

The Subsidy to Infrastructure as an Asset Class

NBER New Developments in Long-Term Asset Management

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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 \$404 billion in AUM by closed infrastructure funds in 2018, up almost 7.0x 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

- 1,594 institutional investors, obtaining exposure on average to 47 underlying infrastructure deals.
- Compared to buyout and RE funds, similar frequency and amounts of capital calls and distributions.
- 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 \$173 billion stock and \$18 billion annual net inflow):

- Relative to other institutional investors: \$2.25 billion per year
- Relative to listed infrastructure funds: \$2.86 billion per year (PME)
- Relative to own RE and buyout funds from same vintage year: from \$1.48 to \$8.45 billion per year

Prequin Infrastructure Database

- **1,594 institutional investors, classified in six types:**
 - Public: 353 public pension funds, 138 government agencies, and 27 sovereign wealth funds.
 - Private: 497 private pension funds, 280 insurance firms and banks, and 299 endowments and foundations.
 - From 61 countries plus several international investors (IFC, EIB, African Development Bank).
 - U.S. investors account for 40% of the sample.
- **Time period 1991–2018.**
- **1,721 direct investments in assets.**
- **4,493 investor-fund observations:**
 - 484 unique funds (421 closed, 34 listed, and 29 open-ended funds).
 - 234 unique GPs.
 - An infrastructure fund invests in multiple assets.
- **4,825 unique infrastructure assets located in 125 countries:**
 - 1,174 UK, 916 US, 260 France, 241 Australia, 215 Canada, 182 Germany, 172 Italy, 146 India, etc.
 - Data on industry, project stage (greenfield vs. secondary), concession backing, and ownership.
- **Final sample: 62,106 investor-deal observations.**

916 U.S. Assets in the Dataset (and 647 Investors)

424 Traditional energy:

Sabine and Freeport LNG Terminals;
Bakken Pipeline; Masspower Plant in
Indian Orchard; Las Vegas Power Plant.



316 Renewable energy:

107 Wind (TX, ID, IL); 95 Solar (CA,
SC, NC); 61 Hydro (ME, CT, PA); 20
Biomass; 9 Geothermal; 24 Diversified.



72 Transportation:

Indiana Toll Road; Goethals Bridge;
Norfolk VA Midtown Tunnel; LaGuardia
Airport Expansion; Ports America.



30 Social:

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



53 Utilities:

Puget Energy (power distribution);
Synagro (waste management);
SouthWest Water Utilities



21 Telecom:

Global Tower Partners (wireless);
Hawaiki Cable (OR-HI-Australia);
SkyBitz (satellite networks)



Investment Approaches in Infrastructure

Few LPs invest **directly**:

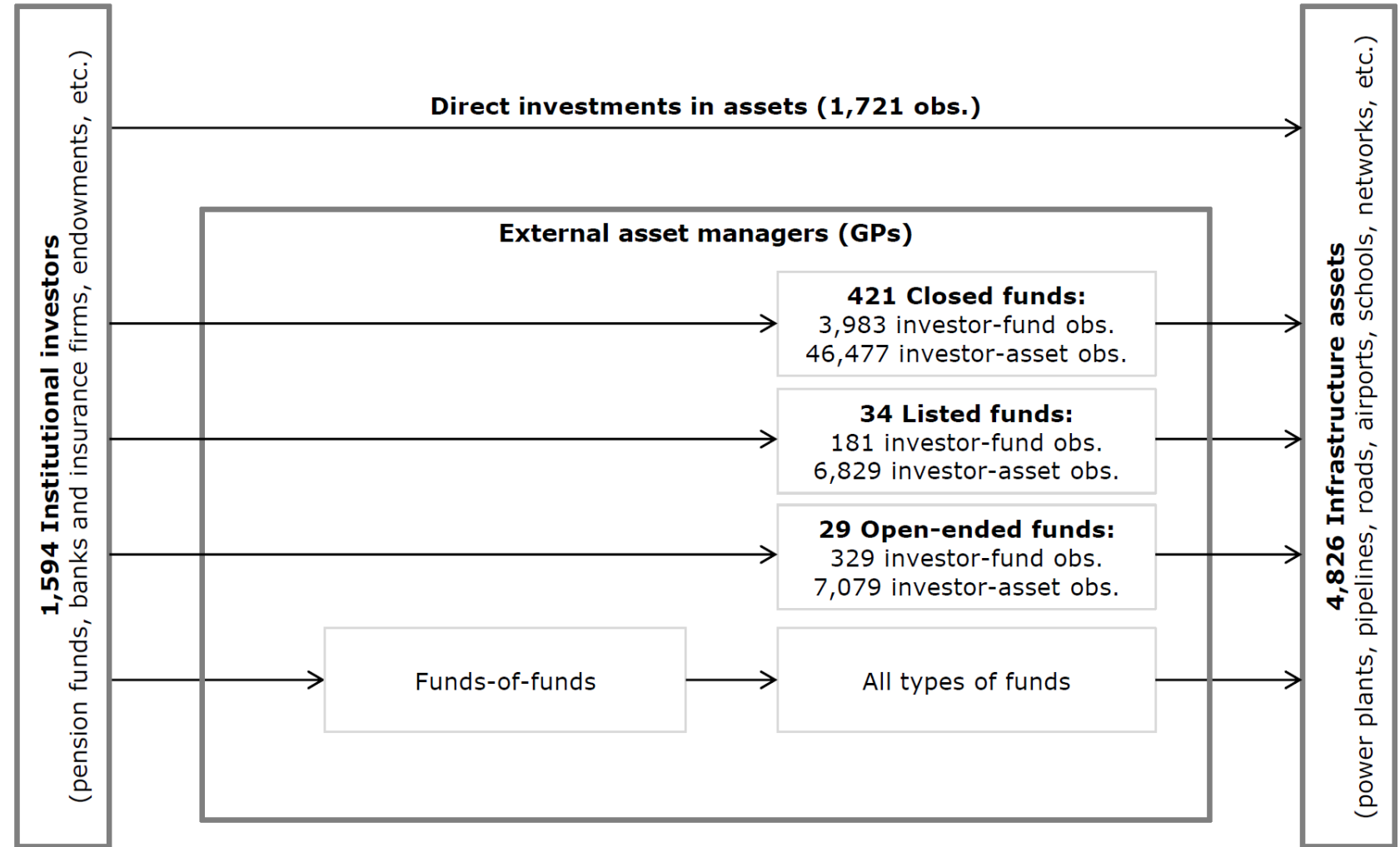
- Commitment to one asset.
- Specialized human capital

Closed funds organized as buyout and VC funds:

- Raised for a specified period (10-12 years).

Listed funds have publicly traded shares.

Open-ended (evergreen) funds are not publicly traded, but offer more liquidity through periodic subscriptions and redemptions.



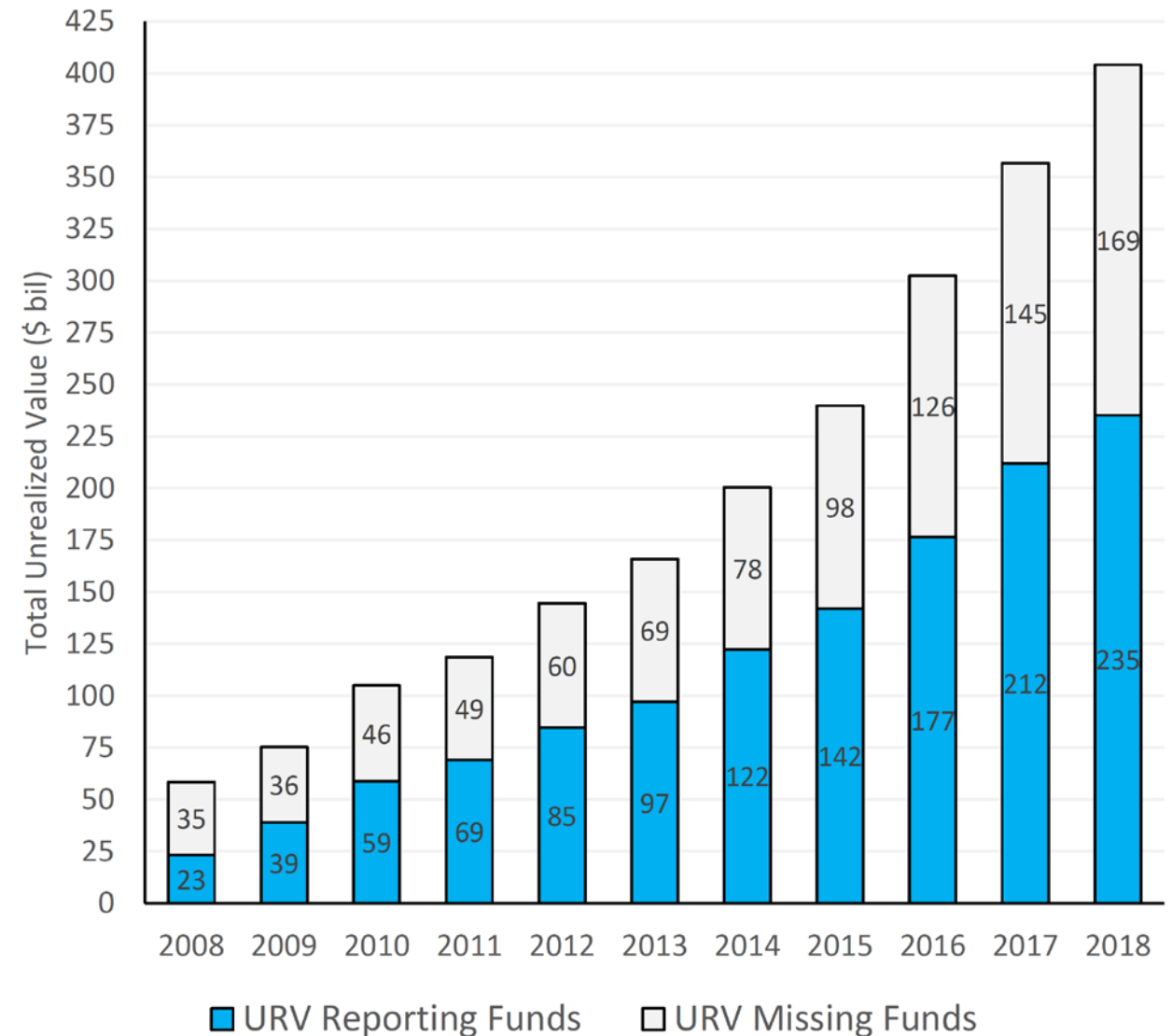
Infrastructure Assets under Management (by Closed Funds)

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.



Example: Chicago Parking Meters (2009)

Description: The Chicago Metered Parking System has approximately 36,000 on-street parking meters throughout Chicago. In 2008, the City of Chicago offered private investors the opportunity to bid for a 75-year concession to operate the metered parking system.

| Investors | Fund | Investment Stake |
|--------------------------------|---------------------------------------|------------------|
| Abu Dhabi Investment Authority | (direct investment) | 25.00 |
| Allianz Capital Partners | (direct investment) | 24.90 |
| Morgan Stanley Infrastructure | North Haven Infrastructure Partners I | 50.10 |

| LP investors in North Haven Infrastructure Partners I | LP Type | LP Country |
|---|-----------------------------|-------------|
| Industry Pension Insurance | Private Sector Pension Fund | Denmark |
| PKA AIP | Public Pension Fund | Denmark |
| Generali Deutschland | Insurance Company | Germany |
| PGB Pensioendiensten BV | Private Sector Pension Fund | Netherlands |
| Telenor Pension Fund | Private Sector Pension Fund | Norway |
| Skandia Life Insurance Company | Insurance Company | Sweden |
| Clwyd Pension Fund | Public Pension Fund | UK |
| Hartford Financial Services Group | Insurance Company | US |
| Athene Annuity & Life Assurance Company of New York | Insurance Company | US |
| Teacher Retirement System of Texas | Public Pension Fund | US |

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.

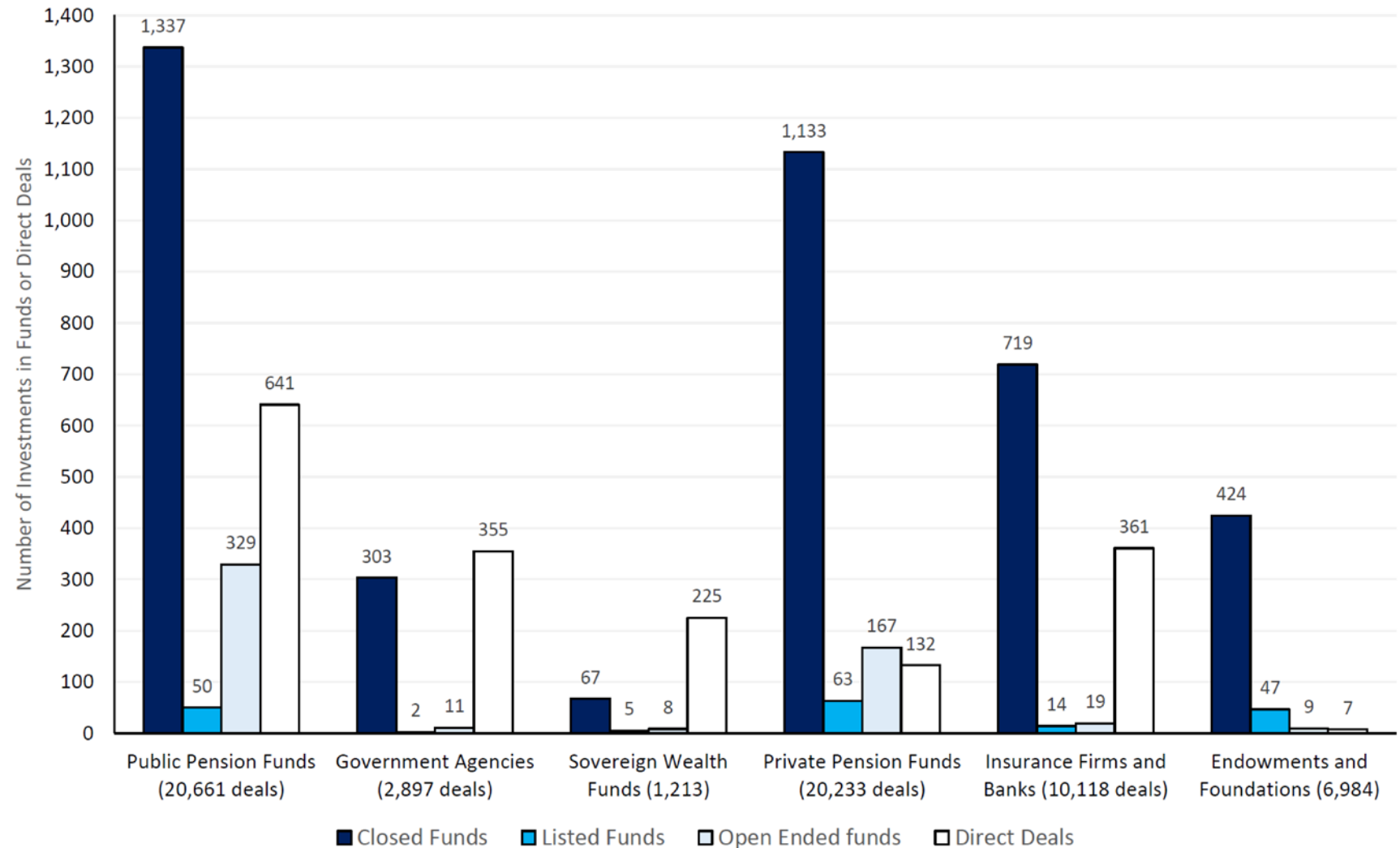
| Investor | Investment stake in % by date | | | |
|--|-------------------------------|--------|--------|--------|
| | Nov-06 | Sep-08 | Oct-08 | Feb-16 |
| Global Infrastructure Partners | 50% | 100% | 75% | Exit |
| AIG Financial Products | 50% | Exit | | |
| Highstar Capital Fund III | | | 25% | Exit |
| 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 72 investors.

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

Institutional Investors and Investment Approach

- On average, **1,594 investors** allocate to 3.16 funds and 1.08 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.



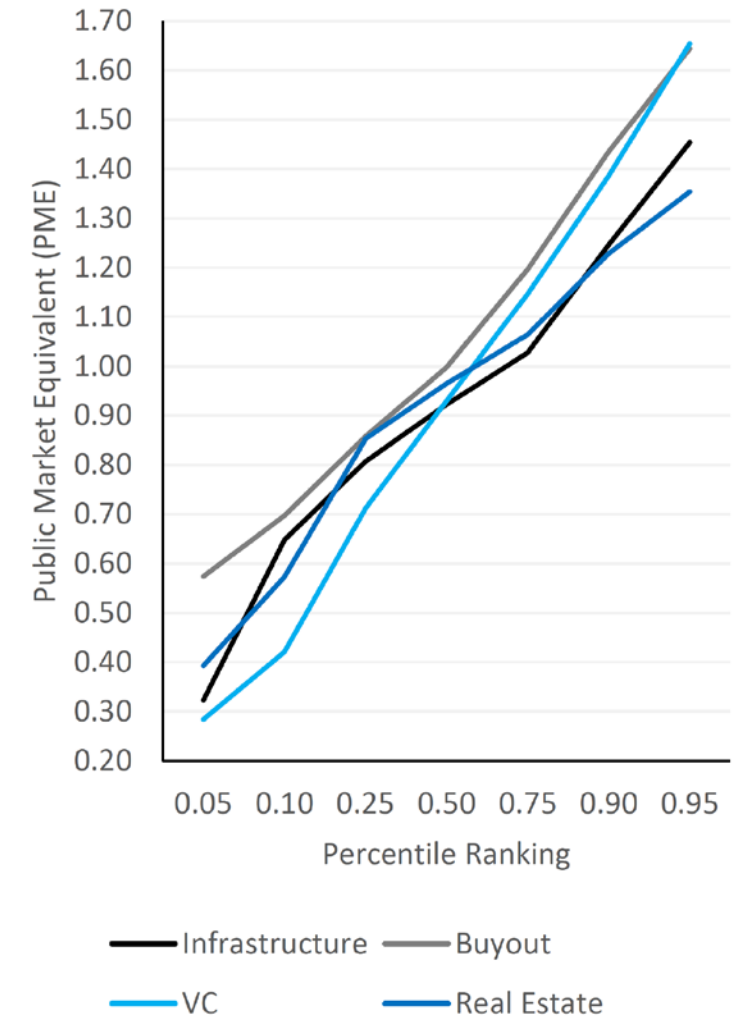
Performance Distribution: Infrastructure vs. Other Funds

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

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

| | Mean | | | Standard Deviation | | |
|-----------------------|-------|--------|----------|--------------------|--------|----------|
| | PME | IRR | Multiple | PME | IRR | Multiple |
| Infrastructure | 0.928 | 11.421 | 1.286 | 0.336 | 13.988 | 0.456 |
| Buyout | 1.052 | 13.486 | 1.494 | 0.387 | 13.022 | 0.522 |
| VC | 0.972 | 10.682 | 1.475 | 0.558 | 23.270 | 0.972 |
| RE | 0.942 | 11.442 | 1.313 | 0.290 | 12.324 | 0.416 |

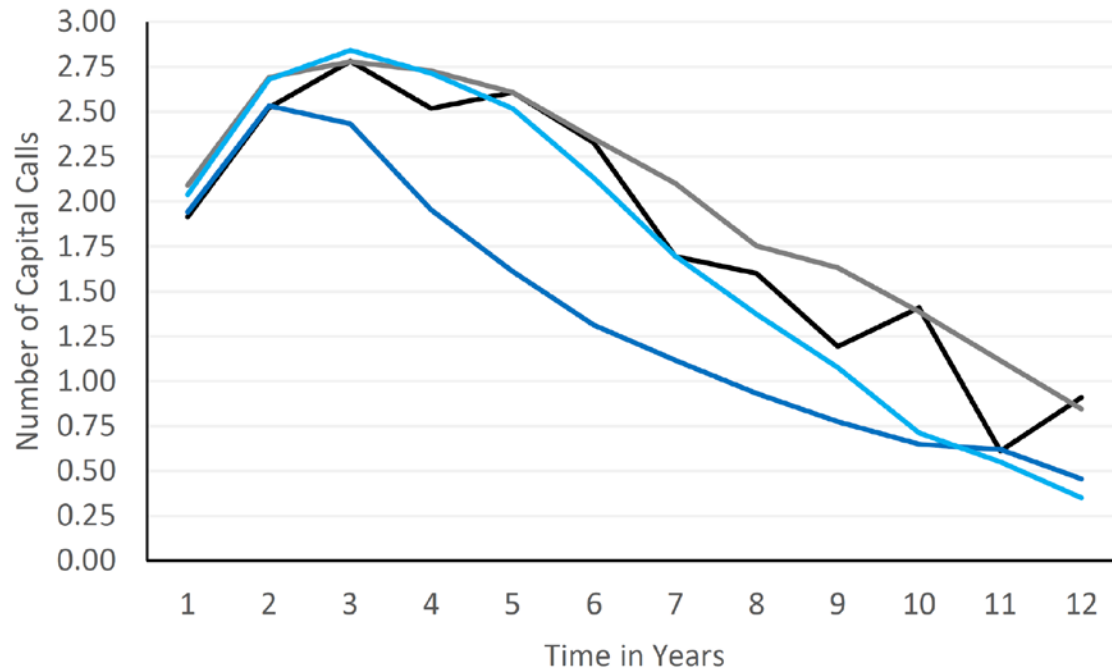
Panel A: Fund Type and PME Distribution



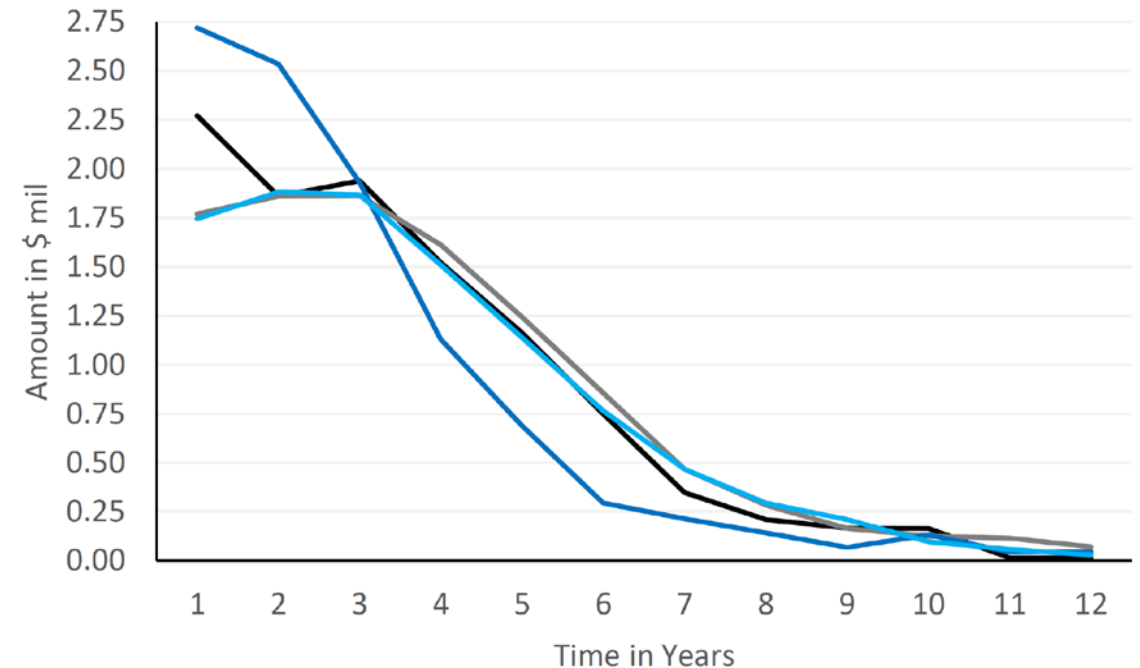
Capital Calls: Infrastructure vs. Other Private Funds

- Standardize the cash flows over the life of a fund (t=1 corresponds to the vintage year).
- The amount of capital called by infrastructure funds over time is statistically and economically indistinguishable from the amount of capital called by buyout and VC funds.
- Differences: real estate funds call a lot of capital at the beginning and have less frequent calls later.

Panel A: Average Number of Capital Calls over Time



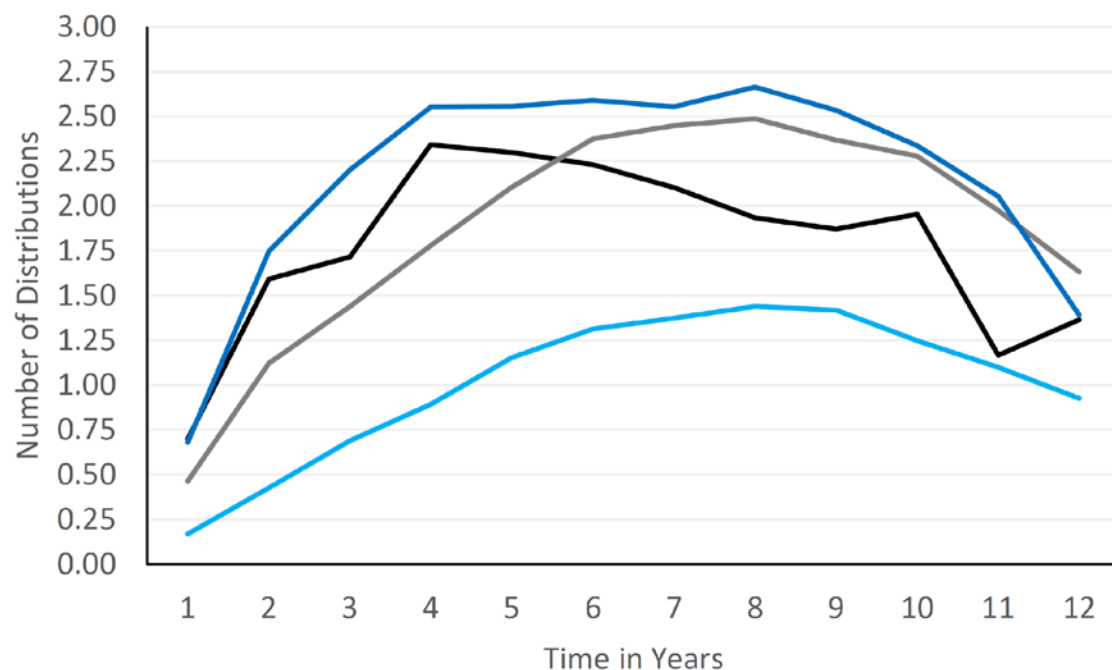
Panel B: Average Amount of Capital Calls over Time



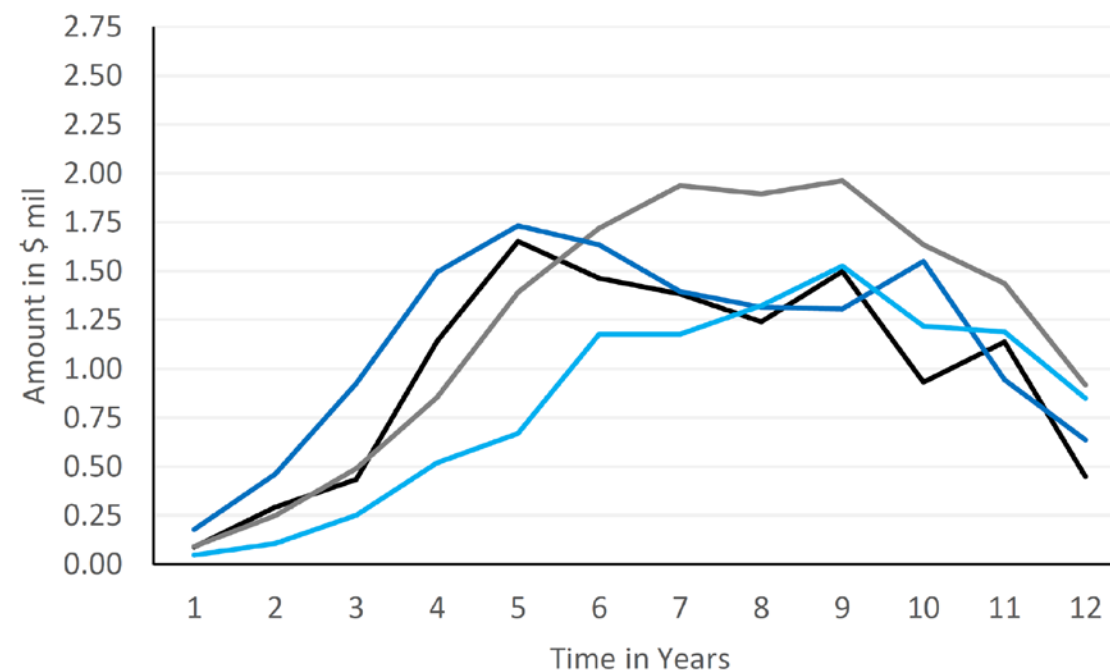
Distributions: Infrastructure vs. Other Private Funds

- Standardize the cash flows over the life of a fund (t=1 corresponds to the vintage year).
- The payout profile provided by infrastructure funds over time is statistically and economically similar to the payout profile provided by buyout and real estate funds (but on average smaller amounts).
- Compared to VC funds, infra and buyout funds have more frequent and larger annual distributions.

Panel C: Average Number of Distributions over Time



Panel D: Average Amount of Distributions over Time



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 the private equity literature when analyzing 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.

Investor-Fund Level: Investor Type and Performance

Public investors underperform: Funds selected by public investors have 2.9 percentage points lower exit rates and deliver 1.28 percentage points lower IRR, 0.061 lower multiple, and 0.041 lower PME.

- 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 4 | %Exited deals | | Net IRR | | Multiple | | PME | |
|------------------------|----------------------|----------------------|----------------------|---------------------|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Public Investor | -0.029*** [0.011] | | -1.277*** [0.479] | | -0.061*** [0.015] | | -0.041*** [0.014] | |
| U.S. Public PF | | -0.060*** [0.016] | | -0.854 [0.656] | | -0.048** [0.019] | | -0.054*** [0.017] |
| Non U.S. Public PF | | -0.002 [0.014] | | -1.654** [0.707] | | -0.086*** [0.025] | | -0.011 [0.023] |
| Government agencies | | -0.015 [0.024] | | -3.057** [1.341] | | -0.011 [0.063] | | -0.090 [0.062] |
| Sovereign wealth funds | | -0.045* [0.024] | | -2.839* [1.585] | | -0.033 [0.056] | | -0.035 [0.038] |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| LP country 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 | 4,493 | 4,493 | 2,523 | 2,523 | 3,385 | 3,385 | 1,968 | 1,968 |
| R-squared | 0.139 | 0.141 | 0.079 | 0.080 | 0.111 | 0.112 | 0.123 | 0.124 |

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 2.99 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 2.84 percentage point higher IRR, 0.09 higher multiple of invested capital, and 0.11 higher PME.
 - Percentage of exited deals proxies well for performance because many funds were raised recently and are still not fully liquidated (liquidated funds by definition have 100% exited deals).

| Table 3 | Reporting | | Net IRR | | Multiple | | PME | |
|-----------------------------|---------------------|---------------------|----------------------|----------------------|---------------------|---------------------|---------------------|---------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| %Exited deals | 0.299** [0.130] | | 28.435*** [3.972] | | 0.915*** [0.156] | | 1.125*** [0.124] | |
| %Exited deals in years 0-5 | | 0.325* [0.169] | | 35.105*** [4.404] | | 1.197*** [0.186] | | 1.215*** [0.129] |
| %Exited deals in years 5-10 | | 0.246 [0.193] | | 15.083** [6.961] | | 0.489* [0.253] | | 0.749*** [0.279] |
| %Exited deals in years >10 | | 0.589 [0.513] | | -5.440 [14.411] | | 0.112 [0.572] | | -1.180 [1.347] |
| Fund Size | 0.213*** [0.033] | 0.210*** [0.033] | -0.811 [0.954] | -0.242 [0.931] | -0.034 [0.034] | -0.024 [0.034] | 0.002 [0.026] | -0.005 [0.026] |
| 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 | 388 | 388 | 147 | 147 | 211 | 211 | 98 | 98 |
| R ² | | | 0.494 | 0.544 | 0.461 | 0.486 | 0.755 | 0.772 |

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

Public investors in general, and U.S. PPFs in particular, have lower probability of exiting a deal

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:

- Region and industry fixed effects.
- Direct deals (flexibility in the exit decisions).

| Table 6 | (1) | (2) | (3) | (4) |
|------------------------|---------------------|---------------------|---------------------|---------------------|
| Public Investor | 0.848*** [0.038] | | 0.871*** [0.036] | |
| U.S. Public PF | | 0.835*** [0.046] | | 0.744*** [0.040] |
| Non U.S. Public PF | | 0.839*** [0.052] | | 0.976 [0.063] |
| Government agencies | | 0.946 [0.108] | | 1.144 [0.229] |
| Sovereign wealth funds | | 0.833* [0.091] | | 0.818** [0.075] |
| Log Investor Size | 1.041*** [0.013] | 1.040*** [0.013] | 1.045*** [0.014] | 1.049*** [0.014] |
| Year First Invest | 1.003 [0.004] | 1.003 [0.004] | 1.005 [0.004] | 1.007* [0.004] |
| #Funds | 1.003 [0.003] | 1.003 [0.003] | 1.000 [0.003] | 1.000 [0.003] |
| Direct deal | 0.479*** [0.101] | 0.475*** [0.099] | 0.490*** [0.098] | 0.473*** [0.090] |
| 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 | 62,106 | 62,106 | 62,106 | 62,106 |

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

Robust to ownership controls

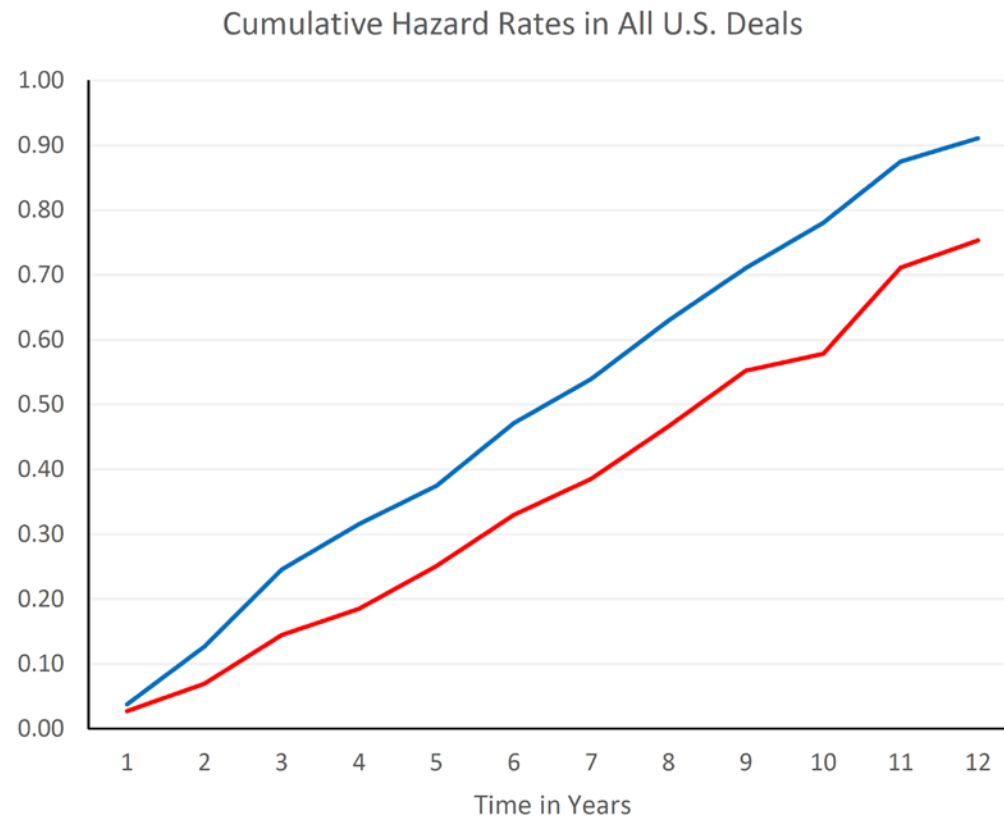
- Number of investors
- Total ownership stake or own investment stake

Other robustness tests

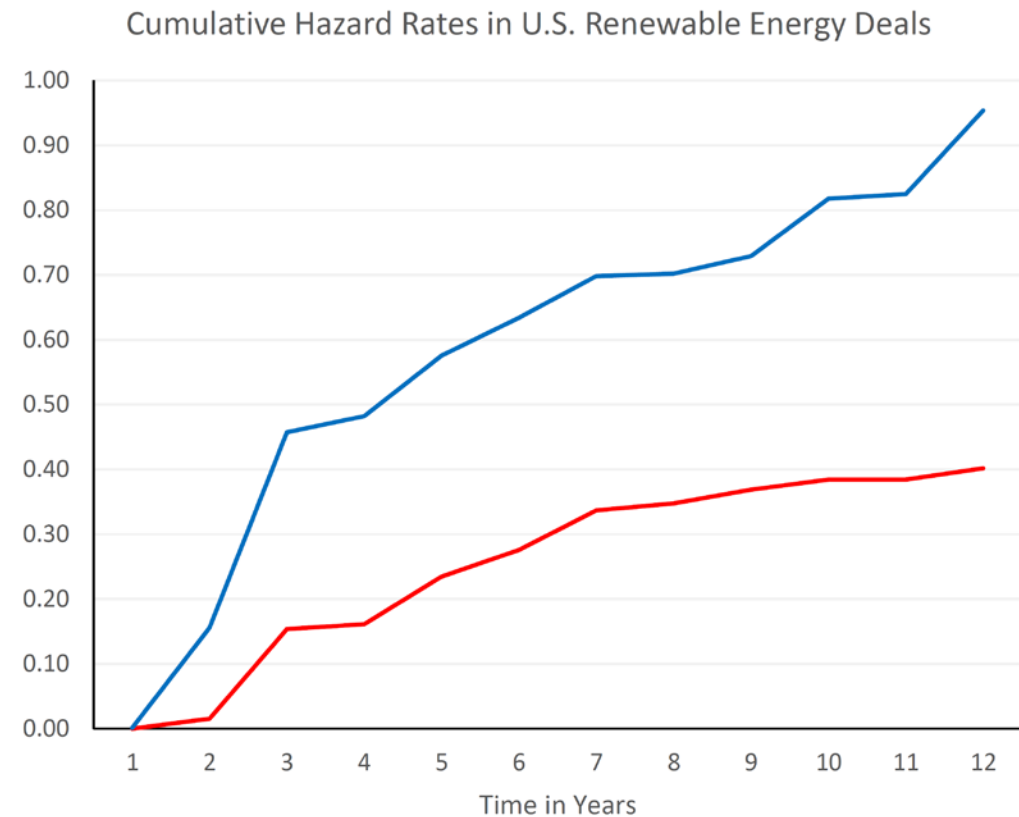
- Cluster standard errors by asset
- Examine only deals of closed funds

U.S. Investors Subsample: Exit Rates by Industry

- U.S. public investors have lower exit rates within all domestic deals.
- The magnitude of the coefficients is relatively larger when U.S. public investors are exposed to domestic U.S. renewable energy.



— U.S. Public Investors — U.S. Private Investors



— U.S. Public Investors — U.S. Private Investors

The Implicit Subsidy from Public Investors to Infrastructure

Three estimates of annual subsidy:

I. Relative to other investors: Public investors have 1.3% lower net IRR, which means \$2.25 billion annual subsidy.

II. Relative to other comparable-risk opportunities: Public investors have a lower PME, so for each new (annual) \$17.9 billion committed, they lose \$2.86 million over the lifetime of the funds.

- PME of 0.925 relative to S&P500.
- PME of 0.840 relative to a value-weighted index of listed infrastructure funds.

III. Relative to own real estate and buyout investments: Public investors experience an annual loss of \$1.48 – \$8.45 billion.

- Investments made by the same investor and in the same vintage year.

| Panel A: Average Public Market Equivalent (PME) | | | |
|---|-------|------------|---------------------|
| Investor type | Obs. | S&P500 PME | VW Listed Infra PME |
| Public investors | 871 | 0.925 | 0.840 |
| Private investors | 1,129 | 0.935 | 0.851 |

| Panel B: Comparison of Infrastructure Funds with Buyout Funds | | | | | | |
|---|------|---------------|----------------|------|----------------|-----------------|
| Investor type | Obs. | Infra Net IRR | Buyout Net IRR | Obs. | Infra Multiple | Buyout Multiple |
| Public investors | 655 | 10.074 | 14.954 | 893 | 1.281 | 1.459 |
| Private investors | 698 | 10.783 | 13.888 | 818 | 1.380 | 1.560 |

| Panel C: Comparison of Infrastructure Funds with VC Funds | | | | | | |
|---|------|---------------|------------|------|----------------|-------------|
| Investor type | Obs. | Infra Net IRR | VC Net IRR | Obs. | Infra Multiple | VC Multiple |
| Public investors | 408 | 9.642 | 13.950 | 578 | 1.270 | 1.682 |
| Private investors | 390 | 10.976 | 12.494 | 471 | 1.394 | 1.533 |

| Panel D: Comparison of Infrastructure Funds with Real Estate Funds | | | | | | |
|--|------|---------------|------------|------|----------------|-------------|
| Investor type | Obs. | Infra Net IRR | RE Net IRR | Obs. | Infra Multiple | RE Multiple |
| Public investors | 477 | 10.292 | 11.146 | 618 | 1.270 | 1.269 |
| Private investors | 519 | 10.662 | 9.812 | 585 | 1.382 | 1.322 |

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.
- 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: \$2.25 billion per year.
- Relative to listed infrastructure funds: \$2.86 billion per year (PME).
- Relative to own RE and buyout funds from same vintage year: from \$1.48 to \$8.45 billion per year.

Explanations of the underperformance of public investors?

- Does not seem to be driven by differences in risk-taking and investment approach
- Lower skill in the selection of funds or only having access to worse-performing funds
- Willingness to take on more marginal investments in order to meet higher allocation or impact target