The Subsidy to Infrastructure as an Asset Class

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Motivation

- **Infrastructure is essential for competitiveness and long run potential growth.**
  - Fernald (1999); Roller and Waverman (2001); Esfahani and Ramírez (2003); Donaldson (2018); etc.
- **Organizations highlighting gap between demand for infrastructure and provision of capital:**
  - U.S. American Society of Civil Engineers: U.S. requires $2 trillion investment infusion.
  - World Bank: $15 trillion gap between global need and projected infrastructure investment to 2040.
- **Institutional investors have become more active in supplying capital to infrastructure:**
  - LP: CalSTRS is doubling its allocation to infrastructure from 2% to 4% of its $230 billion in assets.
  - LP: Norwegian SWF will start investing 2% ($20 billion) in unlisted renewable energy infrastructure.
  - GP: Blackstone working on $40 billion Blackstone Infrastructure Fund, includes $20 billion Saudi money, and so far $2.5 billion from other sources (including U.S. public pension fund) LPs.
  - We estimate $428 billion in AUM by closed infrastructure funds in 2018, up almost 7.5x since 2008.
- **True risk and return characteristics of infrastructure investments are not known.**

What Do Institutional Investors Expect from Infrastructure?

Answer: Steady cash flows in the long run and diversification benefits due to low correlation with other asset classes.

- CalPERS website as of August 2018: "Infrastructure targets stable, defensive investments within the water, energy, waste, transportation, technology, and communications sectors."
- Infrastructure investments are supposed to offer investors long-term, low-risk, inflation-protected and a-cyclical returns. As such, they would be a natural fit with long-lasting, often inflation-linked pension liabilities (see Della Croce, 2012).
- Norwegian Government and Sovereign Wealth Fund 2019: "Allowing for unlisted renewable energy infrastructure is not a climate policy measure. These investments shall be subject to same profitability and transparency requirements as the other investments of the Fund."

Financial industry supports these expectations:

- Deutsche Bank Asset Management (2017): "Infrastructure offers relatively low long-term cash flow volatility compared with other asset classes and can also provide attractive, inflation-hedged returns."
- J.P. Morgan Asset Management (2017) bases its case for infrastructure on "benefits of diversification, inflation protection, and yield, along with a strong focus on ESG principles."

This Research

1. We study the payout profile of infrastructure fund investments:

- 1,664 institutional investors, obtaining exposure on average to 44 underlying infrastructure deals.
- Compared to buyout and RE funds, similar amounts of capital calls and distributions over time.
- Infrastructure funds do not provide more "stable" and long term cash flows; seem to be generating cash by selling assets.

2. We find heterogeneity in performance by type of investor. *Public* investors show:

- Lower exit rates within fund structure, worse net IRR, lower multiples of invested capital, lower PME.
- Robust to project stage and contract characteristics (risk), industry and location controls.

3. We calculate the subsidy from public investors to infra at current exposure levels and inflows (approximately $188.3 billion stock and $23.5 billion annual net inflow):

- Relative to performance of other institutional investors: $1.92 billion per year.
- Risk-adjusted cash flows relative to S&P500: $3.06 billion per year (generalized PME).
- Relative to own RE and buyout funds from same vintage year: from $1.27 to $9.15 billion per year.

Preqin Infrastructure Database

- **1,664 institutional investors, classified in six types:**
  - Public: 370 public pension funds, 166 government agencies, and 36 sovereign wealth funds.
  - Private: 511 private pension funds, 288 insurance firms and banks, and 293 endowments and foundations.
  - From 67 countries plus several international investors (IFC, EIB, African Development Bank).
  - U.S. investors account for 40% of the sample.
- **Time period 1991–2018.**
- **1,771 direct investments in assets.**
- **4,741 investor-fund observations:**
  - 512 unique funds (447 closed, 33 listed, and 32 open-ended funds).
  - 243 unique GPs.
  - An infrastructure fund invests in multiple assets.
- **5,024 unique infrastructure assets located in 128 countries:**
  - 1,232 UK, 954 US, 270 France, 245 Australia, 208 Canada, 185 Germany, 177 Italy, 147 India, etc.
  - Data on industry, project stage (greenfield vs. secondary), concession backing, and ownership.
- **Final sample: 65,799 investor-deal observations.**

954 U.S. Assets in the Dataset (and 681 Investors)

Traditional energy (428 assets):
Sabine and Freeport LNG Terminals; Bakken Pipeline; Masspower Plant in Indian Orchard; Las Vegas Power Plant.

Renewable energy (340 assets):
118 Wind (TX, ID, OK); 102 Solar (CA, SC, OR); 65 Hydro (ME, CT, PA); 21 Biomass; 9 Geothermal; 25 Diversified.

Transportation (75 assets):
Indiana Toll Road; Goethals Bridge; Norfolk VA Midtown Tunnel; LaGuardia Airport Expansion; Ports America.

Social (34 assets):
Long Beach Courthouse; Baylor Clinic; Cottages of Lubbock (student housing); Aston Gardens (senior homes).

Utilities (54 assets):
Puget Energy (power distribution); Synagro (waste management); SouthWest Water Utilities.

Telecom (23 assets):
Global Tower Partners (wireless); Hawaiki Cable (OR-HI-Australia); SkyBitz (satellite networks).

Example: London City Airport (2006–2018)

Description: London City Airport is an international airport serving destinations across the UK and Europe. It is located close to Canary Wharf and the City of London, the centres of London's financial industry. In November 2006, Global Infrastructure Partners and AIG Financial Products acquired 100% of London City Airport via a 50:50 joint venture from Irish businessman Dermot Desmond.

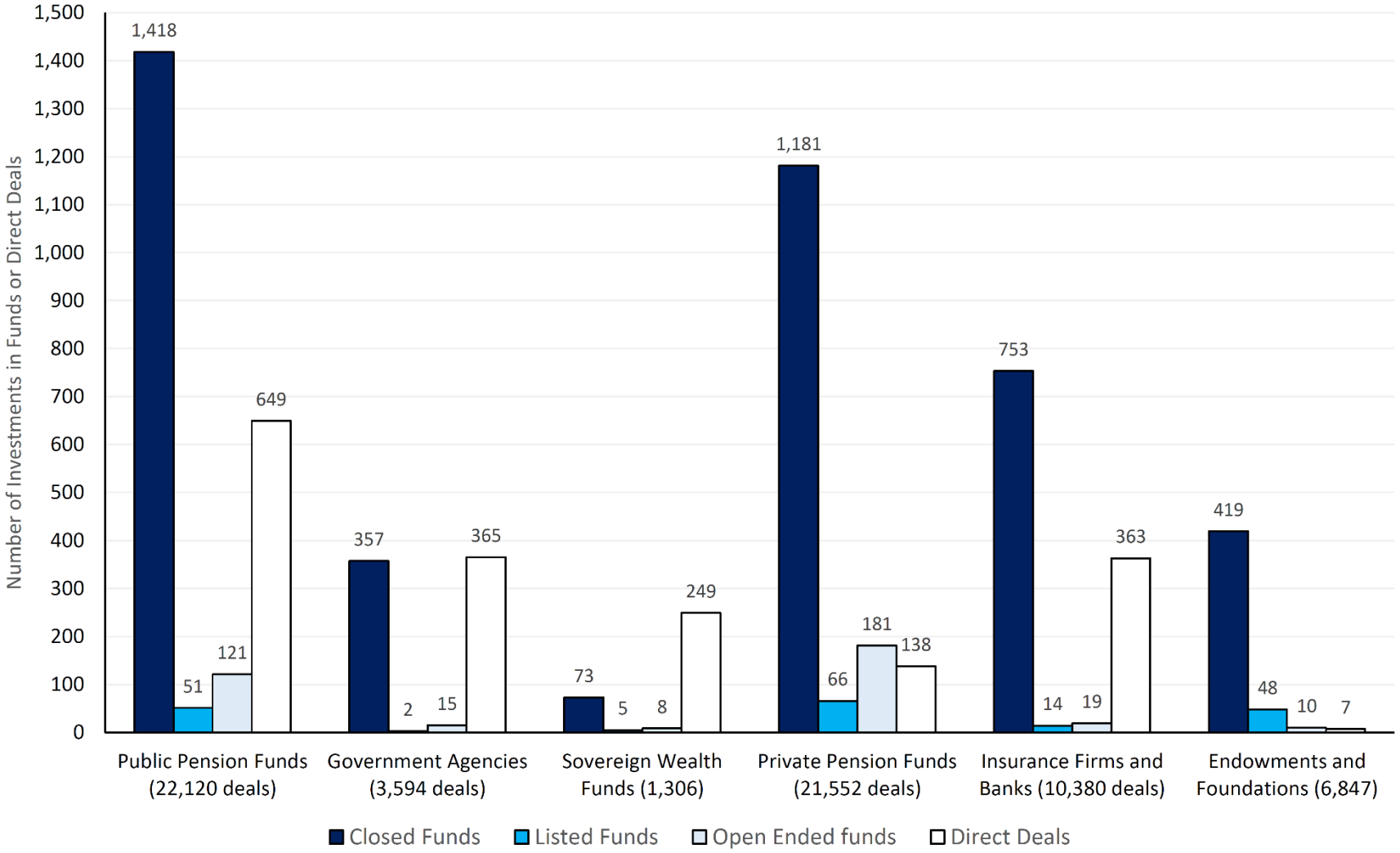
	Investment stake in % by date			
Investor	Nov-06	Sep-08	Oct-08	Feb-16
Global Infrastructure Partners	50%	100%	75%	Exit
AIG Financial Products	50%	Exit		
Highstar Capital Fund III			25%	Exit
Alberta Investment Management Corporation (AIMCo)				25%
OMERS Infrastructure Management				25%
Ontario Teachers' Pension Plan				25%
Kuwait Investment Authority (Wren House Infrastructure Management)				25%

Global Infrastructure Partners is a closed fund with 73 investors.

Highstar Capital Fund III is a closed fund with 41 investors.

Institutional Investors and Investment Approach

- On average, **1,664 investors** allocate to 3.18 funds and 1.06 direct deals.
- Both public and private institutions invest primarily through **closed funds**.
- Sovereign wealth funds and government agencies are more likely to **invest directly**.
- **Public pension funds** gain exposure to assets in a similar way as private sector investors.



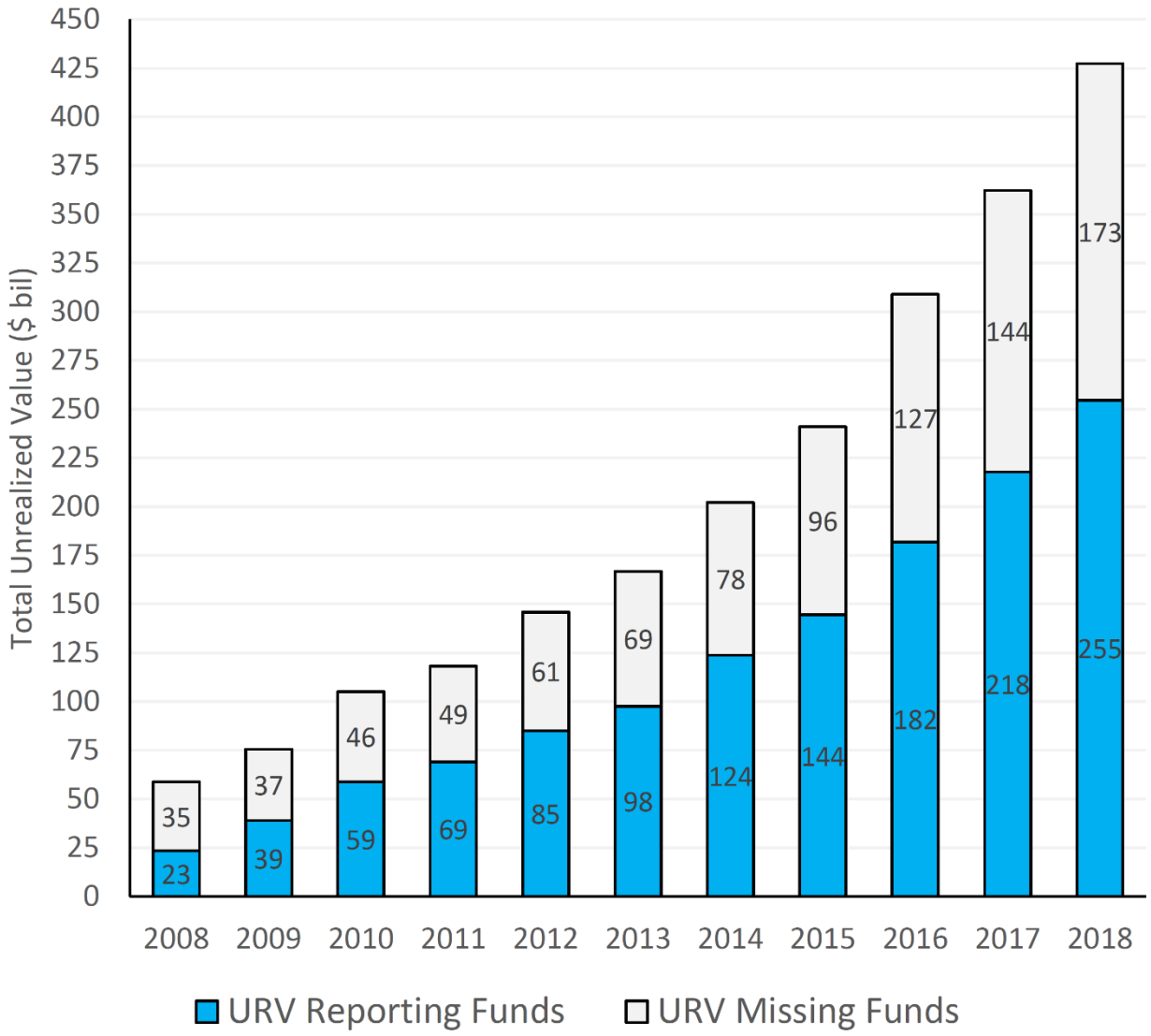
Infrastructure Assets under Management (by Closed Funds)

Based on annual snapshots with unrealized value of assets managed by closed funds:

- Transform the ratio of residual value to paid-in capital (RVPI) into dollar amounts using the percentage of capital called and fund size.
- Assume that every fund that does not report performance holds 25% of the average assets of reporting funds from the same vintage.

Does not include:

- Assets held by listed and open-ended funds.
- Assets held directly by institutional investors.

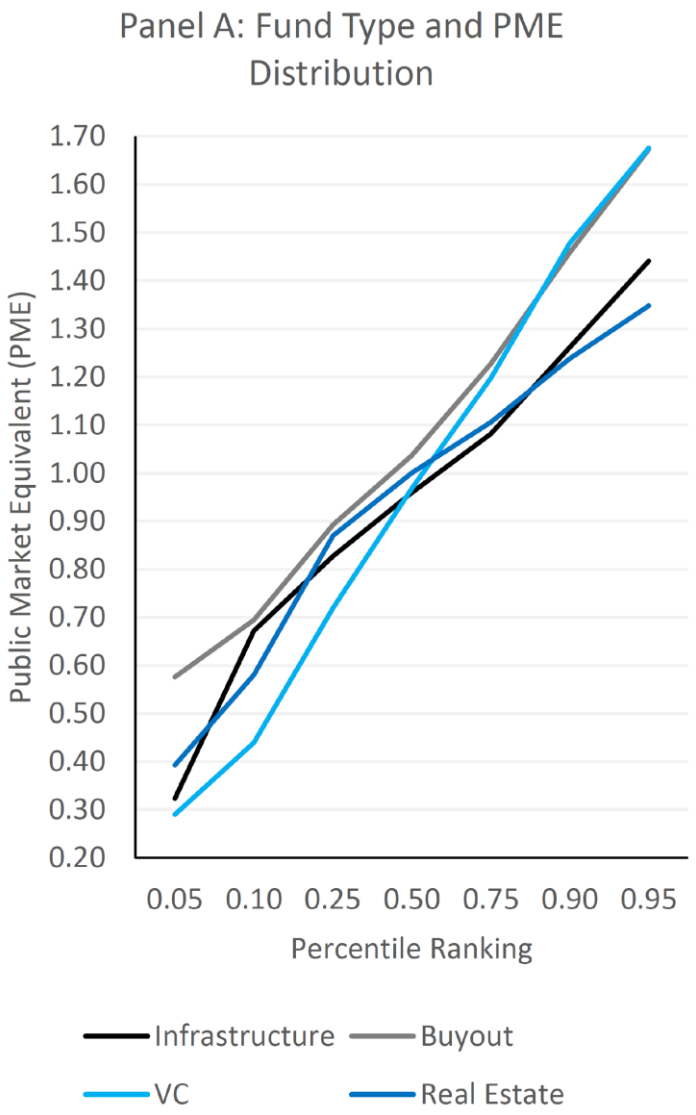


Performance Distribution: Infrastructure vs. Other Funds

Institutional investors expect long-term stable and predictable cash flows from infrastructure, so we look at:

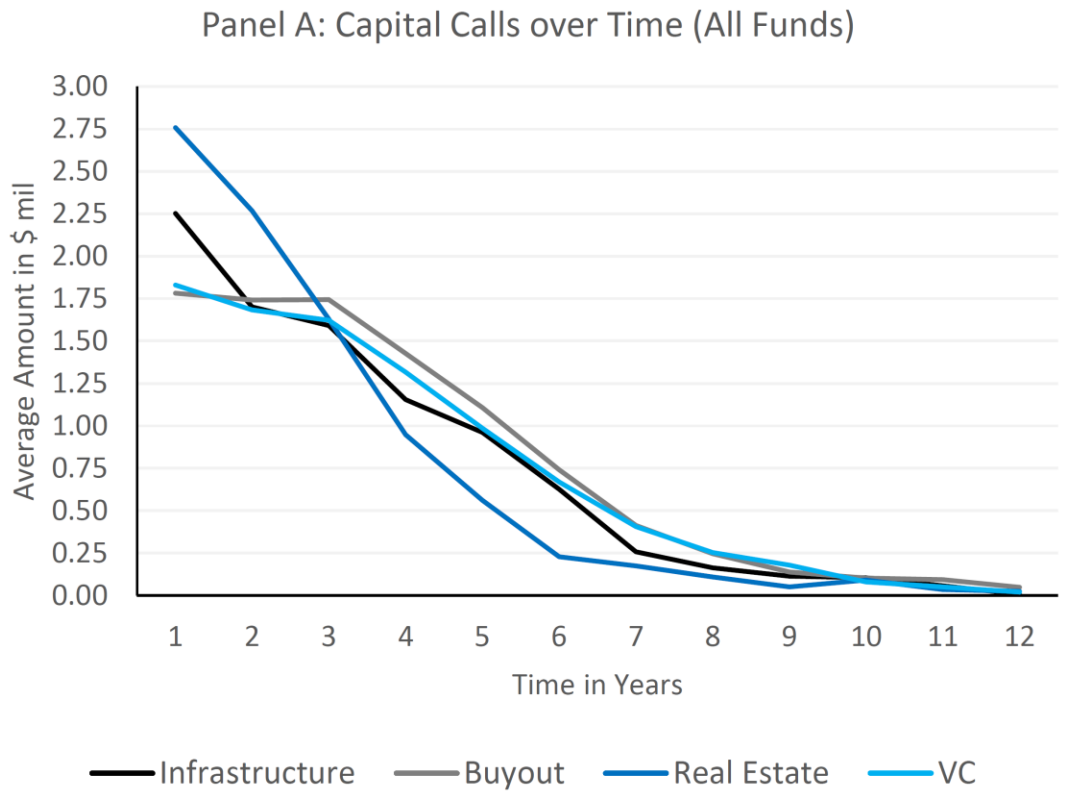
- Standard deviation.
- Performance distribution.
- Annual amounts of capital calls and distributions.

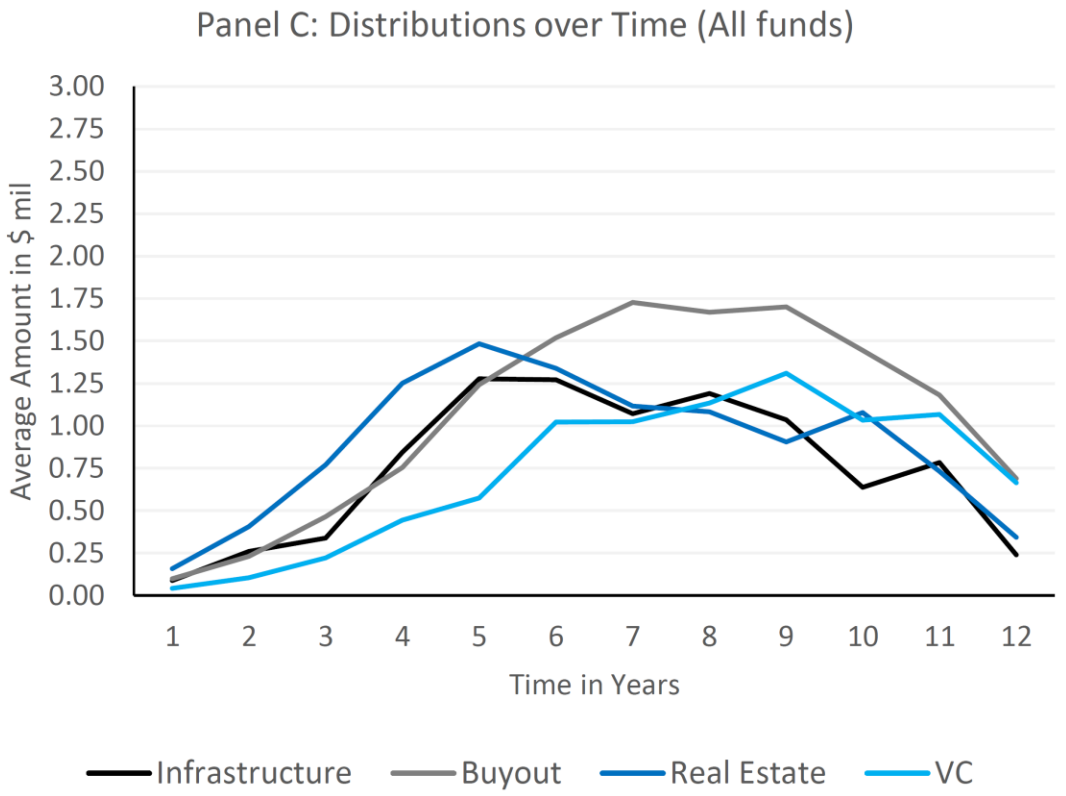
	Mean			Standard Deviation		
	PME	IRR	Multiple	PME	IRR	Multiple
Infrastructure	0.951	11.194	1.352	0.318	12.356	0.530
Buyout	1.079	14.472	1.561	0.388	15.290	0.629
VC	0.999	12.963	1.629	0.557	25.952	1.898
RE	0.963	10.983	1.356	0.283	14.909	0.495



Calls and Distributions: Infrastructure vs. Other Funds

- **Standardize the cash flows** over the life of a fund (t=1 corresponds to the vintage year).
- **Expectations from infrastructure:** larger calls at the beginning and flatter distributions over time.
- **The payout profile provided by infrastructure funds** over time is statistically and economically similar to payout profile provided by buyout and real estate funds (but on average smaller amounts).





Infrastructure Cash Flows and Business Cycle

We follow Robinson and Sensoy (2016) and use two proxies of business cycle:

- Price-dividend ratio (Shiller's data).
- Yield spread (Moody's Baa–Aaa).
- Funds raised during 1990–2018 period.

Results – all private funds are procyclical:

- Results for buyout and VC very similar to Robinson and Sensoy (2016).
- Cash flows delivered by infrastructure funds are high when the price-dividend ratio is high.
- Distributions are more sensitive to the business cycle than capital calls.

Difficult for infrastructure to provide diversification benefits relative to other funds.

Table 3	Funds with U.S. Focus			
	Infra	Buyout	VC	RE
	(1)	(2)	(3)	(4)
Net cash flow as a percentage of committed capital				
ln(P/D)	5.371**	1.716***	8.210***	1.704*
	[2.453]	[0.327]	[2.656]	[0.935]
ln(Yield spread)	0.322	-0.326***	0.014	-0.347**
	[0.261]	[0.057]	[0.225]	[0.138]
Fund age FE	Yes	Yes	Yes	Yes
Observations	1,665	32,620	33,163	12,156
Adjusted R-squared	0.167	0.143	0.052	0.209
ln(distributions as a percentage of committed capital + 1)				
ln(P/D)	1.739***	0.439***	1.688***	1.046***
	[0.431]	[0.059]	[0.099]	[0.111]
ln(Yield spread)	-0.028	-0.196***	-0.256***	-0.220***
	[0.048]	[0.010]	[0.017]	[0.015]
Fund age FE	Yes	Yes	Yes	Yes
Observations	1,665	32,620	33,163	12,156
Pseudo R-squared	0.052	0.050	0.044	0.055

Analysis of Investor Experience in Infrastructure

Fund-level analysis: net IRR, multiple, and PME measures of performance

- Performance measures available only for closed funds.

Deal-level analysis: probability of exiting an investment as a proxy for performance.

- Proxy used in the literature to analyze the performance of buyout and VC funds (Hochberg, Ljungqvist and Lu, 2007; Sorensen, 2007; Phalippou and Gottschalg, 2009).
- Cox proportional hazard model with deal-level controls:
  - Hazard rate of exiting an asset: probability that an exit will come to fruition in year t conditional on it not becoming complete prior to year t.
  - t refers to the number of years after the purchase transaction and it measures event time rather than calendar time.
  - Only full exits, not partial exits.

Linking Two Analyses: Exited Deals and Performance

- **Reporting performance – logit regressions:** a 10 percentage point increase in the percentage of exited deals is associated with a 2.45 percentage point higher probability of reporting IRR and/or Multiple.
- **Performance measures:** a 10 percentage point increase in the percentage of exited deals is associated with a 0.09 higher PME, 2.58 percentage point higher IRR, and 0.08 higher multiple of invested capital.
- **Quick exits:** the positive relation is driven primarily by exited deals within the first five years.

Table 4	Reporting		PME		Net IRR		Multiple	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
%Exited deals	0.245**		0.895***		25.797***		0.760***	
	[0.117]		[0.114]		[3.588]		[0.145]	
%Exited deals in years 0-5		0.314**		1.004***		32.088***		0.971***
		[0.155]		[0.118]		[4.013]		[0.173]
%Exited deals in years 5-10		0.138		0.435*		13.318**		0.360
		[0.173]		[0.252]		[6.346]		[0.253]
%Exited deals in years >10		0.616		-1.714		-6.705		0.285
		[0.523]		[1.301]		[13.386]		[0.580]
Fund Size	0.187***	0.184***	0.009	0.001	-0.793	-0.291	-0.030	-0.023
	[0.030]	[0.030]	[0.025]	[0.025]	[0.870]	[0.848]	[0.033]	[0.033]
Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
%Deal region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
%Deal industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	439	439	97	97	152	152	214	214
R^2			0.724	0.752	0.486	0.537	0.440	0.456

Investor-Fund Level: Investor Type and Performance

Public investors underperform: Funds selected by public investors have 2.000 percentage points lower exit rates and deliver 0.026 lower PME, 1.016 percentage points lower IRR, and 0.048 lower multiple.

- Underestimated underperformance by public investors as their funds are less likely to report returns.

Controls:
- LP size and year of first investment as proxies for negotiating power, experience, or access.
- Indicators for few funds-of-funds and debt funds hold direct equity stakes.
- Deal level proxies for region and industry of asset

Table 5	%Exited deals		PME		Net IRR		Multiple	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Public Investor	-0.020***		-0.026***		-1.016***		-0.048***	
	[0.007]		[0.010]		[0.369]		[0.013]	
U.S. Public PF		-0.039***		-0.025**		-0.214		-0.012
		[0.009]		[0.012]		[0.482]		[0.017]
Non U.S. Public PF		0.004		-0.028		-2.081***		-0.080***
		[0.011]		[0.018]		[0.566]		[0.021]
Government agencies		-0.048***		-0.021		-2.242		-0.131**
		[0.016]		[0.039]		[1.445]		[0.055]
Sovereign wealth funds		-0.018		-0.046**		-2.040*		-0.035
		[0.034]		[0.022]		[1.171]		[0.040]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LP country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
%Deal region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
%Deal industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,201	4,201	1,959	1,959	2,615	2,615	3,355	3,355
R-squared	0.616	0.617	0.512	0.512	0.293	0.295	0.335	0.337

Investor-Deal Level: Exiting a Deal and Investor Type (1)

Public institutional investors in general, and U.S. PPFs in particular, have lower probability of exiting an infrastructure deal:

- Based on column (3), public investors have a 11.6% lower probability of exiting a deal as compared to private investors.

Controls for LP skills: logarithm of the LP's AUM and the year of their first infrastructure investment could capture negotiating power, experience, or ability to access higher-performing GPs.

Controls for deal selection:

- Direct deals (flexibility in the exit decisions).
- Deals accessed through listed and open-ended funds.
- Region and industry fixed effects.
- Deal-level controls for project stage and concession.

Table 6	(1)	(2)	(3)	(4)
Public Investor	0.871***		0.884***	
	[0.035]		[0.037]	
U.S. Public PF		0.885**		0.799***
		[0.043]		[0.045]
Non U.S. Public PF		0.860***		0.945
		[0.046]		[0.060]
Government agencies		0.856		1.014
		[0.089]		[0.161]
Sovereign wealth funds		0.963		0.861
		[0.109]		[0.128]
Direct deal	0.440***	0.439***		
	[0.090]	[0.089]		
Listed	0.336***	0.335***		
	[0.031]	[0.031]		
Open Ended	0.765***	0.762***		
	[0.033]	[0.032]		
Deal controls	No	No	Yes	Yes
LP controls	Yes	Yes	Yes	Yes
LP country FE	No	No	Yes	Yes
Deal region FE	Yes	Yes	Yes	Yes
Deal industry FE	Yes	Yes	Yes	Yes
Cluster	Investor	Investor	Investor	Investor
Observations	65,799	65,799	48,395	48,395

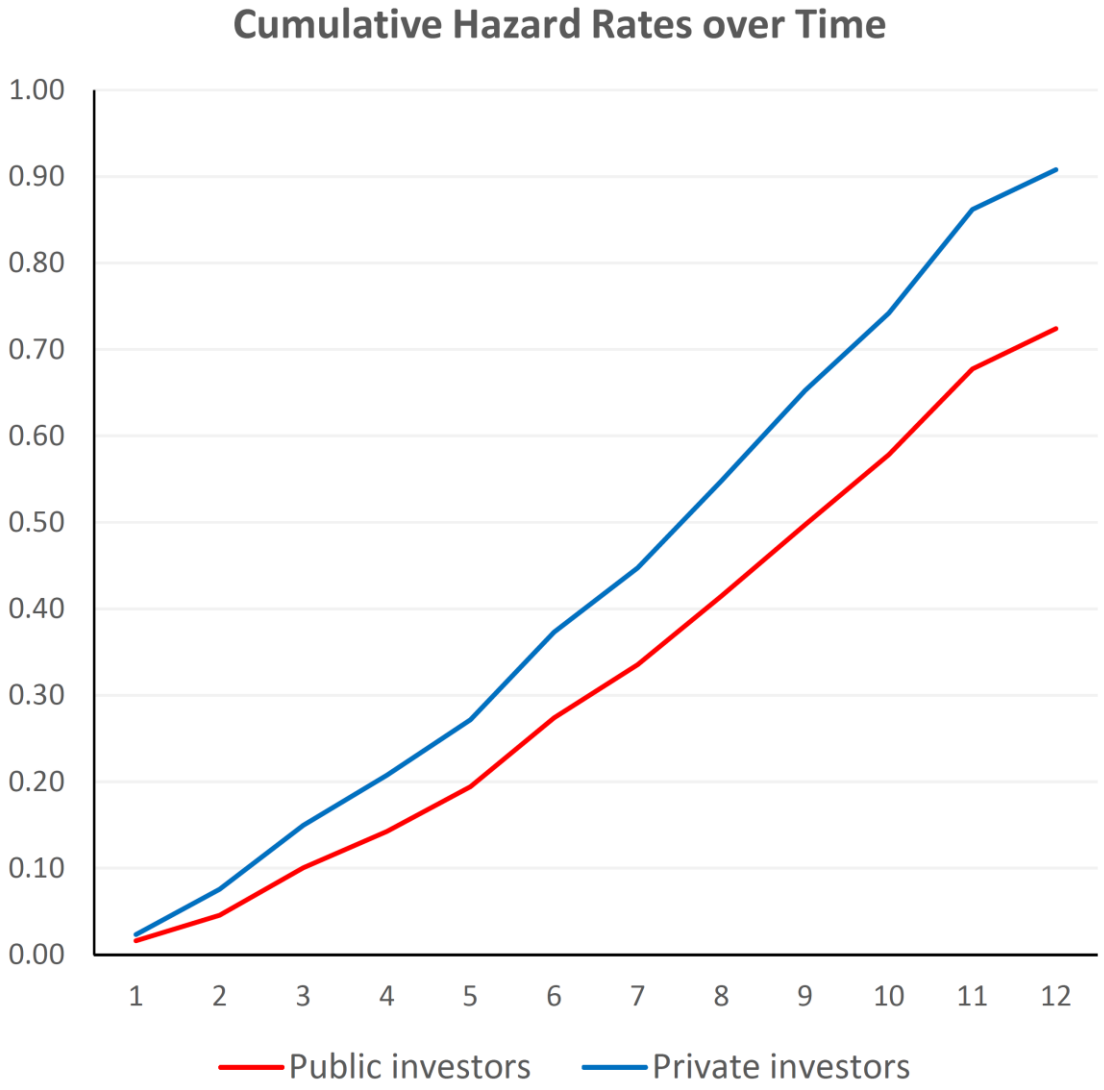
Investor-Deal Level: Exiting a Deal and Investor Type (2)

Robust to more controls for deal characteristics (see Table 6)

- **Greenfield and brownfield** – riskier projects require a longer time for development before they can be sold to other parties.
- **Concession agreement** reduces risk and increases liquidity.
- **Home deals** have lower exit rates.
- **Ownership structure.**
- **Investment stake.**

Exiting a deal by industry (see Table 7):

- The underperformance of all public investors is stronger in **traditional and renewable energy**.
- U.S. public pension funds also have lower exit rates in **transportation**.



The Implicit Subsidy from Public Investors to Infrastructure

Three estimates of annual subsidy:

I. Relative to other investors: Public investors have 1.02% lower net IRR and $188.3 billion under management in infrastructure funds, which means $1.92 billion annual subsidy.

II. Relative to other comparable-risk opportunities: Public investors have a lower PME, so for each new (annual) $23.5 billion committed, they lose $3.06 billion over the lifetime of the funds.

- Korteweg and Nagel (2016) SDF valuation methodology.
- Risk-adjusted generalized PME of 0.870 relative to S&P500.

III. Relative to investments in real estate and buyout funds made by the same investor and in the same vintage year: Public investors experience an annual loss of $1.27 – $9.15 billion.

Panel B: Comparison of Infrastructure with Other Funds

	Net IRR			Multiple		
	Obs.	Infra	Other	Obs.	Infra	Other
Infra vs. Buyout	671	9.724	14.620	875	1.297	1.495
Infra vs. VC	424	9.373	13.161	562	1.278	1.561
Infra vs. Real estate	485	9.913	10.586	605	1.275	1.287

Conclusion

The main investment approach in infrastructure, closed funds, does not meet investor expectations:

- It does not deliver stable cash flows over a long horizon; it is sensitive to the business cycle.
- Payout profile similar to traditional PE buyout, real estate, and VC funds.

Public investors are exposed to deals longer and underperform:

- After controlling for project stage and contract characteristics (risk), industry and location controls.
- The subsidy from public investors to infrastructure at *current* exposure levels:
  - Relative to private institutional investors: $1.92 billion per year.
  - Risk-adjusted cash flows relative to S&P500: $3.06 billion per year (generalized PME).
  - Relative to own RE and buyout funds from same vintage year: from $1.27 to $9.15 billion per year.

Explanations of the underperformance of public investors?

- Does not seem to be driven by differences in risk-taking.
- Does not seem to be driven by differences in preferences and investment approach.
- Could be due to lower skill or only having access to worse-performing funds, but extensive prior experience.
- Willingness to take on more marginal investments in order to meet higher allocation or impact target.

  → Public investors are susceptible to non-financial objectives when investing in infrastructure.