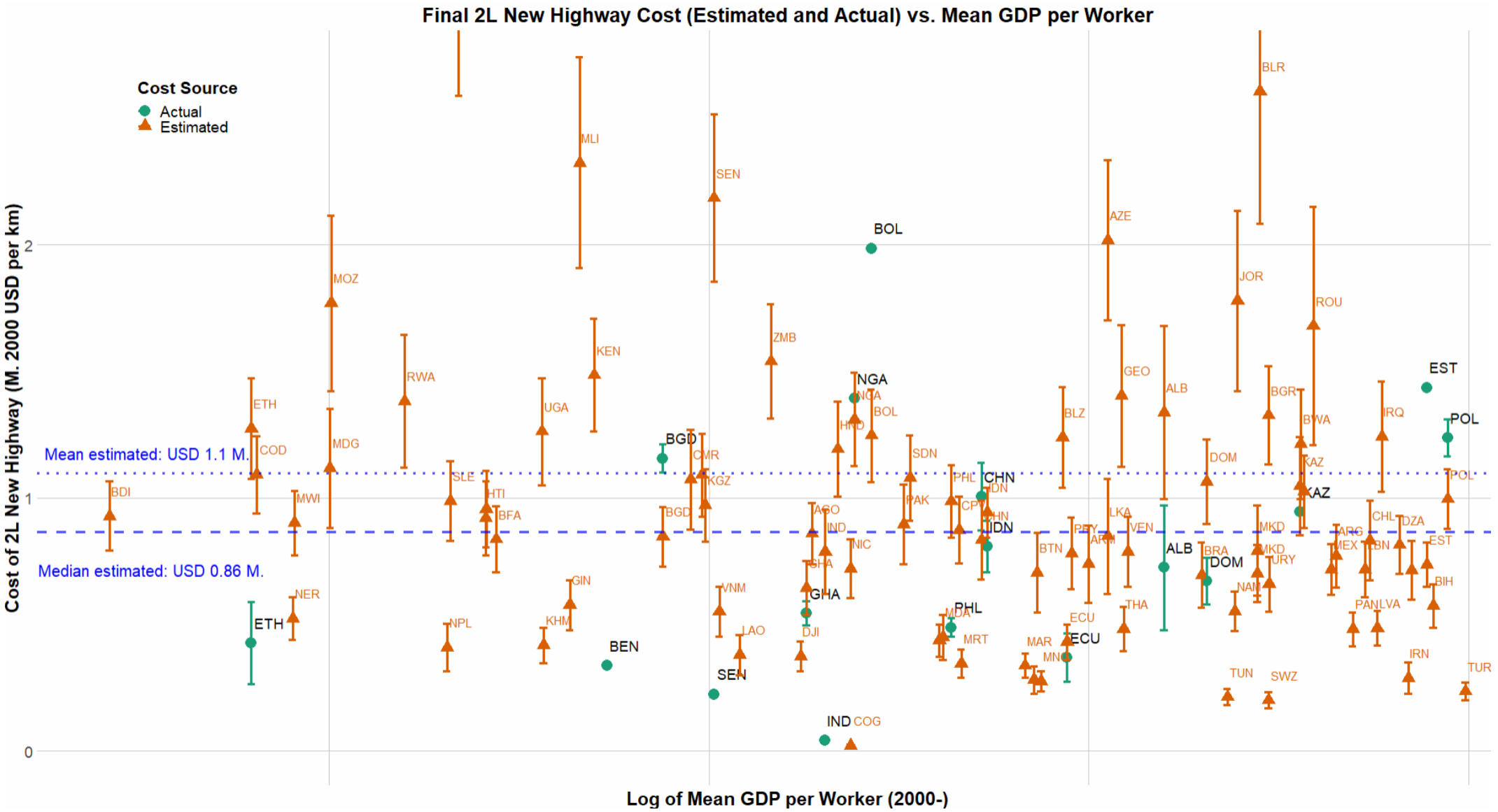
COUNTRY	Countrycode	Estimated Price per km	Lower Bound	Upper Bound	Actual Price per km	No. of New 2L Highways	No. of Other worktypes
Nigeria	NGA	1.3094	1.1247	1.4941	1.3928	1	28
Bolivia	BOL	1.2464	1.0641	1.4286	1.9859	1	20
Poland	POL	0.9958	0.8789	1.1127	1.2383	26	132
Indonesia	IDN	0.9422	0.8442	1.0402	0.8082	13	24
India	IND	0.7874	0.6215	0.9532	0.0420*	1	155

Estimated costs of New 2L Highways and actual costs for selected countries (in Millions of USD), including number of projects.

Source: World Bank ROCKS databases

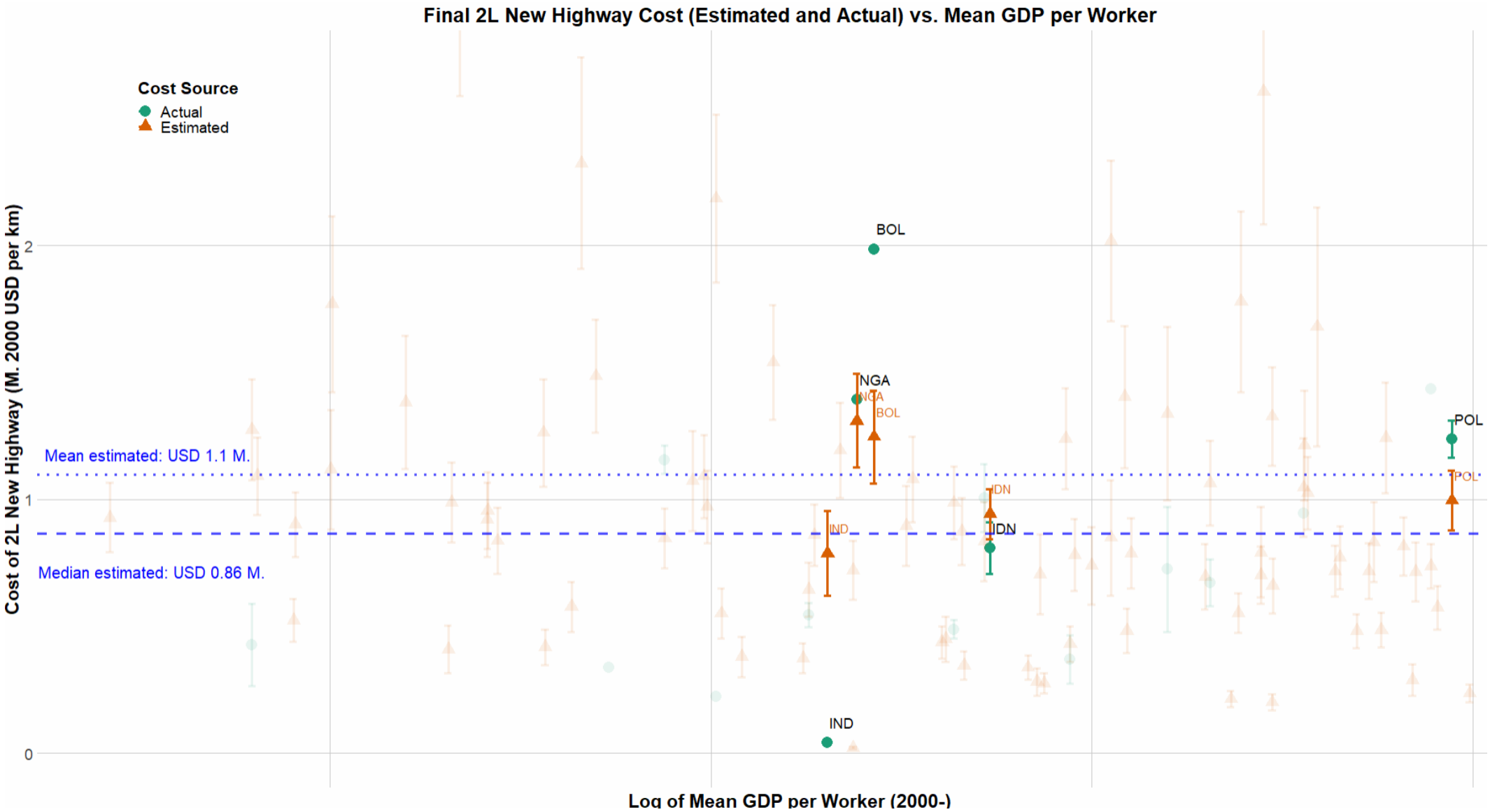
* India has only one small project on New 2L Highways that makes a point of using other worktypes.

High degree of cost heterogeneity



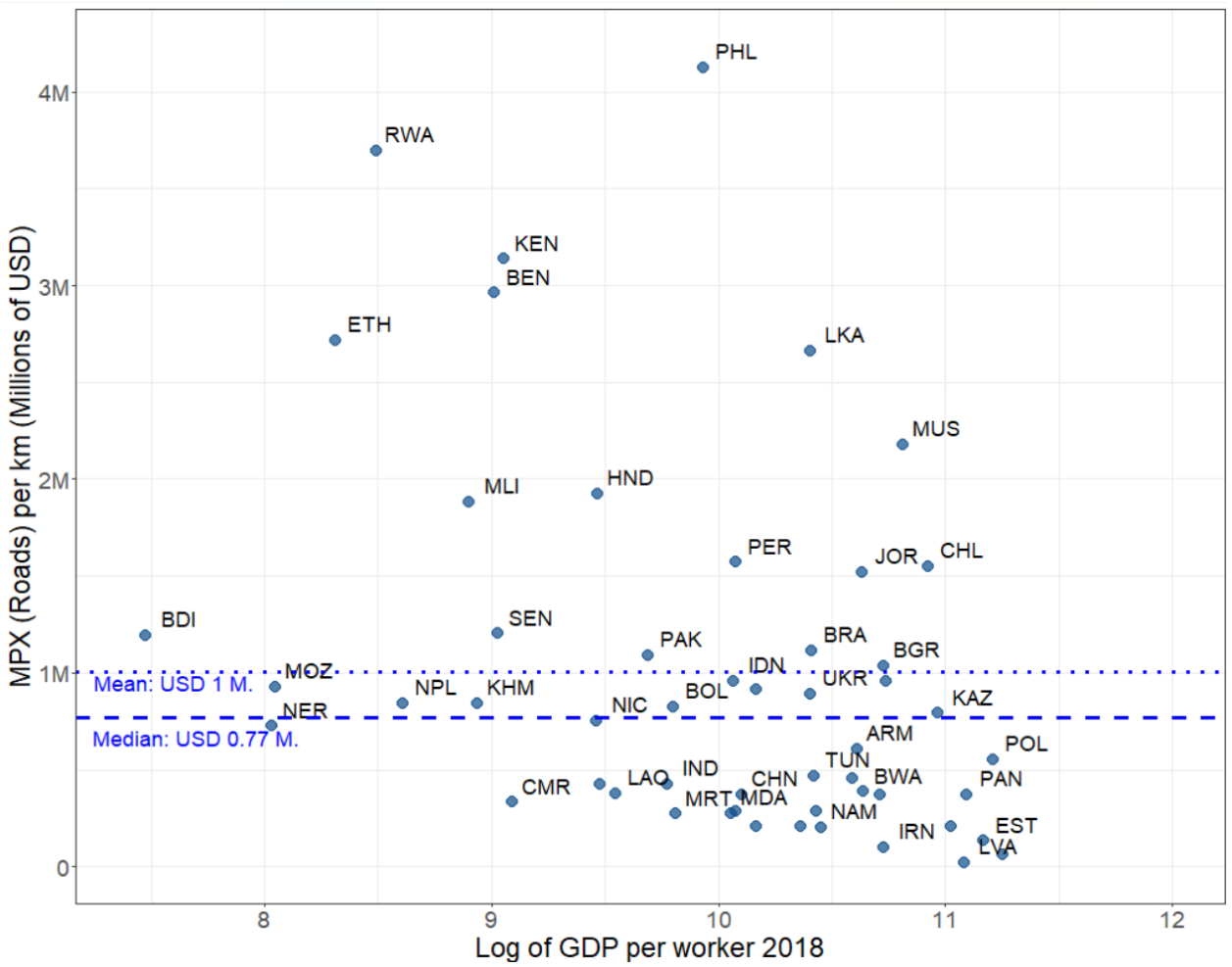
Source: World Bank ROCKS databases and PWT 10.1

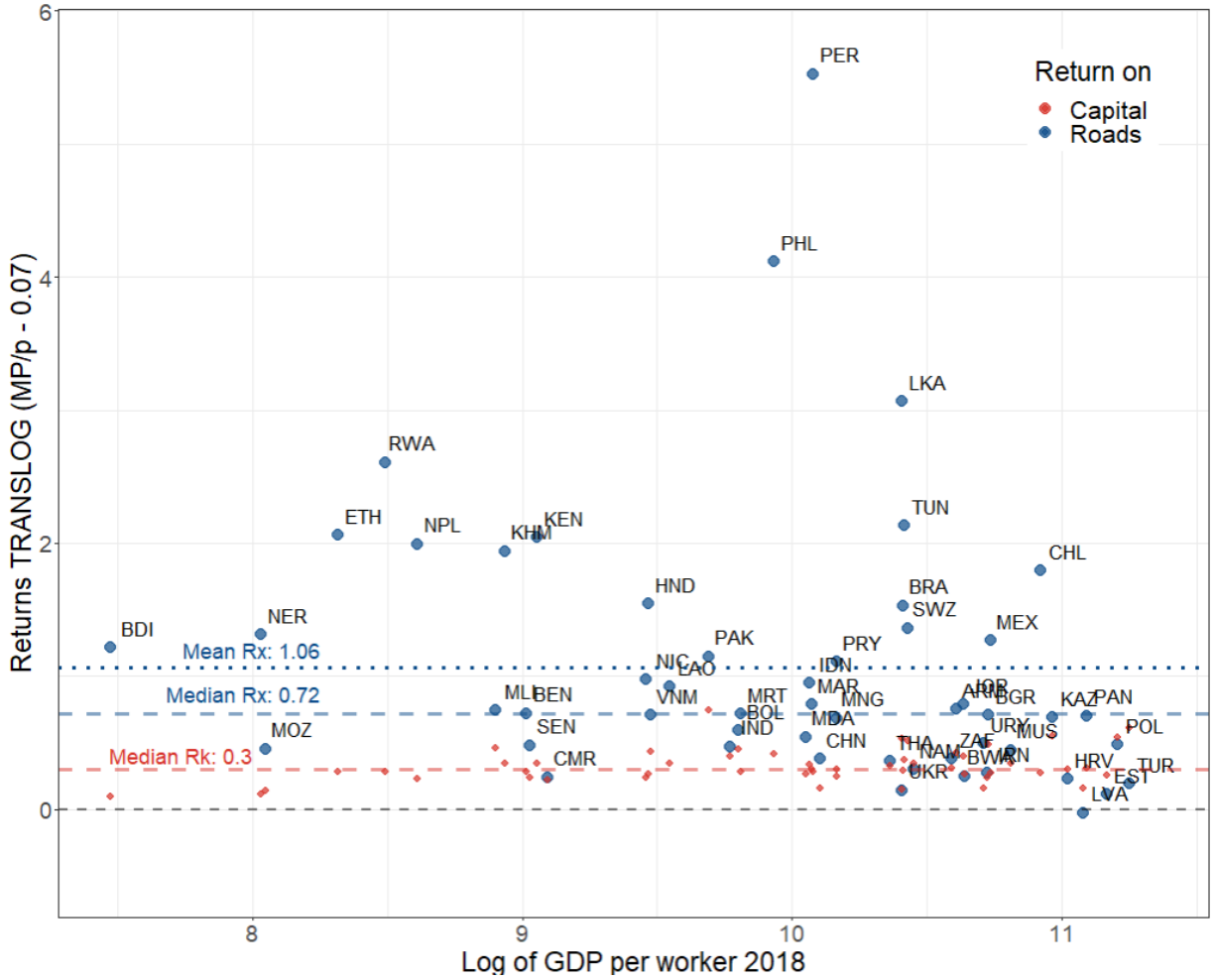
High degree of cost heterogeneity



Source: World Bank ROCKS databases and PWT 10.1

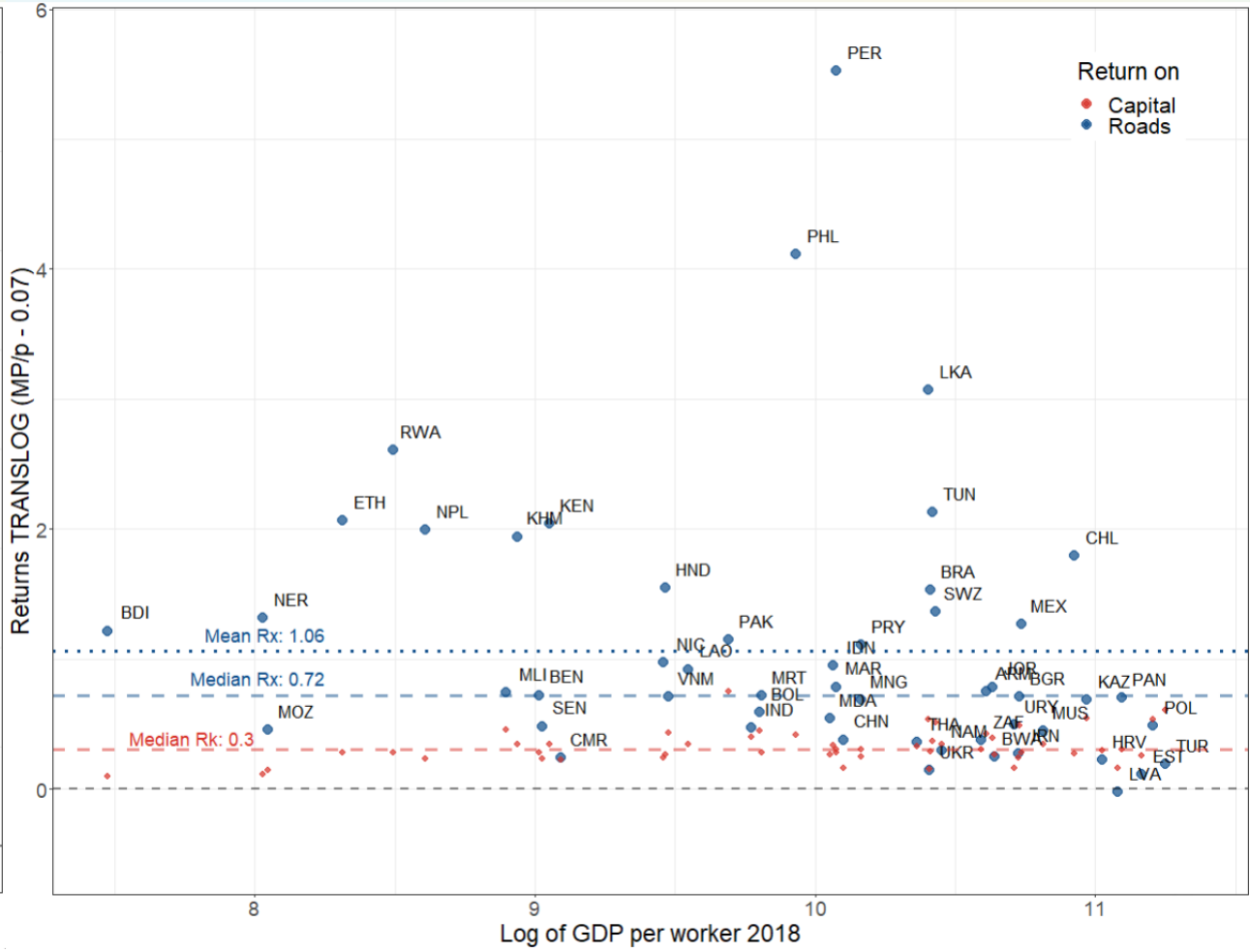
MPX and returns on roads (Rx) and capital (Rk), point estimates





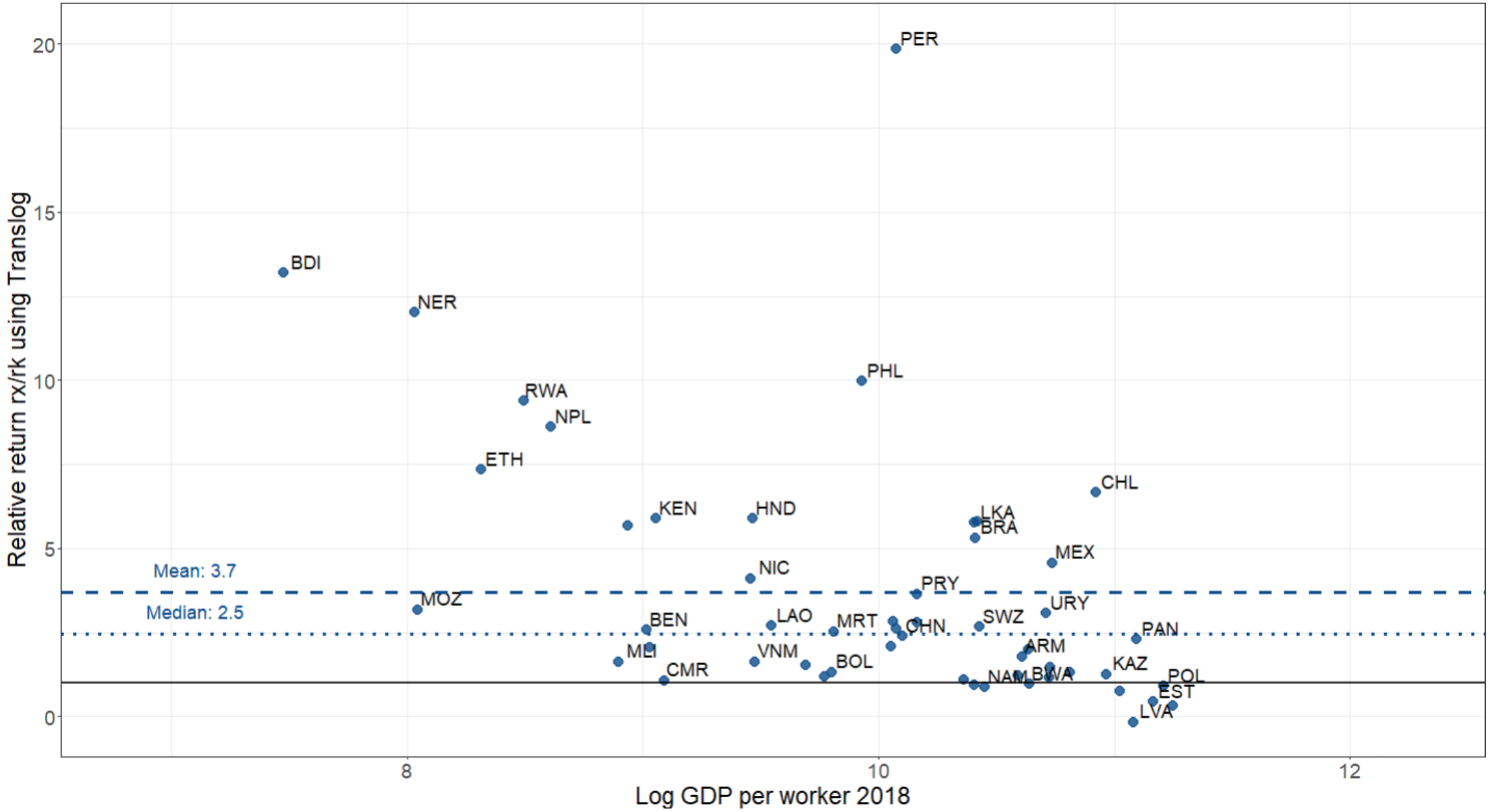
Source: World Bank ROCKS databases and PWT 10.1

Returns on roads (Rx) with actual costs and estimated costs.



Source: World Bank ROCKS databases and PWT 10.1

Hurdle #1: Domestic Efficiency (Rx / Rk)

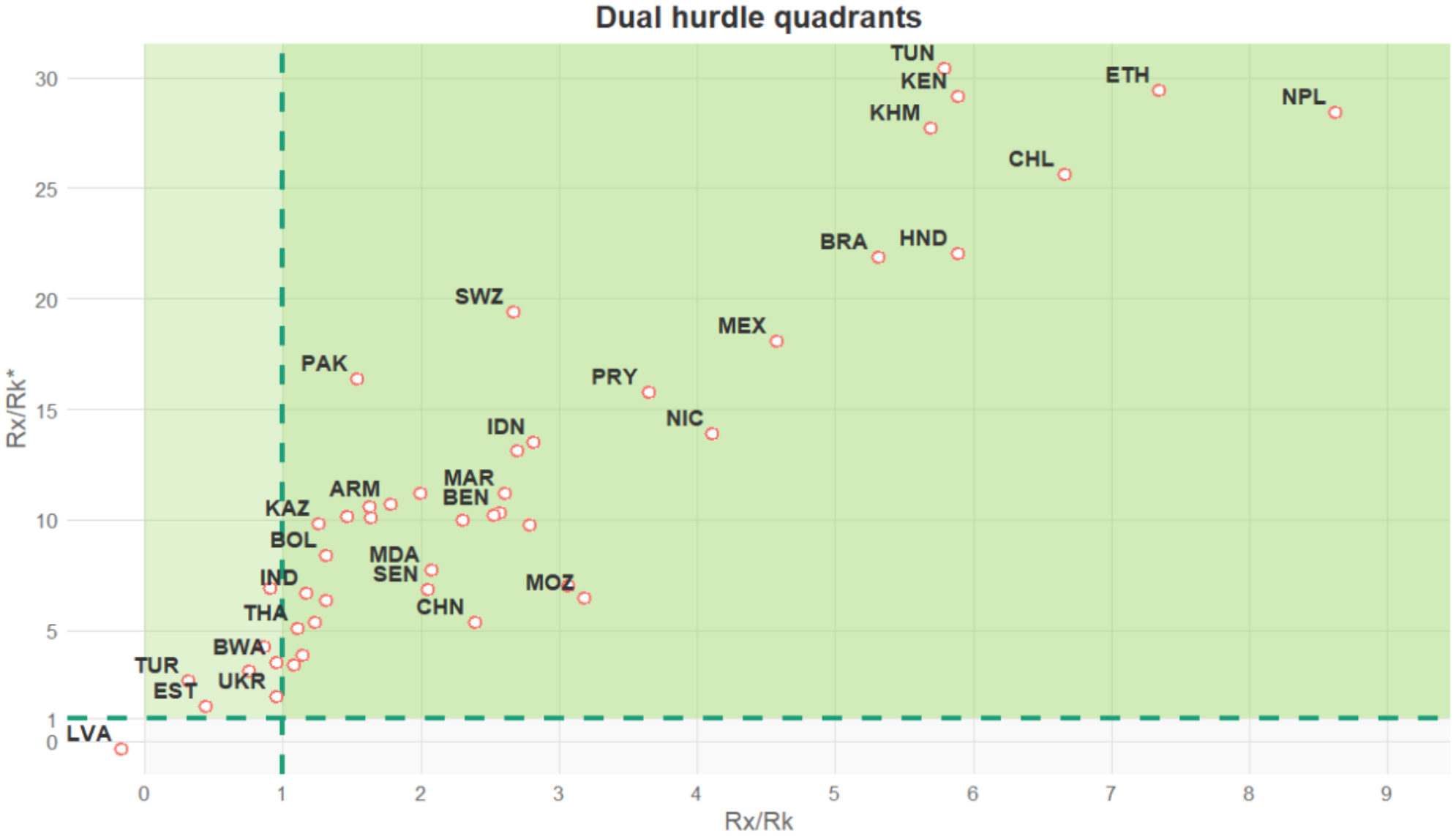


Source: World Bank ROCKS databases and PWT 10.1

Hurdle #2: Foreign Profitability (Rx / Rk*)

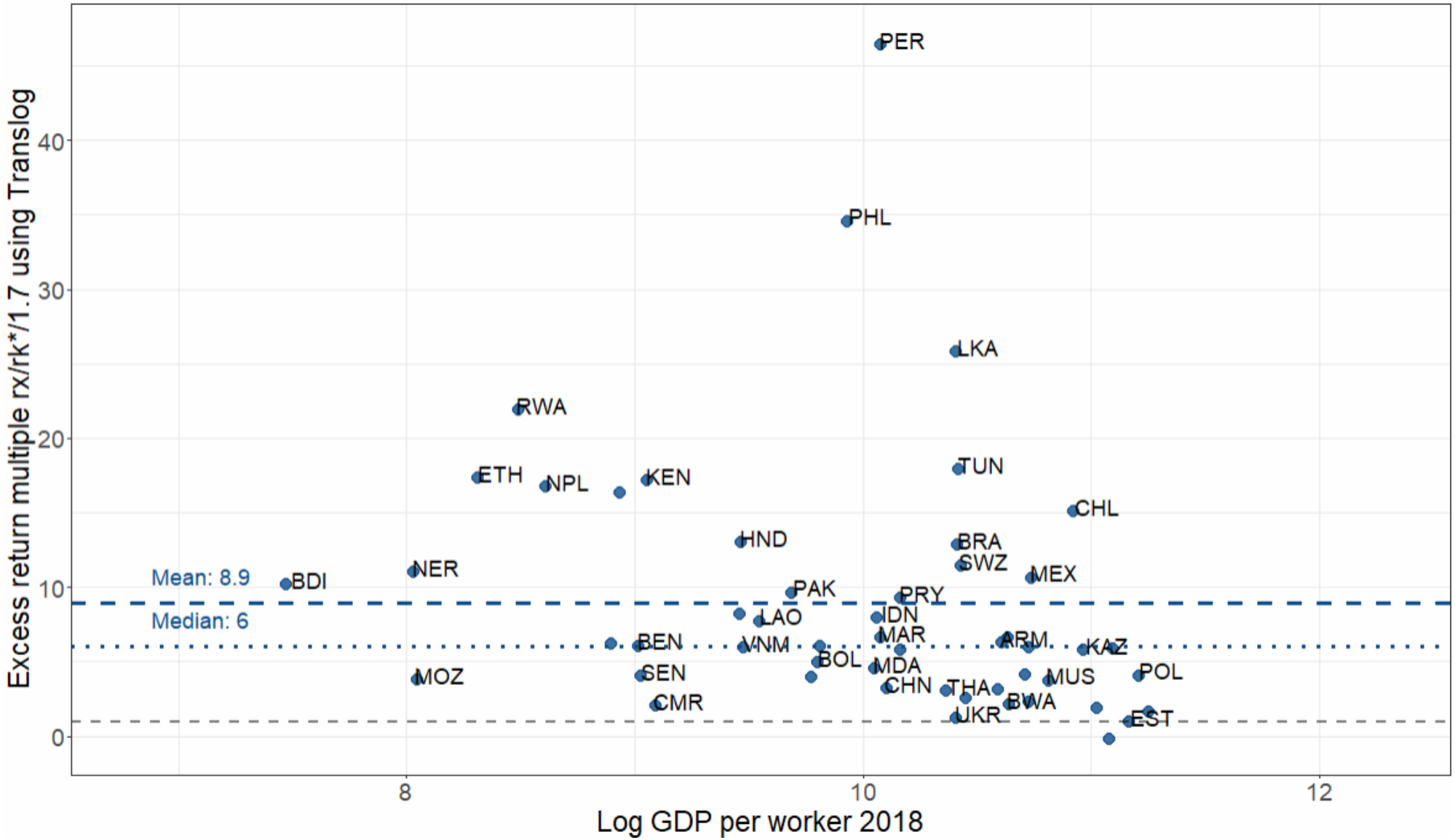
Source: World Bank ROCKS databases and PWT 10.1

Returns on the Dual Hurdle Framework



Source: World Bank ROCKS databases and PWT 10.1

Excess returns multiple (Rx / Rk*) / 1.7



Source: World Bank ROCKS databases and PWT 10.1

WB Road Projects Economic Rate of Return (ERR)

- Over 220 WB completed projects

  (Land based **transport**: Roads, highways, etc.)

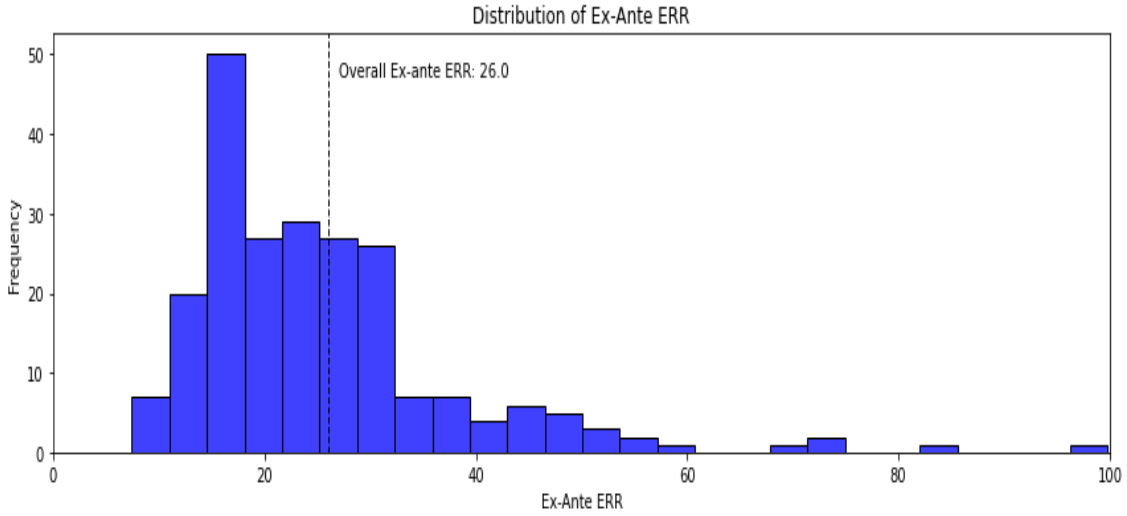
- Time: 2000 – onwards.

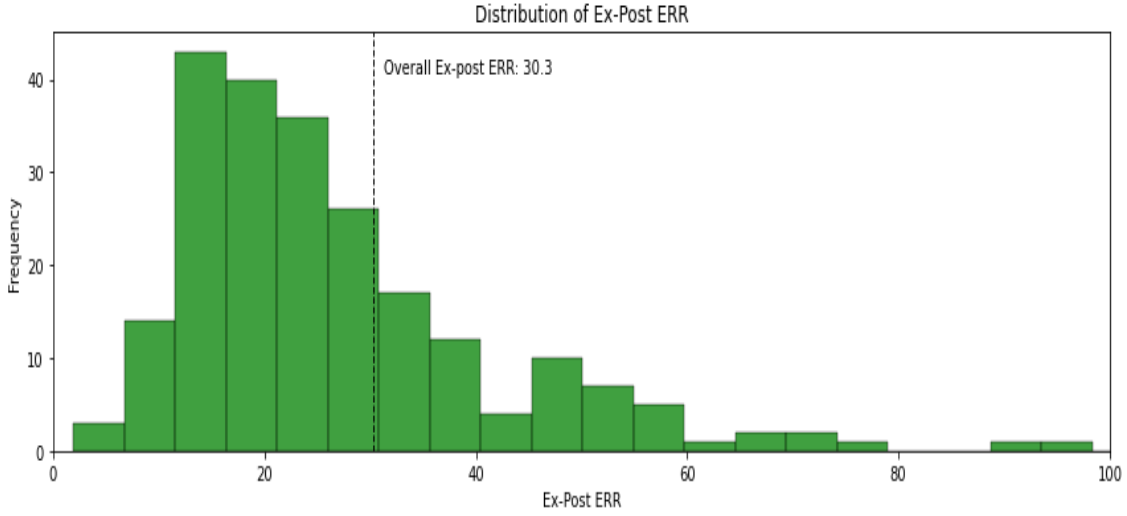
- Ex ante and ex post ERR.

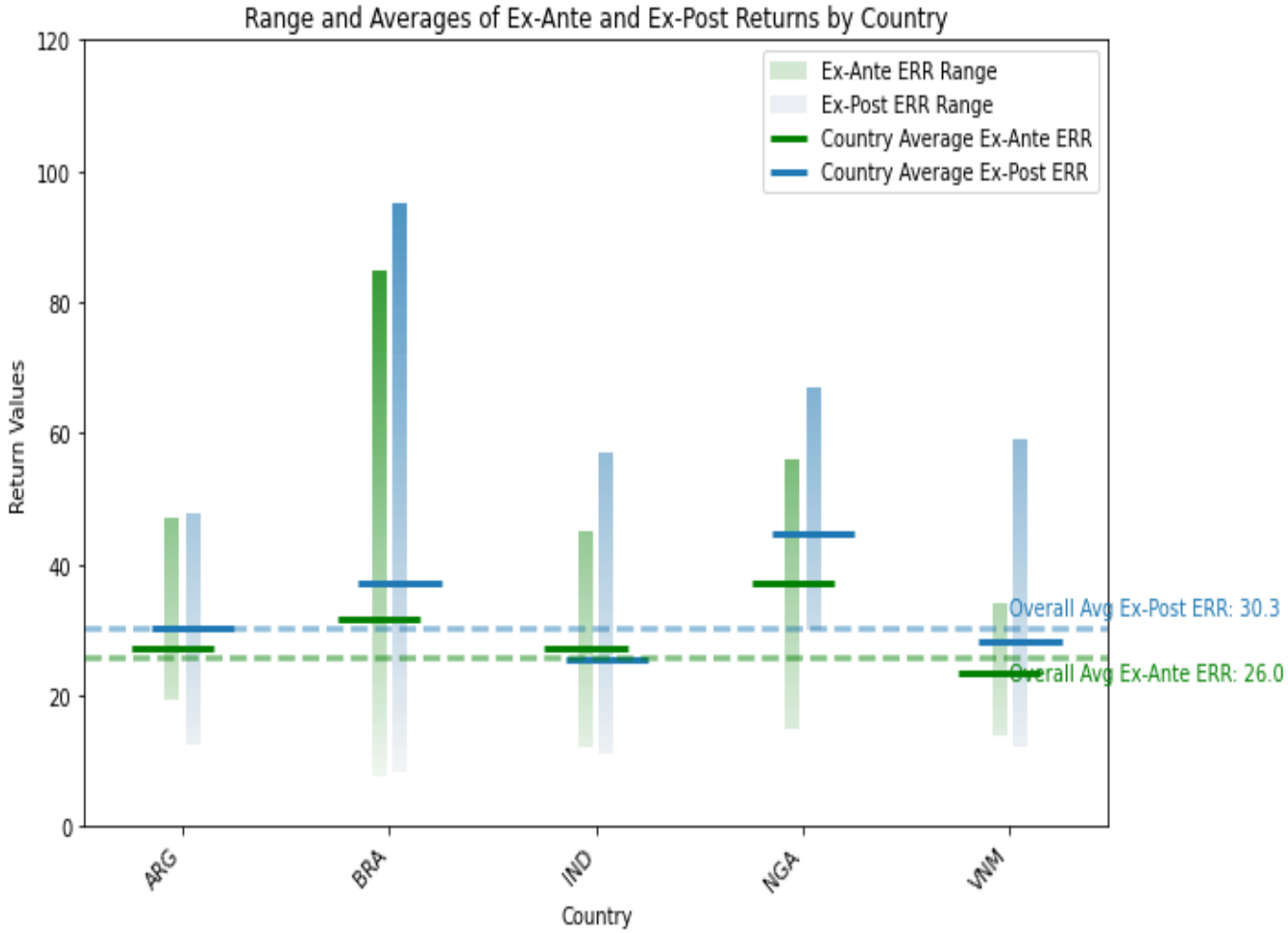
  (From ICRR reports)

Worldcloud from 220 project titles under the Transport category

WB Road Project Economic Rate of Return (ExAnte vs ExPost)







- World Bank Road Projects' Economic Rate of Return (ERR) : ExAnte ERR vs ExPost ERR
- ExAnte estimated ERR is largely aligned with realized ERR.

Macro and Micro Returns Estimates

- Macro estimates (country-specific): Output elasticity of road infrastructure capital and estimated costs.
- Micro estimates (project-specific): Based on the HDM-4 model (travel time costs, vehicle operating costs, etc.)

Country	Macro estimates		Micro estimates (WB)	
	Rx	Rx Range	Rx Ex Ante (Range)	Rx Ex Post (Range)
ETH	2.06	2.39 - 1.82	0.21 (0.14 - 0.31)	0.28 (0.19 - 0.36)
KEN	2.04	2.34 - 1.82	0.27 (0.17 - 0.38)	0.37 (0.31 - 0.41)
MEX	1.26	1.43 - 1.14	0.83 (0.52 - 1.14)	4.30 (1.35 - 7.25)
IDN	0.95	1.02 - 0.89	0.30 (0.18 - 0.41)	0.47 (0.16 - 0.89)
LAO	0.92	1.08 - 0.82	0.28 (0.18 - 0.39)	0.32 (0.28 - 0.35)
SEN	0.48	0.52 - 0.45	0.16 (0.12 - 0.20)	0.16 (0.10 - 0.22)
IND	0.47	0.49 - 0.46	0.27 (0.12 - 0.45)	0.26 (0.11 - 0.57)
MOZ	0.45	0.53 - 0.40	0.22 (0.22 - 0.22)	0.22 (0.22 - 0.22)
CHN	0.38	0.43 - 0.34	0.17 (0.08 - 0.47)	0.20 (0.08 - 0.47)

Source: World Bank project documents, ROCKS databases and PWT 10.1

Concluding Remarks

- Preliminary estimates indicate that the potential welfare gains of capital flows from private-rich capital to public-poor capital can be large.

- But there is a lot of variation across countries and projects.

- “Learning from Lending” has the promise to increase understanding and catalyze real activity by providing updated ingredients for the Dual Hurdle recipe.

Appendix

Data Summary

- Infrastructure: Canning and Bennathan: 1960 - 2002.
- International Road Federation: 2000 – 2021.
- Price/costs of roads from ROCKS database (WB); last update from 2008 and partial update 2015.

- PWT (Capital, GDP, Working Population): 1960 – 2019.
- Barro and Our World in Data (Human Capital): 1950 – 2019.

Social returns on infrastructure, steps

1. Estimate elasticities with respect to capital and road infrastructure, using different production functions.

2. Compute MPK and MPX:

$$MPK_{it} = e_k \frac{Y_{it}}{K_{it}},$$

$$MPX_{it} = MPK_{it} \frac{p_x}{p_k} + e_x \frac{Y_{it}}{X_{it}}$$

3. Returns:

$$r^k = \frac{MPK}{Price\ of\ K} - \delta$$

$$r^x = \frac{MPX}{Price\ of\ X} - \delta$$

Social returns on infrastructure, steps

Estimation: $y_{it} = a_i + b_t + f(k_{it}, h_{it}, x_{it}) + \varepsilon_{it}$

- y_{it}: Logarithm of output per worker for country i at time t.
- a_i: Total Factor Productivity (TFP) level specific to country *i*.
- b_t: Time-specific **dummy** variable representing global shifts in TFP.
- $f(k_{it}, h_{it}, x_{it})$: production function like a Cobb-Douglas or Translog with capital human capital and infrastructure per worker, including lags and leads of the first diff.
- ε_{it}: Error term.

Regressions: 1. Cobb Douglas

Table 1: Regression Results: Dependent Variable log_rgdpew

	Without roads (1)	Including roads (2)	Lower income (1980) (3)	Higher income (1980) (4)
log_kw	0.711***	0.676***	0.623***	0.712***
	(0.009)	(0.012)	(0.016)	(0.017)
log_educ	0.072***	0.116***	0.067***	0.269***
	(0.014)	(0.015)	(0.020)	(0.026)
log_road_w		0.046***	0.092***	-0.018
		(0.010)	(0.014)	(0.014)
Observations	5,698	4,060	1,834	2,158
R2	0.694	0.705	0.706	0.738
Adjusted R2	0.678	0.685	0.687	0.721
F Statistic	1,228.624***	606.544***	275.911***	379.905***
	(df = 10; 5411)	(df = 15; 3802)	(df = 15; 1720)	(df = 15; 2024)

Note: *p<0.1; **p<0.05; ***p<0.01

* Time and country fixed effects and two lags and one lead per independent variable

Regression 2. Translog

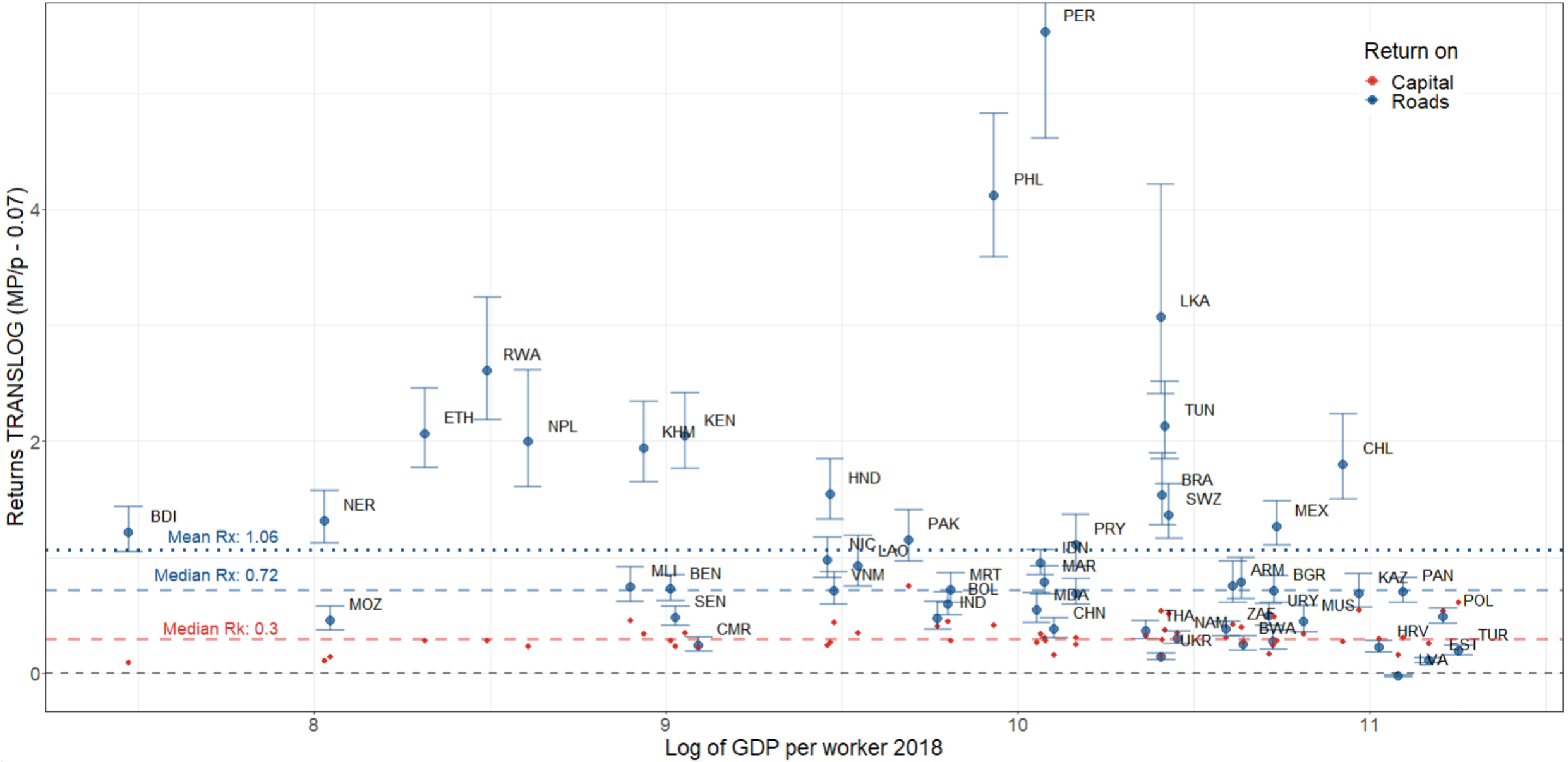
* Time and country fixed effects and two lags and one lead per independent variable

Table 2: Regression Results: Dependent Variable log_rgdpew

	Without roads	Including roads
	(1)	(2)
log_kw	-0.326***	-1.434***
	(0.074)	(0.161)
log_educ	-0.451***	1.266***
	(0.088)	(0.153)
log_road_w		-0.049
		(0.152)
log_kw_sq	0.043***	0.097***
	(0.004)	(0.006)
log_educ_sq	0.074***	0.110***
	(0.010)	(0.012)
log_road_w_sq		-0.022***
		(0.006)
k_h	0.043***	-0.095***
	(0.010)	(0.013)
k_road		-0.023***
		(0.009)
Observations	5,965	4,210
R2	0.768	0.764
Adjusted R2	0.757	0.748
F Statistic	1,712.193*** (df = 11; 5677)	707.687*** (df = 18; 3939)

Note: *p<0.1; **p<0.05; ***p<0.01

MPX and returns on roads with Std. errors on road returns



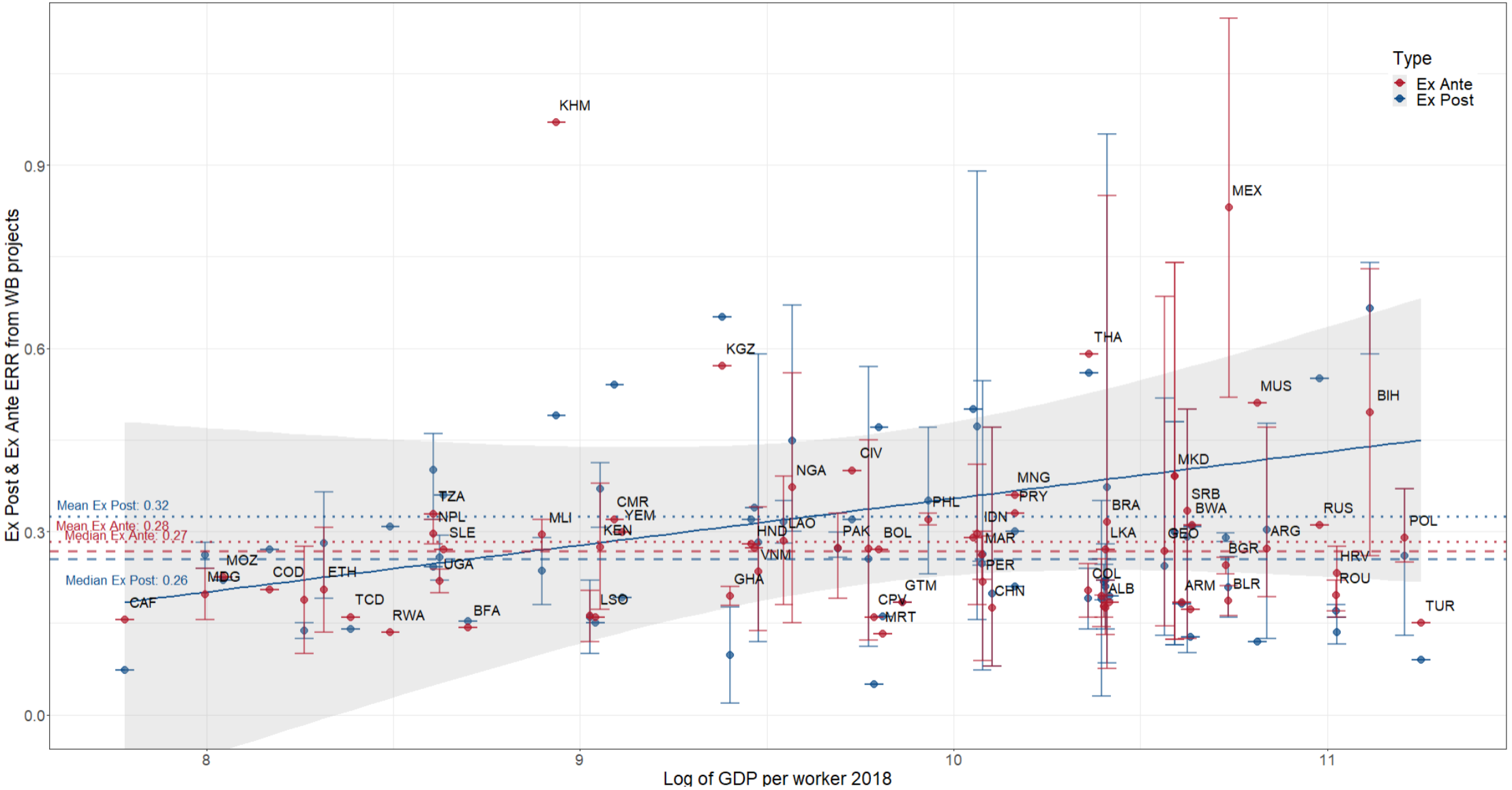
Source: World Bank ROCKS databases and PWT 10.1

Selection of cases

Country	Rx	Rx Range	Relative return Rx/Rk	MPX	Estimated Px (Price Range)
Estonia	**0.11**	0.09 - 0.13	0.44	132,897	737,200 (649,400 - 824,900)
China	**0.38**	0.34 - 0.43	2.39	372,696	833,000 (677,800 - 988,100)
India	**0.47**	0.46 - 0.49	1.17	425,119	787,400 (621,500 - 953,200)
Bolivia	**0.59**	0.57 - 0.61	1.32	822,423	1,246,400 (1,064,100 - 1,428,600)
Armenia	**0.75**	0.69 - 0.84	1.78	606,181	738,900 (587,200 - 890,500)
Indonesia	**0.95**	0.89 - 1.02	2.82	957,088	942,200 (844,200 - 1,040,200)
Burundi	**1.22**	1.07 - 1.41	13.19	1,192,500	928,000 (791,800 - 1,064,200)
Mexico	**1.26**	1.14 - 1.43	4.57	958,452	718,000 (617,500 - 818,600)
Brazil	**1.53**	1.34 - 1.81	5.31	1,113,577	695,500 (567,000 - 824,100)
Chile	**1.80**	1.55 - 2.15	6.66	1,550,696	831,300 (674,100 - 988,500)
Ethiopia	**2.06**	1.82 - 2.39	7.34	2,714,624	1,273,300 (1,075,300 - 1,471,300)
Kenya	**2.04**	1.82 - 2.34	5.89	3,136,543	1,485,000 (1,263,300 - 1,706,800)

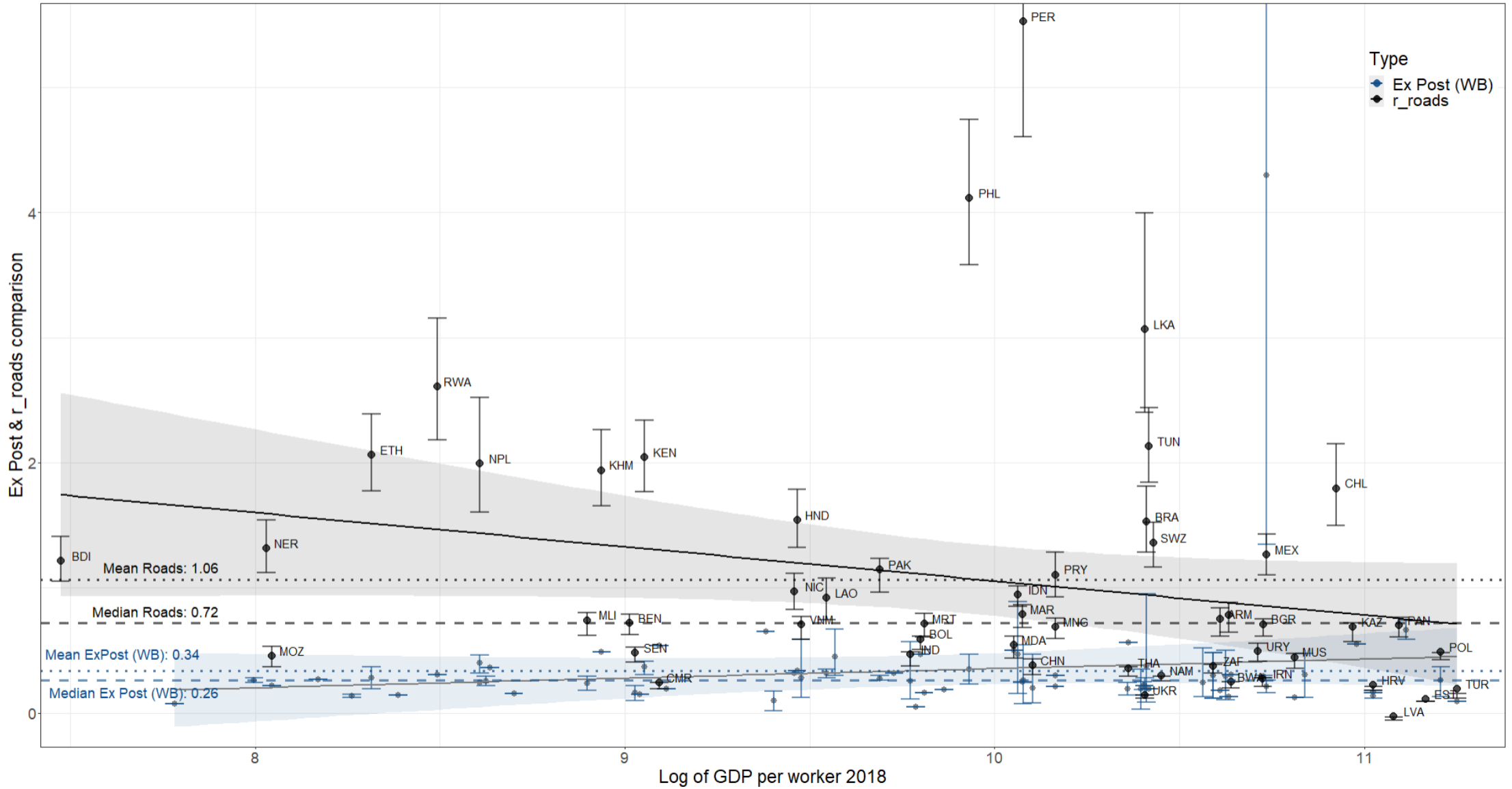
Source: World Bank ROCKS databases and PWT 10.1

Ex ante and ex post ERR from WB documents



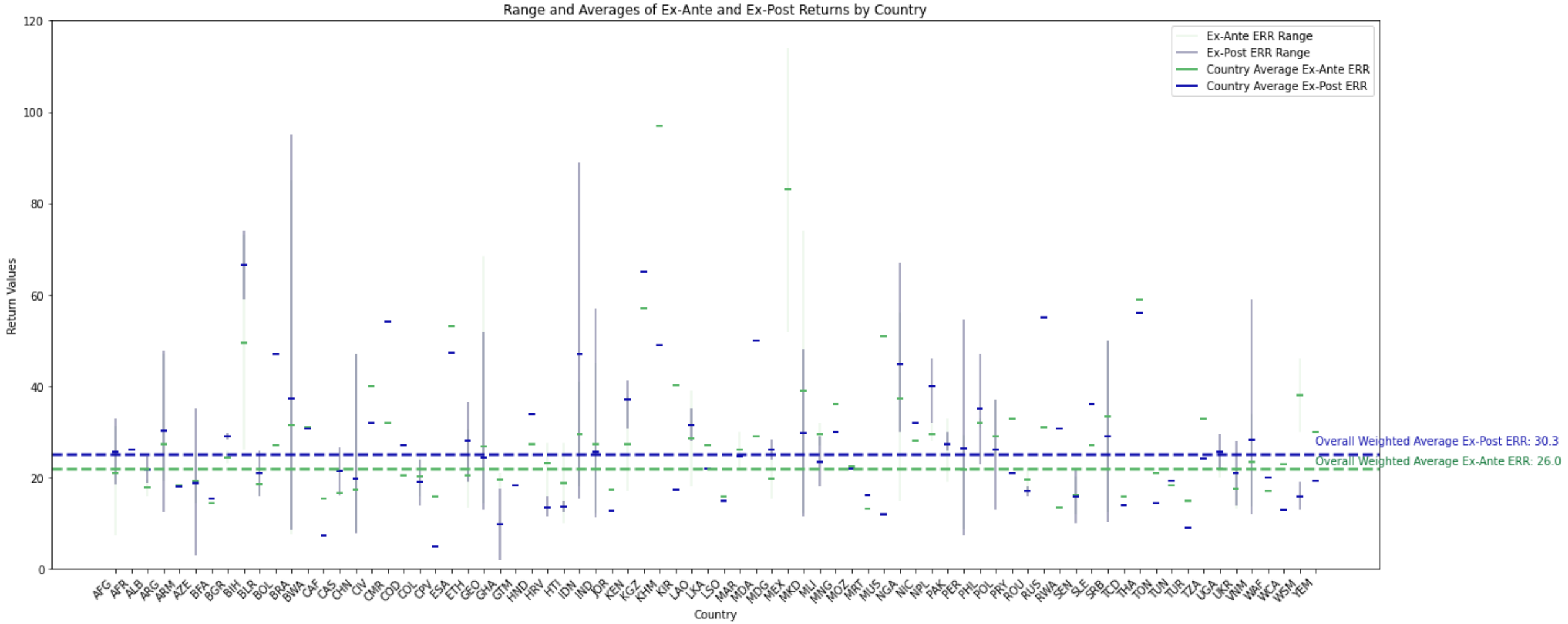
Source: World Bank project documents and PWT 10.1

Ex post ERR from WB and Macro ERR estimates



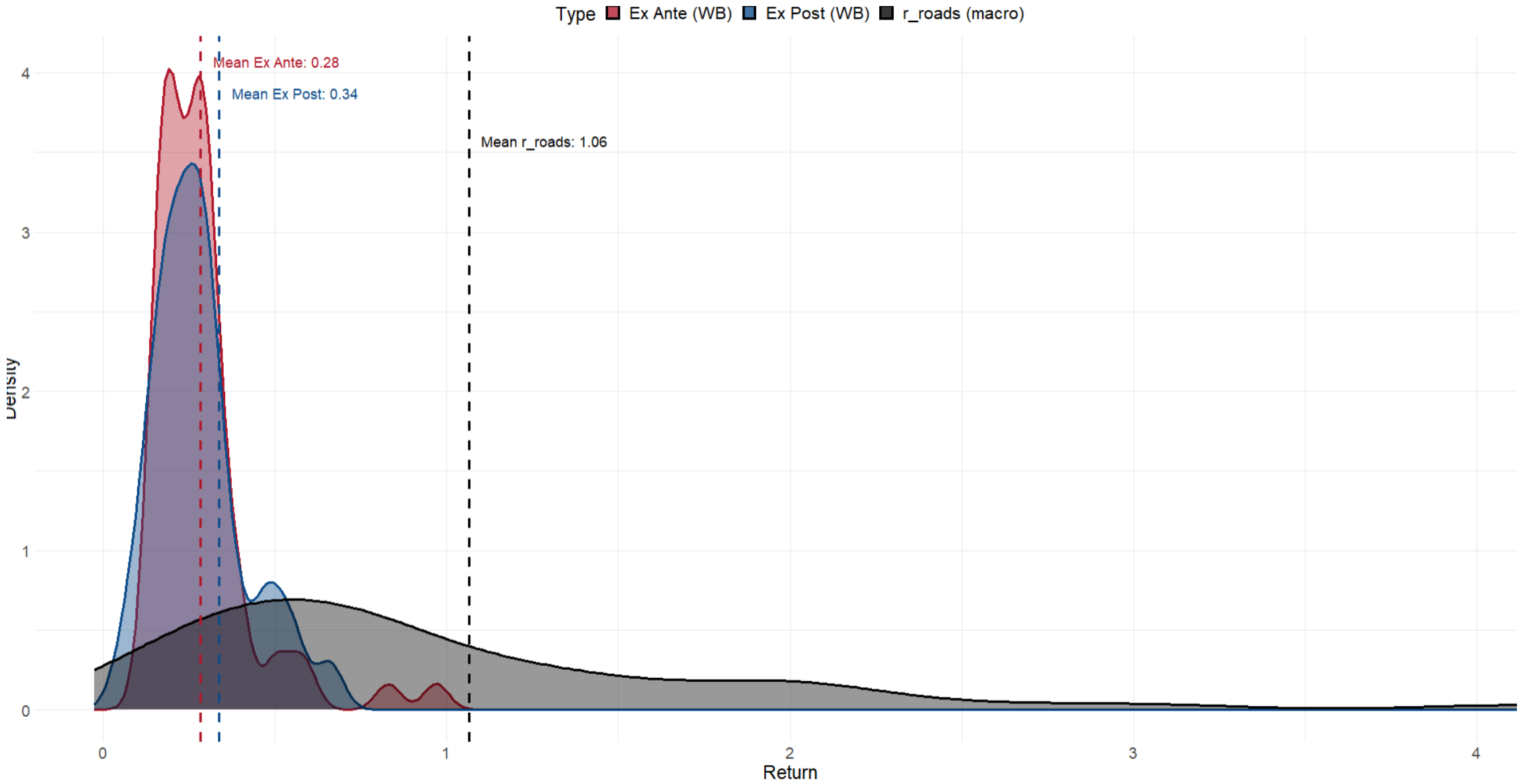
Source: World Bank project documents, ROCKS databases and PWT 10.1

WB Road Project Economic Rate of Return (ExAnte vs ExPost)



- World Bank Road Projects' Economic Rate of Return (ERR) : ExAnte ERR vs ExPost ERR
- ExAnte estimated ERR is largely aligned with realized ERR.
- Weights of overall ERR is estimated based on total project costs

Ex post, Ex ante (WB) and Macro ERR



Source: World Bank project documents, ROCKS databases and PWT 10.1