The Subsidy to Infrastructure as an Asset Class*

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Abstract

We investigate the characteristics of infrastructure as an asset class from an investment perspective of a limited partner. While non U.S. institutional investors gain exposure to infrastructure assets through a mix of direct investments and private fund vehicles, U.S. investors predominantly invest in infrastructure through private funds. We find that the stream of cash flows delivered by private infrastructure funds to institutional investors is very similar to that delivered by other types of private equity, as reflected by the frequency and amounts of net cash flows. U.S. public pension funds perform worse than other institutional investors in their infrastructure fund investments, although they are exposed to underlying deals with very similar project stage, concession terms, ownership structure, industry, and geographical location. By selecting funds that invest in projects with poor financial performance, U.S. public pension funds have created an implicit subsidy to infrastructure as an asset class, which we estimate within the range of $730 million to $3.16 billion per year depending on the benchmark.

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I. Introduction

An adequate supply of infrastructure is an essential ingredient for competitiveness and long run potential growth in any economy (Fernald, 1999; Roller and Waverman, 2001; Esfahani and Ramírez, 2003; Donaldson, 2018). The public and private stock of infrastructure plays a critical role in enhancing the productivity of people and firms by lowering the costs of combining different productive inputs, accessing markets, and increasing mobility and competition. International organizations such as the OECD and World Bank have called attention to an acute need for new or modernized infrastructure and pointed to a disparity between this need and the current level of infrastructure investment.[1] This globally increasing gap between the demand for infrastructure investment and the provision of resources has led to calls for greater recourse to private capital in the infrastructure sector.

Institutional investors, such as pension funds, insurance companies and sovereign wealth funds, are becoming increasingly active alongside governments in the provision of capital to infrastructure funds and projects. The financial industry presents infrastructure as a new alternative asset class – in contrast to standard assets such as equities and bonds and established alternative assets such as buyout, venture capital and real estate – which would deliver new sources of stable return and better diversification of risk.[2] In the last two decades, public and private investors have expressed growing interest in real assets that were perceived as more transparent and stable than complex products presented to them, with a more direct connection to underlying value. Further, infrastructure investments may offer a wide range of social and political benefits in their respective regions (Castells and Solé-Ollé, 2005; Cadot, Röller and Stephan, 2006).

The stated value proposition of infrastructure as an investment is generally that it has attractive financial attributes such as strong returns, a low sensitivity to swings in the business cycle, little correlation with equity markets, long-term stable and predictable cash flows, inflation hedging properties, and low default rates. Based on their economic and financial characteristics,

[1] According to estimates of the Infrastructure 2030 OECD study, the need for infrastructure investments amounts to $60 trillion by 2030, or 3.5% annually of global GDP. The World Bank's Global Infrastructure Outlook forecasts a global infrastructure investment need of $94 trillion by 2040, and a $15 trillion gap between that need and projected infrastructure investment under current trends.

[2] For example, according to 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 total 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 environmental, social, and governance (ESG) principles."

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). Infrastructure has thus been marketed as a useful alternative asset for public pension funds.[3]

Public pension investors also share this view. For example, according to the California Public Employees' Retirement System (CalPERS) website as of August 2018: "Infrastructure targets stable, defensive investments within the water, energy, waste, transportation, technology, and communications sectors."[4] But do the infrastructure investments that public pension funds and other institutional investors make live up to this promise? One challenge to answering this question has been the difficulty of assembling data series of unlisted infrastructure investments that include data on fund cash flows and fundamental risk properties of the underlying assets in these funds.

In this paper, we study the risk and return characteristics of infrastructure investments in a sample covering 640 institutional investors, who each invest on average in five infrastructure funds over the period of 1991–2016. Through these fund placements and direct investments in infrastructure assets, each institutional investor gains exposure to an average of 65 underlying infrastructure deals, whose properties we directly observe. The majority of investments in our sample are made through closed private infrastructure funds that have a private equity type structure.[5]

We find that closed infrastructure funds, the primary vehicle used by U.S. institutional investors, deliver very similar payout profiles to traditional buyout private equity funds. Specifically, we find a similar frequency of capital calls and distributions over time, as well as similar amounts. Infrastructure funds do not provide more stable cash flows to institutional investors than private equity funds. As is the case with buyout and venture funds, closed infrastructure funds also have a finite life of approximately 10–12 years and must sell assets in

[3] According to Deutsche Bank Asset Management (2017), "The cash flows of infrastructure assets with inherently long lives and strong intrinsic value, can provide a good match for the long-term liabilities of certain investors, such as pension funds for example."

[4] Appendix 1 contains similar statements made by other U.S. public pension funds.

[5] U.S. investors in particular predominantly invest in infrastructure through closed infrastructure funds, while non U.S. institutional investors gain exposure to infrastructure assets through a mix of direct investments and fund vehicles. For example, only 3 out of 98 U.S. public pension funds in our sample make direct investments, while 33 out of 100 non U.S. public pension funds in our sample have direct investments. In total, the 3 U.S. public pension funds hold 13 direct deals, while the 33 non U.S. public pension funds hold 248 direct deals.

order to be fully liquidated over this horizon. Overall, we find no economic or statistical difference between the payouts offered by infrastructure and traditional buyout funds.

We also find substantial heterogeneity in performance by the type of institutional investor. Specifically, U.S. public pension funds display worse performance on a number of measures. First, the *deals* to which U.S. public pension funds have exposure have substantially worse exit rates, and we show that this is correlated with worse fund performance. The underlying deal data allow us to demonstrate that this underperformance is not due to differences in deal type, as the differences in exit rates persists even when controlling for deal characteristics such as project stage (greenfield, brownfield, secondary), the region, the existence of a concession agreement with a government, and the industry of the investment (e.g., renewable energy, traditional energy, social, ICT, transport, and utilities sectors). Second, the *funds* that U.S. public pension funds invest in substantially underperform on a net internal rate of return (IRR), multiple of invested capital, and public market equivalent (PME) basis, even when controlling for the percentage of deals in the funds that are in each specific region and industry.

One potential hypothesis that could explain these findings would be that U.S. public pension fund infrastructure investments are less risky than those of other institutional investors. However, we find no evidence of this. The ability to measure deal characteristics allows us in both the deal-level and fund-level analysis to control for factors that capture the riskiness of the underlying assets. Furthermore, when we examine the cash flows of closed funds, we find that the frequency of distributions is equivalent for U.S. public pension funds and other types of institutional investors, with the underperformance reflected in a lower public market equivalent of public pension fund investments. U.S. public pension funds therefore either have access to worse funds than other institutional investors but nonetheless choose to invest in the asset class, or they select worse-performing funds.

By selecting funds that invest in projects with poor financial performance, U.S. public pension funds have created an implicit subsidy to infrastructure as an asset class. Specifically, lower performance of infrastructure investments leads to a lower funding status of promised benefits. Either taxpayers will have to remedy the underfunding through increased contributions, or pension plan members will receive reduced pension benefits. Therefore either taxpayers or pension plan members are subsidizing infrastructure investments through lower returns.

We estimate this subsidy in three ways. First, we consider the estimated net IRR performance of U.S. public pension funds relative to other institutional investors, and assume this performance differential is stable over the approximately $56 billion of U.S. public pension exposure to infrastructure assets. This first calculation requires an assumption that IRR equals the effective rate of return.[6] It implies an annual subsidy of $730 million per year. Second, we consider the PME of infrastructure funds relative to a listed infrastructure index, treating listed infrastructure as the alternative asset that pension funds could have invested in. Estimates here imply a 17% underperformance over the life of the fund. Given that the annual net flows of public pension funds into infrastructure assets amount to $5 billion, the U.S. public pension funds lose $850 million over the lifetime of the fund relative to what they could achieve by investing in an infrastructure index. Third, we consider how infrastructure fund investments performed relative to the general private equity buyout and venture capital investments by the same investors. Relative to these alternatives we observe an even more substantial underperformance and calculate an implicit annual loss relative to buyout funds of as much as $3.16 billion per year. Given the similarity in cash flow profiles that we document, this performance differential is unlikely to be attributable to differential risk.

Our paper contributes to several literatures. First, we contribute to the literature on alternative asset classes that focuses primarily on institutional investors' performance in private equity and real estate assets (see Kaplan and Sensoy (2015) for a recent survey). We extend this work by studying infrastructure, which is a fast-growing asset class, and we describe the underlying assets as well as its performance. Prior research on infrastructure finance has focused primarily on Australian funds and assets.[7] We provide a global overview that covers a longer time period and multiple investment approaches, and we measure differences in underlying assets, contractual terms under which the assets are operated, and the contribution of these assets to fund performance.

[6] IRR equals the effective rate of return if and only if dividends generated by the investment are reinvested at the IRR rate. See Phalippou (2008) and Kaplan and Sensoy (2015) for a further discussion.

[7] Peng and Newell (2007) were the first to analyze infrastructure investments, using data on listed infrastructure companies, listed funds and closed funds from Australia. They find that for listed infrastructure the average return was 22.4% with a volatility of 16%, which compared to a 14.1% return with a 5.8% volatility for unlisted infrastructure. Focusing also on Australia, but analyzing a longer time period that includes the financial crisis of 2008/09, Newell, Peng and de Francesco (2011) and Finkenzeller, Dechant and Shepherd (2010) report a lower performance.

Second, our paper contributes to the literature on the performance and incentives of public institutional investors. Previous research suggests that public pension funds (Hochberg and Rauh, 2013; Bradley, Pantzalis and Yuan 2016; Andonov, Hochberg and Rauh, 2018) and sovereign wealth funds (Bernstein, Lerner and Schoar, 2013; Bortolotti, Fotak and Megginson, 2015) do not always pursue pure value maximization. Infrastructure is an asset class over which government policy has a large influence. Our finding that public pension funds achieve lower performance suggests that they are susceptible to pressure to subsidize the public sector. That is, at least in asset classes closely linked to government policies, it seems that public pension funds are not pursuing strategies whose goals are pure value maximization.

Third, we add to the literature on the drivers of differences in performance across types of institutional investors. Lerner, Schoar and Wongsunwai (2007) find that endowments invest in private equity funds that deliver greater performance, but Sensoy, Wang and Weisbach (2014) show that the outperformance of endowments disappears over time as the private equity industry matured and the persistence in performance declined. Our result that endowments and foundations select infrastructure funds that deliver higher returns, while public pension funds underperform, shows that university endowments still are better equipped to identify, access, and invest in the relatively stronger opportunities in young, growing asset classes.

The remainder of this paper is organized as follows. Section II describes the data and our sample. Section III compares the cash flows delivered by infrastructure funds with the cash flows delivered by private equity buyout and venture capital funds. Section IV provides results on institutional investors' performance in infrastructure. Section V examines exit patterns within infrastructure deal types. Section VI measures the implicit subsidy to infrastructure as an asset class. Section VII concludes.

II. Data

There are numerous reasons why data in the field of infrastructure investing poses challenges for researchers. First and foremost, it is the lack of transparency that is typical of unlisted investments due to their proprietary nature. The practical result of this is that the characteristics and performance of such assets are often not publicly disclosed. Second, owing to both the usual annual reporting of unlisted investment vehicles plus the overall, still relatively

short, history of infrastructure investments, only recently has the asset class generated a body of data that is large enough to conduct substantive multivariate analysis.

In this paper, we focus on equity positions of institutional investors in infrastructure assets.[8] We obtain data on infrastructure investments from Preqin. Figure 1 depicts the investment approaches through which investors can gain equity exposure to infrastructure projects. Investors can invest in infrastructure assets directly or through different types of funds run by professional managers, referred to as general partners (GPs). Few investors decide to invest directly in assets as it requires a greater financial commitment to a single asset, as well as specialized human capital to select, manage, and monitor these assets. Our sample covers 38,676 investor-deal observations and only 1,096 observations are direct investments.

When investing through infrastructure funds, institutional investors can select between three fund types: closed, listed, and open-ended funds. The vast majority of institutional investors gain exposure to infrastructure assets through closed funds. Closed funds are organized in a similar way as buyout and venture capital. These funds are raised for a specified period (typically 10 to 12 years, with possible short extensions) and are governed by partnership agreements between the investors and the fund's principals. Investments are made by the limited partners (LPs) at the start of the fund's life, often referred to as the vintage year. Closed funds account for 29,068 investor-deal observations.

The remaining observations are split between listed and open-ended funds. Listed infrastructure funds have publicly traded shares. Institutional investors can gain exposure to their underlying assets by buying shares of listed funds instead of signing a separate partnership agreement. Open-ended (evergreen) funds are not publicly traded, but they also offer more liquidity to the investors through periodic subscriptions and redemptions. Importantly, unlike closed funds, both listed and open-ended funds do not have a clear termination date and may be better designed to provide long-term exposure to infrastructure assets. Closed funds are expected to focus more on exiting positions in assets as they need to distribute cash back to the LPs.

Investors can also access infrastructure projects through funds-of-funds. In Preqin, we do not observe the portfolio of funds selected by funds-of-funds and we cannot link the investor to the underlying infrastructure assets. Therefore, we exclude pure funds-of-funds from the analysis

[8] We do not analyze institutional investors acting as debt providers in infrastructure projects.

but we keep in the sample a small number of funds-of-funds that have some direct exposure to infrastructure assets in addition to the portfolio of fund investments.

Infrastructure has emerged as an asset class in the last decade and it has experienced a steady increase in the flow of funds. To show this increasing trend, we rely on the reported unrealized value of assets when estimating the value of assets under management by closed infrastructure funds. Specifically, we download the time-series of annual performance snapshots for the time period 2008–2017 from Preqin and use the ratio of residual value to paid-in capital to estimate the time-series of assets under management. We transform the ratio of residual value to paid-in capital to dollar amounts using the percentage of capital called and fund size.

Figure 2 shows the unrealized value of assets managed by closed infrastructure funds over time. We estimate that over the past ten years, the amount of assets under management by infrastructure funds with performance reported in Preqin increased from $23 to $222 billion. On the one hand, this estimate could overstate the asset under management if infrastructure funds overestimate the value of their unrealized assets (Phalippou and Gottschalg, 2009). On the other hand, this estimate significantly understates the assets under management because it considers only the assets managed by infrastructure funds that report performance in the Preqin database. For example, in 2017, we have performance statistics of 270 closed funds, while in the period 2006–2017 there are 870 closed (but not yet liquidated) funds in the Preqin database.

We attempt to remedy this by making additional imputations in the upper bars of Figure 2. Specifically, we assume that every fund that does not report performance holds 25% of the average assets of reporting funds from the same vintage, yielding $145 billion in unrealized value in non-reporting funds and a total of $367 billion in total unrealized value across all funds. Note that this total does not include the assets held by listed and open-ended funds, nor does it include the infrastructure assets held directly by institutional investors.

The increasing trend in infrastructure assets under management presented in Figure 2 is likely to continue in the coming years as many investors are targeting higher allocation weights to infrastructure than their current actual asset allocation. For example, in 2017, the Employees Retirement System of Texas (2017) reported in their annual report a target allocation of 4%, compared to an actual allocation of 1.7%, while the Maine Public Employees Retirement System (2017) reported in the annual report a target allocation of 10%, compared to an actual allocation of 7.2%.

We collect the investments made by six types of institutional investors. Three types of investors belong to the public sector: public pension funds, government agencies, and sovereign wealth funds.[9] The other three types of investors come from the private sector: private pension funds, insurance firms and banks, and university endowments and foundations. Table 1 presents summary statistics by institutional investor. Our sample contains 640 institutional investors from 38 countries, plus several international financial institutions which are classified as international instead of being assigned to one country. In Panel A we present summary statistics for all institutional investors, while in Panel B we limit attention to U.S. institutional investors only, which account for 40% of our sample. These investors make commitments to 425 unique funds (368 closed, 27 listed, and 30 open-ended funds) managed by 206 unique GPs. Directly and through funds, they gain exposure to 3,687 unique infrastructure assets. There can be multiple deals (transactions) in one asset during the sample period. We observe 3,081 investor-fund observations and 1,096 direct investments in infrastructure assets. Since an infrastructure fund invests in multiple assets, our sample contains 38,676 investor-deal observations.

The largest groups of institutional investors are public and private pension funds, with a share of 33.94% and 29.87% of the investor-deal observations respectively. Government agencies and sovereign wealth funds account for 4.00% and 1.91% of our sample. Insurance firms and banks represent 24.52% of the sample, and endowments and foundations represent the remaining 5.77%. Panel A shows that the institutional investors in our sample have an average of $61.55 billion in assets under management (AUM), and invest on average in 4.69 funds and 1.71 direct deals. Through the funds and direct investments, institutional investors gain exposure to an average of 60.43 deals. We observe substantial cross-sectional variation in investor size. Sovereign wealth funds are the largest institutional investors, while endowments and foundations are the smallest. Figure 3 presents the investment approach by investor type. All institutions invest primarily through closed infrastructure funds. Sovereign wealth funds and government agencies are more likely to invest directly in infrastructure assets. There is no large cross-sectional dispersion in the investment approach choices of the other types of institutional investors. Public pension funds gain

[9] We classify also development banks as government agencies. Our sample of government agencies includes investments made by the International Finance Corporation (IFC), European Investment Bank (EIB), African Development Bank, U.S. Overseas Private Investment Corporation, and U.K. CDC Group, among others.

exposure to assets in a similar way as private pension funds, insurance firms, banks, endowments and foundations.

Infrastructure deals can be classified into three categories based on the project stage: greenfield, brownfield, and secondary stage. The greenfield stage designation refers to physical assets that do not exist and need to be constructed. Investors finance the building of the asset as well as the maintenance after it is designed, built, and became operational. The brownfield stage designation provides exposure to assets that require improvements, repairs or expansion. These assets are usually partially operational and may already be generating income. Secondary stage assets provide exposure to fully operational assets that require no further investment for development. The key difference lies in the maturity of the asset and the available asset-specific experience, which is substantially less in the case of greenfield and brownfield investments. This difference might lead to a significantly higher degree of uncertainty and risk in greenfield and brownfield compared to secondary stage projects. Indeed, compared to investments in secondary projects, investments in greenfield and brownfield projects do not generally distribute profit in the first years but instead require capital commitments, which results in a so-called J-curve effect. In our sample, around 63.8% of the investor-deal observations provide exposure to secondary deals. Greenfield projects account for 22.5% of the deals and brownfield projects account for 13.8% of the deals. The exposure to different projects does not differ across the larger types of institutional investors. The only exception is government agencies which are more likely to invest in greenfield and brownfield projects.

We next present summary statistics on the contractual agreements of the deal. The concession variable is an indicator for whether a deal involves either a concession or a privatization agreement with the government or other public entity. In the case of a concession, an investor enters into an agreement with the government to have the exclusive right to operate, maintain and invest in an infrastructure asset for a given number of years. We classify as a concession only a transaction in which the government is involved as a counterparty. We do not consider resale transactions when one investor exits and sells a position in a concession deal to another investor to be a concession deal, as the government is not directly involved in the transaction.[10] We find that on average 9.1% of the deals in an investor portfolio are backed by a concession agreement.

[10] Our results are robust to alternative concession definitions.

Table 1 also presents summary statistics on the ownership structure in deals. *#Investors* counts the average number of investors in the same deal. When constructing this variable, we count multiple LPs investing through the same infrastructure fund only once. Many infrastructure deals are relatively large transactions and, on average, 1.68 investors jointly execute a deal. *Investment Stake* measures the average investment stake of the infrastructure fund through which the LPs accessed the deal. *Total Stake* is the average stake of all investors in the deal. Investors on average obtain 57.8% ownership in the underlying asset and all investors jointly have 73.9% ownership in the underlying asset.

Figure 4 presents the distribution of deals by industry for each investor type. We classify the deals into seven industries. The largest industry is traditional energy and it includes investments in coal and nuclear power plants, natural resources pipelines, refineries, and natural resource storage facilities. Renewable energy captures investments in wind, solar, hydro, biomass, and geothermal power facilities. The transportation industry includes investments in toll roads, parking lots and service stations, tunnels, bridges, railroads and rolling stocks, airports and aircraft, sea ports, cargo shipping vessels, and logistics. Social infrastructure combines investments in hospitals, medical facilities, senior homes, student accommodation, education facilities, public buildings, prisons, defense accommodation, and police stations. The utilities industry includes investments in water treatment plants, water distribution, power distribution, sewage treatment plants, sewage networks, and waste management. The telecom industry covers investments in mobile phone, landline phone, wireless, internet, cable television, and satellite networks. The final category covers diversified infrastructure projects. Overall, the infrastructure asset class encompasses projects from different industries, highlighting the importance of controlling for industry type in our analysis.

Our sample includes infrastructure assets located in 124 countries. In our analysis, we account for differences in geographical location by classifying the assets into seven regions: Northern America (USA and Canada), Latin America and Caribbean, Western Europe, Eastern Europe, Asia, Africa, and Oceania. Panel A of Figure 5 shows the distribution of deals by region for each investor type. Around 88% of the exposure of public pension funds, private pension funds, insurance firms, banks, endowments and foundations is to deals in developed markets and 12% is to deals in emerging markets. Government agencies and sovereign wealth funds invest relatively more in infrastructure projects located in emerging markets. Panel B focuses on the subsample of

U.S. investors only. U.S. institutions allocate a similar proportion of their capital to assets in emerging markets, but within developed markets they invest relatively more in their home country. For instance, U.S. public pension funds invest 65.35% of their capital in assets located in Northern America, while for endowments and foundations this percentage increases to 83.29% of their investments.

We generate a *%Home deals* variable based on the location of the deal relative to the location of the institutional investor. Since the U.S. is a very large country in our sample with a geographically disperse network of institutional investors, we define the *%Home deals* variable for U.S. investors as deals located in the same state (not country) as the institutional investor. Panel B of Table 1 shows that institutional investors allocate around 25% of their capital to projects located in their home state or country under this definition.

III. Comparison of Infrastructure Funds with Buyout and VC Funds

Institutional investors often incorporate infrastructure as an alternative asset class in their portfolio, under the expectation that it will deliver steady cash flows in the long run and diversification benefits due to low correlation with other asset classes. Indeed, investors often describe infrastructure assets as a match for their long-term inflation-linked liabilities.[11] The asset management industry promotes infrastructure as a new asset class that will deliver stable cash flows with a low correlation with the business cycle (Deutsche Bank Asset Management, 2017; J.P. Morgan Asset Management, 2017). Furthermore, recent literature has recognized the importance of cash flow data for achieving a complete picture of the performance of vehicles with a private equity structure (Ang et al, 2018).

In Table 2 and Figure 6, we compare the cash flows delivered by closed infrastructure funds with the cash flows delivered by buyout and venture capital (VC) funds. We use cash flow data from Preqin for funds with a 2002 vintage or later and focus on the annual frequency of capital calls and distributions as well as on the annual amounts of these capital calls and distributions. If closed infrastructure funds deliver more stable cash flows, as argued by the finance industry and expected by investors, their payouts would be expected to have more stable frequency and amounts over the entire life of a fund. We standardize the cash flows over the life of a fund, so that time

[11] In Appendix 1, we quote several statements made by U.S. public pension funds that explain their expectations and motives for investing in infrastructure.

period *t=1* corresponds to the vintage year of the fund. We present the timeline of cash flows for the first 12 years of the fund life, as most closed funds are designed to exist for approximately 12 years and are fully divested by that time.

Table 2 and Figure 6 show that the payout profile provided by infrastructure funds does not differ from the payout profile provided by buyout funds. The only significant difference is in the frequency of capital calls as buyout funds draw on capital commitments more frequently. However, the amount of capital calls and the dollar amount of distributions over time provided by infrastructure funds is statistically and economically indistinguishable from the dollar amount of capital calls and the amount of distributions over time delivered by buyout funds. As compared to VC funds, infrastructure funds have a similar timeline of capital calls but more frequent and larger annual distributions.

Table 2 shows that the number of buyout and VC funds raised since 2002 is significantly greater than the number of infrastructure funds raised in the same time period. One potential worry is that infrastructure funds differ in their focus and size from the average buyout and VC funds. In Appendix Figure IA.1, we replicate the analysis from Figure 6, but instead of using the cash flows of the entire sample of buyout and VC funds with available cash flow data, we use only the cash flows of a matched subsample. We create this subsample by matching infrastructure funds with buyout and VC funds based on three criteria: vintage year, geographical focus (U.S., Europe and Rest-of-World), and fund size (closest match). The results with the matched subsample confirm that infrastructure and buyout funds have a similar profile of capital distributions over time. Moreover, in the matched subsample, we also observe that infrastructure and VC funds have a similar (statistically and economically) profile of capital calls and distributions.

In Table 2, we also present the public market equivalent (PME) performance measure. We use the returns on the S&P 500 stock market index to calculate the PMEs and find that infrastructure funds have performed similarly to the public market with an average PME of 0.987. The PMEs delivered by buyout and VC funds in the same time period are 1.048 and 0.974, respectively.

Overall, the typical structure of cash flows over time provided by infrastructure funds does not differ from the payout policy offered by more established alternative assets, like buyout and VC funds. Based on the payout profiles, we conclude that it will be difficult for closed

infrastructure funds to meet investor expectations for stable cash flows with diversification benefits.

IV. Performance Differences across Institutional Investors

In this section, we move the analysis from an asset class level to an investor level and study the investor experience in infrastructure, specifically the probability of exiting an infrastructure investment while controlling for the characteristics of the infrastructure asset. The fraction of exited investments has been used a proxy for performance in the private equity literature when analyzing the performance of buyout and venture capital funds (Hochberg, Ljungqvist and Lu, 2007; Sorensen, 2007; Phalippou and Gottschalg, 2009). Exiting a deal is an informative indicator of performance in our setting because the majority of infrastructure deals are made by closed funds organized in the same way as private equity funds. We also verify the positive link between deal exits and performance later in this section.

To examine performance differences across types of institutional investors, we estimate Cox proportional hazard models. The hazard event of interest is defined as a sale transaction that results in a full (not partial) exit of an equity position in an infrastructure asset during a year. We estimate the hazard rate of exiting an asset, defined as the probability that an exit will come to fruition in year *t* conditional on it not becoming complete prior to year *t*. In this setting, *t* refers to the number of years after the purchase transaction and it measures event time rather than calendar time. Estimation of the model delivers coefficients that can be interpreted as hazard ratios. A hazard ratio lower than one indicates that as the value of the covariate increases, the hazard rate of exiting a deal decreases.

In Table 3, observations are at the investor-deal level. As explanatory variables, we use indicators for institutional investors from the public sector: U.S. public pension funds, non U.S. public pension funds, government agencies, and sovereign wealth funds. The omitted category is investors from the private sector. We control for the natural logarithm of the LP's AUM and for the year of their first infrastructure investment. These two variables could capture negotiating power, experience, or ability to access higher-performing GPs for reasons unrelated to investor type. *#Funds* measures the total number of investments in infrastructure funds by investor. *Direct deal* is an indicator variable for direct investments in infrastructure deals. In each model we include LP country, deal industry, and deal region fixed effects. We cluster standard errors by investor

(Columns (1) to (6)), fund (Column (7)), or asset (Column (8)). In the Cox proportional hazard model the coefficient estimates are robust to any baseline hazard function, which implies that the specification is robust to any time-specific common factors, equivalent to controlling for year fixed effects (Dinc and Gupta, 2011).

Our results show that U.S. public pension funds have a lower probability (based on the hazard ratio) of exiting an infrastructure deal. As shown in Column (3) – which includes fixed effects at the level of the deal region as well as deal industry and LP country – U.S. public pension funds have a 20.8% lower probability of exiting an infrastructure deal as compared to institutional investors from the private sector. Non U.S. public pension funds also seem to have lower exit rates compared to private sector institutional investors, although the effect is not consistently statistically significant. Government agencies and sovereign wealth funds do not exhibit different exit rates.

We analyze exit rates as a proxy for performance, but the infrastructure asset class includes heterogeneous projects. Recognizing that the differences in exit rates could potentially be due to differences in the selection of projects, we take several approaches. First, we control for project industry and geographical location through the inclusion of fixed effects. Second, we include an indicator control variable for *direct deals*, which offer more flexibility in the exit decisions. When investing through funds, institutional investors generally do not have the power to influence the timing of exit decisions, whereas when they invest directly they can make such decisions. We observe that direct deals in infrastructure have economically significantly longer holding periods and around 30% lower exit rates, as institutional investors who devote substantial financial and human capital to direct investing are willing to make long-term commitments.

Third, in Column (4), we add controls for concession agreement, project stage, and location of the deal in the same country (state) as the LP. As expected, the coefficients on the greenfield and brownfield variables are below one, indicating that these (riskier) projects require a longer time for development before they can be sold to other parties. Secondary deals that are fully operational are more liquid and transact faster. Deals backed by a concession agreement exhibit a higher probability of exit. This implies that a concession agreement has the potential to reduce risk and increases the liquidity of a deal. Institutional investors also see lower exit rates for deals located in their country.

Fourth, in Columns (5) and (6), we add controls for the total number of investors in the same deal and the ownership position. The investment stake and total stake differ if there are multiple investors in the same transaction. We observe a lower probability of exiting a deal when multiple investors are involved and when the investor obtains a higher ownership stake.

In Columns (7) and (8), we show that our results are robust to clustering standard errors in two alternative ways. First, we cluster the standard errors by infrastructure fund. This estimation automatically excludes direct deals as there is no fund involved as an intermediary. Second, we cluster the standard errors by infrastructure asset. These robustness tests account for the fact that multiple institutional investors can invest in the same fund or in the same asset.

In the Internet Appendix, we estimate two robustness tests of our results. First, in Internet Appendix Table IA.1, we include an indicator variable for all other institutional investors except public pension funds. We find that all other institutional investors have hazard ratios above one, but particularly private sector pension funds, endowments and foundations display a higher probability of exiting deals. Based on Column (6), endowments and foundations have around a 60.2% higher probability of exiting an infrastructure deal in year *t,* if they have not been exited it previously, than public pension funds. Second, in Internet Appendix Table IA.2, we focus on the subsample of investor-deal observations accessed through closed funds, because closed funds have an ending term and stronger incentive to exit a deal faster. We exclude deals accessed directly or through listed and open-ended funds as these investment approaches do not have a clear ending term and have more flexibility in the exit decisions. The results in Internet Appendix Table IA.2 are similar to the results in Table 3: U.S. public pension funds (and to some extent non U.S. public pension funds) have a significantly lower probability of exiting deals.

Overall, we document that public pension funds display lower exit rates relative to other institutional investors even after controlling for deal characteristics. While differences in allocation to specific deal types could be driven by variation in objectives, beliefs or preferences about the properties of different deals, the fact that the coefficients on U.S. and non U.S. public pension funds remain unchanged after controlling for deal type (industry, location, stage, concession, and ownership stake) suggests that the differences in exit rates between institutional investors do in fact proxy for differences in performance.

In Table 4 we test directly whether exit rates are indeed related to performance, as they could in theory also capture differences in investment horizon or other preferences. We analyze

three performance measures: (i) the probability of reporting any performance statistics in Preqin; (ii) the net IRR; and (iii) the net multiple of invested capital. The analysis is on a fund level. We limit attention to closed funds, as Preqin collects performance data only for these funds and they have clear objectives to exit deals faster. The other investment approaches (listed funds, open-ended funds, and direct deals) do not have a predefined ending term and thus do not face an incentive to exit deals quickly.

Columns (1) and (2) present the results of logit regressions and the dependent variable equals one if a closed infrastructure fund reports either the net IRR or multiple of invested capital in the Preqin database. Infrastructure is a relatively new asset class and many funds still do not report any return measures. However, this argument is reasonable for funds started in recent years, but not for funds that have existed for a longer time period. Therefore, in Table 4, we control for vintage year of the fund as well as the percentage allocated to projects in difference industries and geographical regions. The vintage year indicators are designed to control for a truncated distribution of deal exits. In Column (1), we find that a 10 percentage point increase in the percentage of exited deals is associated with a 2.79 percentage point higher probability of reporting performance. We also observe that larger funds are more likely to report performance.

In Columns (3) and (5), we find more direct evidence that exiting a deal proxies for better performance. Based on Column (3), a 10 percentage point increase in the percentage of exited deals is associated with a 1.82 percentage point higher net IRR. Based on Column (5), a 10 percentage point increase in the percentage of exited deals is associated with an increase in the multiple of invested capital by around 0.06.

Within infrastructure, the percentage of exited deals proxies well for performance because many funds were raised recently and are still not fully liquidated. If there are many liquidated funds, the percentage of exited deals will be a weaker proxy of performance because liquidated funds by definition have already exited all their investments. Therefore, in Columns (4) and (6), we split the percentage of exited deals based on the holding period. We examine separately the relation between performance and the percentage of exited deals in the first five years after the transaction date, in five to ten years after the transaction, and in more than ten years after the transaction date. We find that the positive relation between performance and exit rates is driven by relatively quick exits within the first five years after the investment date. Investments held for a period of longer than 10 years seem to be negatively related to performance, even after controlling

for the share of fund investments in different deal regions and deal industries. This result further confirms that for closed infrastructure funds, a quick exit might well be the objective when making investment decisions and that exit rates are a valid proxy for analyzing the performance of different institutional investors in this asset class.

In Table 5, we extend the analysis by examining the performance on an investor-fund level. The advantage compared to Table 3 is that we can directly include return measures, like net IRR and multiple of invested capital, as dependent variables. The disadvantage compared to Table 3 is that we can analyze only the performance of investments through closed funds, but not to listed funds, open-ended funds, and direct deals. We include two additional control variables for fund type. *FOF* is an indicator variable equal to one for infrastructure funds labeled primarily as funds-of-funds but still holding few deals directly. The negative coefficient is consistent with prior literature on funds-of-funds.[12] *Debt fund* is an indicator variable that captures infrastructure funds investing in both debt and equity securities related to infrastructure. The negative performance coefficient could be explained if such funds previously held an underperforming loan and were forced to restructure it in an equity stake. The best-performing debt funds will likely not have any direct equity stakes and will not be in our sample.

The results in Table 5 confirm that public pension funds exhibit lower performance. U.S. public pension funds invest in infrastructure funds that have 7.10 percentage points lower exit rates, 1.32 percentage points lower net IRR, and 0.058 lower multiple of invested capital. Non U.S. public funds also seem to underperform compared to other institutional investors, although the coefficients are significant only when using the multiple of invested capital as a performance measure. That said, the coefficients in Columns (4) to (9) could underestimate the underperformance of U.S. public pension funds if there is selection bias in the availability of performance data. In particular, U.S. public pension funds hold more infrastructure funds with lower exit rates and these funds deliver on average lower returns and are less likely to report

[12] In private equity, Andonov, Hochberg and Rauh (2018) and Harris, Jenkinson, Kaplan and Stucke (2018) document that fund-of-funds deliver lower returns than other fund types. In hedge funds, Brown, Goetzmann and Liang (2004) and Ang, Rhodes-Kropf and Zhao (2008) find that funds-of-funds underperform individual hedge funds. The underperformance by funds-of-funds primarily arises from the extra layer of fees (French, 2008). However, the performance of funds-of-funds from an investor perspective needs to be compared to individual funds that the investors would have been able to select and access if not investing through fund-of-funds (Ang, Rhodes-Kropf and Zhao, 2008; Harris, Jenkinson, Kaplan and Stucke, 2018).

performance in Preqin. Table 4 shows that the performance measures are more likely to be missing for funds with lower exit rates.

Overall, our results indicate that U.S. public pension funds hold infrastructure deals longer, and that their lower exit rates proxy for lower performance. There are four potential explanations for the underperformance of U.S. public pension funds.

First, the differences in exit rates and performance could be due to differences in preferences for gaining long-term exposure to infrastructure assets. However, as shown in Figure 3, U.S. public pension funds are equally likely to invest through closed funds, i.e., the investment approach with the strongest incentive to exit deals faster, and are no more likely to invest directly or through listed and open-ended funds, which offer more flexibility to hold deals longer. The underperformance of public pension funds also does not seem to be due to preferences for different projects, as controlling for detailed deal characteristics does not attenuate the coefficient of their underperformance. Thus, we observe limited support for the explanation based on different preferences.

Second, U.S. public pension funds could gain exposure to less risky infrastructure investments than other institutional investors and these safer assets will deliver lower returns. We test for this hypothesis in two ways. First, we use deal characteristics, like project stage, location, and concession agreement, as proxies for factors that capture the riskiness of the underlying assets. Second, in Table 6, we examine the cash flows delivered by closed funds to their investors. If public pension funds are exposed to less risky assets, then they should receive steadier cash flows over time from these assets. We find that the frequency of distributions is equivalent for public pension funds and other types of institutional investors. However, U.S. public pension funds receive more frequent capital calls. In line with the previous performance results, U.S. public pension funds earn a lower PME of around 3.8% from their infrastructure funds. The lower PME shows that the similar frequency of distributions over time is not compensated by higher distribution amounts. Therefore, we do not find support for the lower-risk hypothesis.

Third, U.S. public pension funds frequently state that they expect stable long-term cash flows, while our results suggest that their infrastructure fund managers look for capital appreciation and sales during the limited life of the fund. However, this misalignment of objectives is unlikely to explain lower performance, as U.S. public pension funds are making the decision to

invest in closed infrastructure funds with limited life even though they are familiar with this business model based on extensive prior experience with buyout and VC funds.

Finally, the underperformance of U.S. public pension funds could be due to lower skill in the selection of infrastructure funds, or continued investment in infrastructure despite perhaps only having access to worse-performing funds. U.S. public pension funds may also have different objectives, such as finding back-door ways to increase allocation to alternative assets in order to maintain high expected returns on their plan assets. If some pension funds have a higher target allocation to infrastructure, and if the universe of good investments available to them is limited, those with higher target allocations may take on more marginal investments in order to meet the target.

Our results seem to be in line with the last of these interpretations – that public pension funds either have lower skill in manager selection or worse access to funds, but continue to invest in the asset class in order to justify increased exposure to private markets more generally. The performance differences in infrastructure across types of institutional investors are similar to the literature on performance of institutional investors in private equity. The evidence that endowment funds perform better in infrastructure at present, when this asset class is still in a growth stage, is in line with the evidence that endowments performed better than other investors in private equity investments in the 1990s, before the private equity industry matured (Lerner, Schoar and Wongsunwai, 2007; Sensoy, Wang and Weisbach, 2014). Our results suggest that university endowments still possess an information advantage and are able to identify and access well-performing managers in young asset classes.

V. Exit Rates and Deal Characteristics

In this section, we extend the performance analysis by examining deal exit patterns within deal types. We limit our attention to the subsample of U.S. institutional investors as they represent the largest group in our sample and most of the variation in performance comes from U.S. public pension funds. Table 7 presents results of a survival analysis using Cox proportional hazard model. The event of interest is again the decision to exit a deal in year *t* conditional on not exiting the deal prior to year *t*. We start with the entire sample of all deals to which U.S. investors are exposed, and afterwards we focus on smaller subsamples based on industry, location, project stage, and concession. Public pension funds are the dominant group of investors from the U.S. public sector.

There are three U.S. state investment funds (sovereign wealth funds) investing in infrastructure: Alaska Permanent Fund Corporation, New Mexico State Investment Council, and North Dakota Legacy Fund. We include an indicator for these state investment funds, but we are cautious in our interpretation as the sample is small.[13]

The results in Column (1) confirm that U.S. public pension funds have a 32.4% lower probability of exiting an infrastructure deal as compared to U.S. institutional investors from the private sector. The three U.S. sovereign wealth funds also display significantly lower exit rates.

In Columns (2) to (4), we analyze the exit rates within the three largest industries based on the number of deals: traditional energy, renewable energy, and transportation.[14] The other industrial categories are too small for a separate analysis. We find that U.S. public pension funds have lower exit rates within all three industries. However, the magnitude of the coefficients is relatively larger within renewable energy and transportation industries. U.S. public pension funds have around a 44.8% lower probability of exiting a renewable energy deal, and a 40.5% lower probability to exit a transportation deal.

In Columns (5) and (6), we split the deals based on location into home (U.S.) deals and international deals. U.S. public pension funds have lower exit rates on their portfolio of both domestic and international deals. The economic magnitude seems to be larger for domestic deals.

In Columns (7) and (8), we split the sample based on project stage. We combine greenfield and brownfield deals as both of them provide exposure to assets that are not fully operational and require significant investments. We observe that U.S. public pension funds have lower exit rates for both greenfield/brownfield and secondary deals. Therefore, their underperformance does not arise from exposure to deals associated with differential risk. In Columns (9) and (10), we split the sample based on whether the deal is backed by a concession agreement as additional measure of the riskiness of the project. The sample of concession deals in the portfolio of U.S. investors is small and covers only 488 investor-deal observations. We find that U.S. public pension funds have lower exit rates for both deals with and without a concession agreement.

[13] There is also one U.S. government agency, Overseas Private Investment Corporation, acting as an infrastructure investor but we do not include a separate indicator for this single investor.

[14] When examining deals within traditional and renewable energy, we cannot control for a concession indicator because there are almost no concessions in these industries. The vast majority of the concessions is offered for deals in the transportation, social, and utilities industries.

Overall, we find that the lower exit rates and underperformance of U.S. public pension funds are not driven by a specific subsample of infrastructure deals. They display lower rates in all major industries, locations, and project types. The lower exit rates and underperformance seem to be relatively larger within domestic renewable energy and transportation projects, but they are not entirely driven by these deals.

VI. The Implicit Subsidy

By selecting funds that invest in projects with poor financial performance, U.S. public pension funds have created an implicit subsidy to infrastructure as an asset class, as the underperformance will negatively affect their funding status. Depending on whether unfunded pension liabilities will ultimately be remediated through contribution increases from taxpayers or benefit cuts, this subsidy is provided by either taxpayers or pension plan members, or a mix of both. We measure the value of this subsidy in three ways.

First, relative to other global infrastructure investors, we estimate an underperformance in terms of net IRR of 1.3% of the value of the investment each year (see Table 5). If the share of U.S. public pension funds in the total value of infrastructure fund assets under management is given by their share in investor counts (98 out of a total of 640, i.e., 15.3%), then U.S. public pension funds have a total $56.2 billion under management in infrastructure funds.[15] If held stable, and if IRR can be taken as a proxy for effective rate of return experienced by investors, then the 1.3% lower net IRR would imply an annual subsidy of $730 million. With U.S. public pension fund assets under management rising at a rate of 28% per year, this subsidy would be expected to double every three years.[16]

This first calculation has several drawbacks. The net IRR equals the rate of return experienced by investors if and only if dividends generated by the investment are reinvested and earn that same rate of return. Furthermore, a calculation of the subsidy based on the estimated performance differential between US public pension fund investments and the fund investments of other institutional investors implicitly assumes that global infrastructure fund investments made

[15] $56.2 billion is 15.3% of the $367 billion in assets under management in Figure 2.

[16] Several large public pension fund investors foresee substantial increases in their allocations to infrastructure. For example, Pennsylvania Public School Employees' Retirement System (2014; 2017) increased its infrastructure allocation target from 3% in 2014 to 8% in 2017. In 2017, Employees Retirement System of Texas (2017) has a target allocation of 4%, compared to actual allocation of 1.7%, and Maine Public Employees Retirement System (2017) targets 10%, compared to actual allocation of 7.2%.

by these other institutional investors are on the efficient frontier and therefore are an appropriate benchmark.

To address the possibility that there are other comparable-risk opportunities in the investible universe that might have similar expected returns, we develop a second measure of the underperformance of U.S. public pension funds in the infrastructure asset class, based on the Public Market Equivalent (PME) approach of Kaplan and Schoar (2005). Panel A of Table 8 shows that relative to the S&P 500, U.S. public pension funds infrastructure investments have a PME of 0.93, implying a 7% underperformance over the life of the fund. Relative to a value-weighted index of listed infrastructure funds, however, the PME of U.S. public pension funds' infrastructure investments is only 0.83, implying a 17% underperformance over the life of the fund.[17] Thus, for each new (annual) $5 billion committed, public pension funds lose $850 million over the lifetime of the fund relative to what they could have achieved if investing in this listed infrastructure index. This estimate is around 13% larger than the one based on the net IRR regression, and has the benefit of not relying on an assumption about the validity of IRR as a performance measure.[18]

Our final measure of the underperformance of U.S. public pension funds considers how their infrastructure fund investments performed relative to their own private equity investments. Given our findings that the shape of the cash flow profiles of infrastructure fund investments are similar to the profiles of general private equity buyout fund investments, we argue that this is an appropriate comparison. In Panels B and C of Table 8 we compare the performance of investments in infrastructure funds with the investments in buyout and VC funds made by the same investor and in the same vintage year. We present the average net IRR and multiple of invested capital delivered by infrastructure, buyout, or VC funds. We find that U.S. public pension funds invested in buyout funds that deliver a 5.62% (14.400 – 8.778) higher net IRR and a 20% (1.436 – 1.238)

[17] We calculate the value-weighted return index of listed infrastructure funds using an international sample of 52 listed funds. We download the return series from Datastream. The weights assigned to the returns of each fund are based on the market capitalization of the fund. We update the weights monthly. The number of listed funds in the value-weighted index increases over time from 2 funds in 1994 to 10 funds in 2002 and further to 46 funds in 2016. This increase matches well the number of closed funds reporting cash flow data: 1 fund in 1994, 4 funds in 2002, and 89 funds during the entire sample period. We estimate two robustness tests of the PME results. First, our results are robust to comparing the performance of listed and closed funds only in the later subperiod 2004-2016 when the number of both listed and closed funds is higher. Second, our results are robust to annual instead of monthly adjustment of the weights in the value-weighted return index.

[18] Unlike the net IRR measure, the PME approach adjusts for market movements and is robust to variations in the timing and systematic risks of the underlying cash flows as well as potential GP manipulations (Kaplan and Schoar, 2005; Kaplan and Seonsoy, 2015; Sorensen and Jagannathan, 2015).

higher multiple of invested capital than their infrastructure funds. They also invested in VC funds that deliver a 4.24% (12.887 – 8.650) higher net IRR and a 28% (1.509 – 1.228) higher multiple of invested capital than their infrastructure funds. Based on our estimation, U.S. public pension funds have around $56.2 billion invested in infrastructure assets and the difference in net IRR relative to buyout funds would imply an annual loss of $3.158 billion. The difference in net IRR relative to VC funds would imply an annual loss of $2.382 billion relative to what U.S. public pension funds could have achieved if they could have committed more capital to their existing VC funds instead of investing in infrastructure funds.

VII. Conclusion

In this paper, we analyze infrastructure as an asset class available to institutional investors. We find that closed infrastructure funds have payout profiles similar to traditional buyout private equity funds. When analyzing the frequency and amounts of capital calls and distributions, we find no evidence of differences between the cash flows provided by closed infrastructure and the cash flows offered by buyout funds. We conclude that closed infrastructure funds, typically structured with a finite life of around 10-12 years, generate most of their returns through capital gains and relatively quick exits. Infrastructure funds do not provide more stable cash flows to institutional investors than private equity funds, even though many institutional investors justify the inclusion of the infrastructure asset class in their portfolio on the grounds that they expect infrastructure investments to deliver stable cash flows over a long horizon.

We examine also the experience of various types of institutional investors within the infrastructure asset class. We find that public pension funds hold infrastructure deals longer. However, their lower exit rates proxy for lower performance and do not capture differences in preferences for gaining long-term exposure to infrastructure assets. First, public pension funds prefer investing through closed funds and their investment approaches choices are similar to private sector pension funds, insurance firms, banks, endowments and foundations. Second, the underperformance of public pension funds also is not due to preferences for different projects as controlling for deal characteristics does not attenuate the coefficient of their underperformance. We control for project stage and the inclusion of concession agreements as proxies for riskiness of the deal, as well as industry and location as proxies for different preferences. While our evidence on performance comes from investments through a closed fund structure, we note that there would

be no a priori reason to expect that agency problems or governance issues that contribute to the underperformance of U.S. public pension funds would disappear in a direct investment context.

The underperformance of U.S. public pension funds is economically and statistically significant. We find that U.S. public pension funds obtain around 1.32 percentage points lower net IRR and a multiple of invested capital that is lower by 0.058. The underperformance of U.S. public pension funds is stronger in renewable energy and transportation assets located in U.S., but it also persists across the other industry types as well as internationally. The finding that U.S. public pension funds' infrastructure investments are not on the efficient frontier of infrastructure investments has important implications if U.S. public pension funds are planning to scale up the extent of their infrastructure investing. Either taxpayers are providing a subsidy – if they will make up for unfunded liabilities that emerge as a result of the underperformance – or beneficiaries provide the subsidy, if they will take pension cuts as a result of the underperformance.

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Table 1: Summary Statistics

We collect data for 640 institutional investors in infrastructure. In Panel A we report summary statistics for all institutional investors in our sample, whereas in Panel B we limit attention to the subsample of U.S. institutional investors. Investor size presents the average assets under management ($ bil.) and Year first infra is the year of the LP's first investment in infrastructure. #Funds and #Direct deals measure the average number of investments in infrastructure funds and direct deals by investor. #Deals reports the the average number of deals to which an investors gains exposure (investing through funds exposes an investor to multiple deals). %Greenfield, %Brownfield, and %Secondary capture the project stage and report the percentage of greenfield, brownfield, and secondary deals, respectively. %Concession is the percentage of deals that are a concession or privatization agrements with the government or other public institution. %Home deals measures the percentage of deals located in the same country as the institutional investor. For U.S. investors, we define this variable as located in the same state as the institutional investor. *#Investors* counts the average number of investors in the same deal (multiple LPs investing through the same infrastructure fund are not counted multiple times). *Investment stake* measures the average investment stake of the infrastructure fund through which the LPs accessed the deal. *Total Stake* is the average stake of all investors in the deal.

	All Institutional Investors	Public Pension Funds	Government Agencies	Sovereign Wealth Funds	Private Pension Funds	Insurance Firms and Banks	Endowments and Foundations
Panel A: Institutional Investors from All Countries							
#Investors	640	198	33	15	186	156	52
Investor Size	61.552	33.283	94.837	247.826	15.861	146.203	3.813
Year First Invest	2004.748	2006.086	2005.303	2006.357	2003.323	2004.288	2005.365
#Funds	4.687	5.556	4.467	4.167	4.637	4.207	3.288
#Direct Deals	1.712	1.318	4.939	9.333	0.785	2.474	0.000
#Deals	60.431	64.742	35.697	49.200	62.102	65.109	42.942
%Greenfield	0.225	0.192	0.409	0.217	0.192	0.280	0.184
%Brownfield	0.138	0.126	0.185	0.122	0.140	0.132	0.165
%Secondary	0.638	0.682	0.406	0.661	0.668	0.588	0.651
%Concessions	0.091	0.075	0.115	0.145	0.095	0.117	0.031
%Home Deals	0.250	0.213	0.247	0.166	0.291	0.312	0.092
#Investors	1.686	1.646	1.912	2.074	1.702	1.735	1.381
Investment Stake	0.578	0.604	0.499	0.506	0.571	0.551	0.645
Total Stake	0.739	0.748	0.720	0.686	0.739	0.724	0.768
Panel B: U.S. Institutional Investors							
#Investors	271	98	1	3	78	47	44
Investor Size	39.122	31.343	8.184	27.895	20.749	120.149	3.937
Year First Invest	2004.897	2007.041	2005.000	2008.667	2002.731	2003.383	2005.318
#Funds	5.135	5.316	6.000	7.500	5.671	5.512	3.341
#Direct Deals	0.269	0.133	0.000	0.333	0.141	1.021	0.000
#Deals	57.753	48.143	24.000	74.000	69.000	73.021	42.568
%Greenfield	0.180	0.179	0.435	0.157	0.181	0.178	0.182
%Brownfield	0.155	0.155	0.348	0.105	0.154	0.136	0.176
%Secondary	0.664	0.666	0.217	0.738	0.665	0.686	0.643
%Concessions	0.033	0.034	0.043	0.039	0.034	0.045	0.016
%Home Deals	0.035	0.044	0.000	0.000	0.031	0.029	0.029
#Investors	1.495	1.549	1.261	1.944	1.514	1.511	1.297
Investment Stake	0.654	0.647	0.623	0.557	0.645	0.665	0.681
Total Stake	0.780	0.781	0.696	0.734	0.769	0.796	0.787

Table 2: Comparison of the Cash Flows of Infrastructure Funds with Buyout and VC Funds

We compare the cash flows of closed infrastructure funds with buyout and venture capital (VC) funds. The sample includes funds raised in the period 2002–2016. Row *Funds* presents the number of funds that provide cash flow data in Preqin during this period. We standardize the cash flows over time. Year 1 captures the first year when a GP calls capital from LPs. We follow Kaplan and Schoar (2005) and calculate PME as the ratio of the sum of discounted distributions to the sum of discounted capital calls. The discount rate is the total return on S&P 500 index to the date of the capital call or distribution. We present the number of capital calls and distribution per year as well as the amounts of capital calls and distributions per year in $ mil. The t-tests measure whether the timeline of cash flows delivered by infrastructure funds differs from the timeline of cash flows delivered by buyout and VC funds.

Year	Infrastructure				Buyout				VC			
	Number Calls	Number Distri.	Amount Calls	Amount Distri.	Number Calls	Number Distri.	Amount Calls	Amount Distri.	Number Calls	Number Distri.	Amount Calls	Amount Distri.
Funds	78				764				572			
PME	0.987				1.048				0.974			
1	1.938	0.630	1.839	0.065	1.910	0.403	1.488	0.048	1.980	0.146	1.506	0.014
2	2.466	1.521	1.595	0.254	2.725	1.133	1.822	0.233	2.658	0.440	1.752	0.096
3	2.705	1.623	1.909	0.446	2.805	1.388	1.830	0.415	2.866	0.661	1.790	0.219
4	2.560	2.160	1.660	0.994	2.823	1.755	1.608	0.832	2.828	0.912	1.540	0.456
5	2.500	2.167	1.237	1.223	2.650	2.042	1.311	1.202	2.569	1.177	1.181	0.678
6	2.263	1.921	0.955	1.701	2.442	2.337	0.880	1.550	2.178	1.278	0.785	1.016
7	1.484	2.194	0.386	1.571	2.093	2.451	0.534	1.804	1.768	1.279	0.518	1.054
8	1.333	1.792	0.161	1.420	1.751	2.438	0.299	1.773	1.457	1.364	0.331	1.192
9	1.176	1.941	0.211	1.306	1.572	2.280	0.187	1.798	1.051	1.278	0.184	1.302
10	1.000	2.167	0.133	1.203	1.256	2.085	0.120	1.472	0.640	1.034	0.087	0.987
11	0.000	0.444	0.000	1.423	0.996	1.848	0.128	1.367	0.466	0.883	0.065	0.949
12	0.400	1.400	0.816	0.927	0.706	1.258	0.068	0.705	0.291	0.690	0.026	0.580
T-tests												
Buyout	-4.231***	-0.805	0.685	-0.832								
VC	-1.220	5.625***	1.241	5.363***								

Table 3: Exiting a Deal and Investor Type

This table presents results of a survival analysis using Cox proportional hazard model. The event of interest is a sale transaction that results in a full (not partial) exit of an equity position in an infrastructure asset. We present the hazard ratios. *U.S. Public PF* and *Non U.S. Public PF* are indicator variables for U.S. and non U.S. public pension funds. *Government agency* and *Sovereign wealth funds* are indicators for these two types of public institutional investors. We control for the natural logarithm of LP AUM and year of first infrastructure investment. *#Funds* measures the number of investments in infrastructure funds by investor. *Direct deal* is an indicator variable for direct investments in infrastructure deals. *Concession* is an indicator variable equal to one if an investor enters a concession deal with the government. *Greenfield* and *Brownfield* are indicators for project stage (the omitted category is secondary stage). *Home deal* is an indicator for deals located in the same country (state) as the investor. *#Investors* counts the total number of investors in the same deal (multiple LPs investing through the same infrastructure fund are not counted multiple times). *Investment stake* measures the investment stake of the infrastructure fund through which the LPs accessed the deal. *Total Stake* is the total stake of all investors in the deal. We control for LP country, deal industry, and deal region fixed effects. We cluster standard errors by investor, fund, or asset. We report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
U.S. Public PF	0.820***	0.826***	0.792***	0.777***	0.779***	0.803***	0.797**	0.803***
	[0.059]	[0.058]	[0.054]	[0.053]	[0.051]	[0.052]	[0.082]	[0.055]
Non U.S. Public PF	0.893	0.873*	0.926	0.940	0.929	0.921	0.924	0.921**
	[0.071]	[0.072]	[0.073]	[0.070]	[0.072]	[0.071]	[0.092]	[0.038]
Government agencies	1.094	0.882	1.060	1.106	1.238	1.275	1.029	1.275*
	[0.365]	[0.263]	[0.350]	[0.359]	[0.374]	[0.404]	[0.310]	[0.162]
Sovereign wealth funds	1.231	1.038	1.194	1.147	1.010	1.134	0.987	1.134
	[0.217]	[0.178]	[0.212]	[0.208]	[0.224]	[0.226]	[0.255]	[0.145]
Log Investor Size	1.029	1.032*	1.033*	1.030*	1.030*	1.029*	1.029	1.029***
	[0.019]	[0.019]	[0.019]	[0.017]	[0.018]	[0.018]	[0.020]	[0.010]
Year first infra	0.988*	0.994	0.995	0.993	0.998	0.995	0.997	0.995
	[0.007]	[0.006]	[0.007]	[0.007]	[0.007]	[0.007]	[0.015]	[0.007]
#Funds	1.001	1.002	1.001	1.000	0.998	0.998	0.998	0.998
	[0.006]	[0.006]	[0.006]	[0.005]	[0.006]	[0.005]	[0.006]	[0.003]
Direct deal	0.710*	0.665**	0.723*	0.733*	0.899	0.751		0.751**
	[0.136]	[0.128]	[0.142]	[0.136]	[0.257]	[0.142]		[0.099]
Concession				2.074***	2.910***	2.424***	2.474***	2.424***
				[0.145]	[0.222]	[0.172]	[0.569]	[0.429]
Greenfield				0.746***	0.681***	0.666***	0.667**	0.666***
				[0.037]	[0.037]	[0.035]	[0.125]	[0.087]
Brownfield				0.620***	0.536***	0.552***	0.548***	0.552***
				[0.028]	[0.028]	[0.027]	[0.104]	[0.084]
Home Deal				0.729***	0.718***	0.752***	0.753*	0.752***
				[0.065]	[0.066]	[0.067]	[0.110]	[0.064]
#Investors					0.922***	0.941***	0.946	0.941
					[0.014]	[0.012]	[0.048]	[0.053]
Investment Stake					0.822***			
					[0.049]			
Total Stake						0.989	0.978	0.989
						[0.062]	[0.238]	[0.190]
LP country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Deal region FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Deal industry FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Investor	Investor	Investor	Investor	Investor	Investor	Fund	Asset
Observations	38,671	38,671	38,671	38,407	30,942	33,608	32,637	33,608

Table 4: Percentage Exited Deals and Performance

In this table we analyze the subsample of closed infrastructure funds, and exclude listed and open-ended funds as well as direct investments in infrastructure assets, because Preqin provides performance data only for closed funds. Observations are at the infrastructure fund level. Columns (1) and (2) presents results of logit regressions in which the dependent variable equals one if a closed infrastructure fund reports either the net IRR or multiple of invested capital in the Preqin database. We present the marginal effects (elasticities) at the means of the independent variables. In the other columns, we limit attention to infrastructure funds reporting performance. In columns (3) and (4) performance is measured using the net internal rate of return (IRR), whereas in columns (5) and (6) performance is measured using net multiple of invested capital. *%Exited deals* measures the percentage of exited deals from the total deals made by the fund. %Exited deals in years 0-5, 5-10, and >10 capture the percentage of exited deals in the first five years after the transaction date, in five to ten years after the transaction, and in more than ten years after the transaction date. *Fund size* is the natural logarithm of the assets managed by the infrastructure fund. We include vintage year fixed effects and control for the percentage allocated to different infrastructure industries and geographical regions. We report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	Reporting		**Net IRR**		**Multiple**	
	(1)	(2)	(3)	(4)	(5)	(6)
%Exited deals	0.279*		18.222***		0.637***	
	[0.167]		[4.638]		[0.171]	
%Exited deals in years 0-5		0.251		18.741***		0.690***
		[0.201]		[5.006]		[0.189]
%Exited deals in years 5-10		0.303		17.229		0.564
		[0.269]		[11.656]		[0.385]
%Exited deals in years >10		0.609		-16.071		-0.214
		[0.542]		[41.974]		[0.655]
Fund Size	0.168***	0.165***	-0.673	-0.390	-0.038	-0.030
	[0.036]	[0.036]	[1.043]	[1.101]	[0.034]	[0.035]
Vintage FE	Yes	Yes	Yes	Yes	Yes	Yes
%Deal region	Yes	Yes	Yes	Yes	Yes	Yes
%Deal industry	Yes	Yes	Yes	Yes	Yes	Yes
Observations	323	323	121	121	187	187
R^2			0.412	0.417	0.487	0.493

Table 5: Investor Type and Performance

This table presents results of regressions in which the dependent variable is the performance in closed infrastructure funds. Observations are at the investor-fund level. In columns (1) to (3) performance is measured using the percentage exited deals. In columns (4) to (6) performance is measured using the net internal rate of return (IRR), whereas in columns (7) to (9) performance is measured using net multiple of invested capital. *U.S. Public PF* and *Non U.S. Public PF* are indicator variables for U.S. and non U.S. public pension funds. We control for the natural logarithm of LP AUM and year of first infrastructure investment. *#Funds* measures the number of investments in infrastructure funds by investor. *FOF* and *Debt Fund* are indicator variables for infrastructure funds that do not take only equity positions in infrastructure deals, but that also act as fund-of-funds or debt fund. We include investor (LP) country fixed effects and control for the percentage of deals in the portfolio of each infrastructure fund in different industries and geographical regions. We cluster standard errors by institutional investor and report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	Percentage exited deals			**Net IRR**			**Multiple of invested capital**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
U.S. Public PF	-0.066***	-0.072***	-0.071***	-1.219*	-1.502**	-1.323**	-0.070***	-0.064***	-0.058***
	[0.017]	[0.017]	[0.017]	[0.664]	[0.645]	[0.651]	[0.020]	[0.021]	[0.021]
Non U.S. Public PF	-0.012	-0.003	0.001	0.167	-0.530	-0.403	-0.048**	-0.052**	-0.048*
	[0.016]	[0.015]	[0.015]	[0.961]	[0.928]	[0.916]	[0.023]	[0.024]	[0.025]
Log Investor Size	0.008*	0.005	0.005	-0.388**	-0.335**	-0.305**	-0.010*	-0.011*	-0.011*
	[0.004]	[0.004]	[0.004]	[0.158]	[0.154]	[0.154]	[0.006]	[0.006]	[0.006]
Year first infra	-0.012***	-0.012***	-0.012***	0.026	-0.001	0.014	-0.008***	-0.009***	-0.008***
	[0.002]	[0.002]	[0.002]	[0.066]	[0.064]	[0.065]	[0.003]	[0.003]	[0.002]
#Funds	-0.003***	-0.003***	-0.004***	0.045	0.039	0.033	-0.002	-0.002*	-0.003*
	[0.001]	[0.001]	[0.001]	[0.047]	[0.047]	[0.047]	[0.001]	[0.001]	[0.001]
FOF			-0.184***			-5.043*			-0.128*
			[0.023]			[3.016]			[0.075]
Debt Fund			-0.113*			-20.766***			-0.429***
			[0.069]			[0.836]			[0.045]
LP country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
%Deal region	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
%Deal industry	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Observations	2,958	2,958	2,958	1,393	1,393	1,393	1,910	1,910	1,910
R-squared	0.107	0.128	0.131	0.039	0.057	0.081	0.058	0.063	0.069

Table 6: Frequency of Cash Flows and Performance

This table presents results of regressions in which the dependent variables measure different aspects of the cash flows experienced by institutional investors holding closed infrastructure funds. Observations are at the investor-fund level. In columns (1) and (2), #Calls measures the number of capital calls (transfers from LP to GP) per year. In columns (3) and (4), #Distributions is the number of capital distributions from GP to LP per year. In columns (5) and (6), the dependent variable is the public market equivalent (PME) performance measure. *U.S. Public PF* is an indicator variable for U.S. public pension funds. We control for the natural logarithm of LP AUM and year of first infrastructure investment. *#Funds* measures the number of investments in infrastructure funds by investor. *Fund Age* measures the age of teh infrastructure fund. We include investor (LP) country fixed effects and control for the percentage of deals in the portfolio of each infrastructure fund in different industries and geographical regions. We cluster standard errors by institutional investor and report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	#Calls		**#Distributions**		**PME**	
	(1)	(2)	(3)	(4)	(5)	(6)
U.S. Public PF	0.222***	0.210***	-0.068	-0.059	-0.039**	-0.038**
	[0.063]	[0.061]	[0.076]	[0.077]	[0.017]	[0.018]
Log Investor Size	-0.017	-0.008	-0.013	-0.006	-0.000	0.001
	[0.017]	[0.017]	[0.017]	[0.017]	[0.005]	[0.005]
Year First Invest	0.014*	0.013*	-0.011	-0.014*	-0.002	-0.003
	[0.007]	[0.007]	[0.008]	[0.008]	[0.002]	[0.002]
#Funds	0.009**	0.008*	0.003	0.001	-0.000	-0.000
	[0.004]	[0.004]	[0.004]	[0.004]	[0.001]	[0.001]
Fund Age	0.001	0.005	0.100***	0.099***	-0.033***	-0.032***
	[0.016]	[0.016]	[0.017]	[0.017]	[0.005]	[0.005]
LP country FE	Yes	Yes	Yes	Yes	Yes	Yes
%Deal industry	Yes	Yes	Yes	Yes	Yes	Yes
%Deal region	No	Yes	No	Yes	No	Yes
Observations	980	980	980	980	980	980
R-squared	0.146	0.160	0.147	0.159	0.124	0.132

Table 7: U.S. investors: Exiting a deal by industry, location and project type

This table presents results of a survival analysis using Cox proportional hazard model. The event of interest is a sale transaction that results in a full (not partial) exit of an equity position in an infrastructure asset. We present the hazard ratios. We limit attention to the subsample of U.S. institutional investors. In column (1) we analyze all infrastructure deals made by U.S. investors. In Columns (2), (3),a nd (4) we analyze separately deals in the three main industries - traditional energy, renewable energy, and transportation. In Columns (5 and (6) we split the sample based on geographical location into domestic U.S. deals and outside non U.S. deals. In Columns (7) and (8) we split the sample based on project stage into deals in greenfield and brownfield stage, and deals in secondary stage. In columns (9) and (10) we split the sample into deals with and without concession agreement. *Public PF* is an indicator variable for U.S. public pension funds. *State Investment Funds* is an indicator for three U.S. sovereign wealth funds (state funds). We control for the natural logarithm of LP AUM and year of first infrastructure investment. *#Funds* measures the number of investments in infrastructure funds by investor. *Concession* is an indicator variable equal to one if an investor enters a concession deal with the government. *Greenfield* and *Brownfield* are indicators for project stage (the omitted category is secondary stage). *Home deal* is an indicator for deals located in the same state as the investor. *#Investors* counts the total number of investors in the same deal (multiple LPs investing through the same infrastructure fund are not counted multiple times). We control for deal industry and deal region fixed effects. We cluster standard errors by institutional investor. We report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	All deals (1)	Traditional energy (2)	Renewable energy (3)	Transport (4)	U.S. deals (5)	non U.S. deals (6)	Greenfield brownfield (7)	Secondary (8)	Without concession (9)	With concession (10)
Public PF	0.676***	0.721***	0.552***	0.595***	0.662***	0.827*	0.712***	0.669***	0.685***	0.516**
	[0.049]	[0.054]	[0.079]	[0.112]	[0.046]	[0.094]	[0.073]	[0.054]	[0.049]	[0.168]
State Investment Funds	0.437***	0.519***	0.138***	1.719*	0.293***	0.809	0.687**	0.410***	0.430***	0.766
	[0.084]	[0.061]	[0.104]	[0.527]	[0.047]	[0.208]	[0.119]	[0.113]	[0.080]	[0.154]
Log Investor Size	1.024	1.029	0.979	0.979	1.016	1.023	1.025	1.024	1.021	1.076
	[0.018]	[0.021]	[0.027]	[0.034]	[0.018]	[0.047]	[0.021]	[0.022]	[0.018]	[0.068]
Year first infra	1.015**	1.020**	1.031*	0.995	1.016**	0.991	1.016*	1.018**	1.018**	0.941***
	[0.008]	[0.009]	[0.017]	[0.013]	[0.008]	[0.011]	[0.009]	[0.009]	[0.008]	[0.016]
#Funds	1.009*	1.009	1.020**	0.998	1.007	1.011	1.015**	1.006	1.010**	0.993
	[0.005]	[0.006]	[0.010]	[0.009]	[0.005]	[0.012]	[0.006]	[0.006]	[0.005]	[0.018]
Concession	1.925***			1.349*	1.196	1.657***	1.095	2.488***		
	[0.246]			[0.225]	[0.210]	[0.299]	[0.271]	[0.307]		
Greenfield	0.631***	0.596***	0.478***	0.407***	0.562***	1.133			0.640***	0.569***
	[0.037]	[0.036]	[0.066]	[0.088]	[0.036]	[0.134]			[0.039]	[0.124]
Brownfield	0.501***	0.585***	0.205***	0.522***	0.419***	1.408***			0.504***	0.507**
	[0.027]	[0.030]	[0.027]	[0.128]	[0.022]	[0.180]			[0.026]	[0.164]
Home Deal	1.025	1.173**	0.687**	1.116			0.869	1.098	1.011	3.346*
	[0.073]	[0.092]	[0.119]	[0.283]			[0.114]	[0.090]	[0.073]	[2.326]
#Investors	0.910***	1.052**	0.615***	0.992	0.850***	0.994	1.027	0.898***	0.896***	0.975
	[0.016]	[0.027]	[0.044]	[0.063]	[0.020]	[0.023]	[0.030]	[0.021]	[0.018]	[0.044]
Deal region FE	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Deal industry FE	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No
Cluster	Investor	Investor	Investor	Investor	Investor	Investor	Investor	Investor	Investor	Investor
Observations	15,443	8,271	2,747	2,195	10,411	5,032	4,943	10,500	14,955	488

Table 8: Analyzing the Performance of U.S. Investors

This table summarizes the performance of the main types of U.S. investors. Panel A presents the average public market equivalent (PME) by investor type. We estimate the PME relative to the S&P 500 stock market index and a value-weighted index of listed infrastructure funds. In Panels B and C, we compare the performance of investments in infrastructure funds with the investments in buyout and VC funds made by the same investor. We match the investments infrastructure investments with buyout and VC investments made by the same investor and in the same vintage year. We present the average net IRR and multiple of invested capital delivered by infrastructure, buyout, or VC funds. The number of observations changes because it depends on making investments in infrastructure, buyout or VC in the same vintage year and on the availability of performance data for these investments.

Panel A: Average Public Market Equivalent (PME)

Investor type	Obs.	S&P500 PME	VW Listed Infra PME
Public pension funds	272	0.933	0.829
Private pension funds	206	0.973	0.839
Insurance firms and banks	140	0.968	0.836
Endowments and foundations	97	1.001	0.857

Panel B: Comparison of Infrastructure Funds with Buyout Funds

Investor type	Obs.	Infra Net IRR	Buyout Net IRR	Obs.	Infra Multiple	Buyout Multiple
Public pension funds	270	8.778	14.400	346	1.238	1.436
Private pension funds	195	11.223	14.548	237	1.372	1.588
Insurance firms and banks	139	9.315	14.414	159	1.336	1.558
Endowments and foundations	65	11.142	10.872	75	1.388	1.494

Panel C: Comparison of Infrastructure Funds with VC Funds

Investor type	Obs.	Infra Net IRR	VC Net IRR	Obs.	Infra Multiple	VC Multiple
Public pension funds	200	8.650	12.887	257	1.228	1.509
Private pension funds	128	10.398	8.636	161	1.345	1.431
Insurance firms and banks	70	9.363	11.948	87	1.332	1.568
Endowments and foundations	50	12.868	16.347	62	1.452	2.072

Figure 1: Investing in Infrastructure

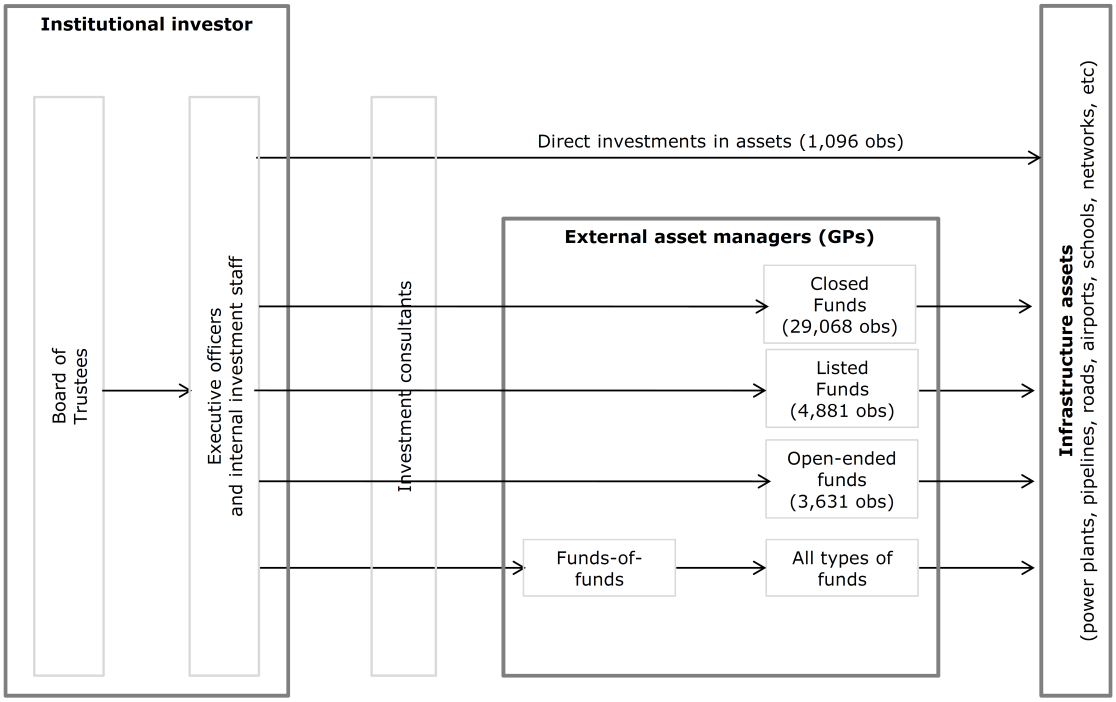


Figure 2: Closed Infrastructure Funds: Unrealized Value as a Proxy of AUM ($ bil)

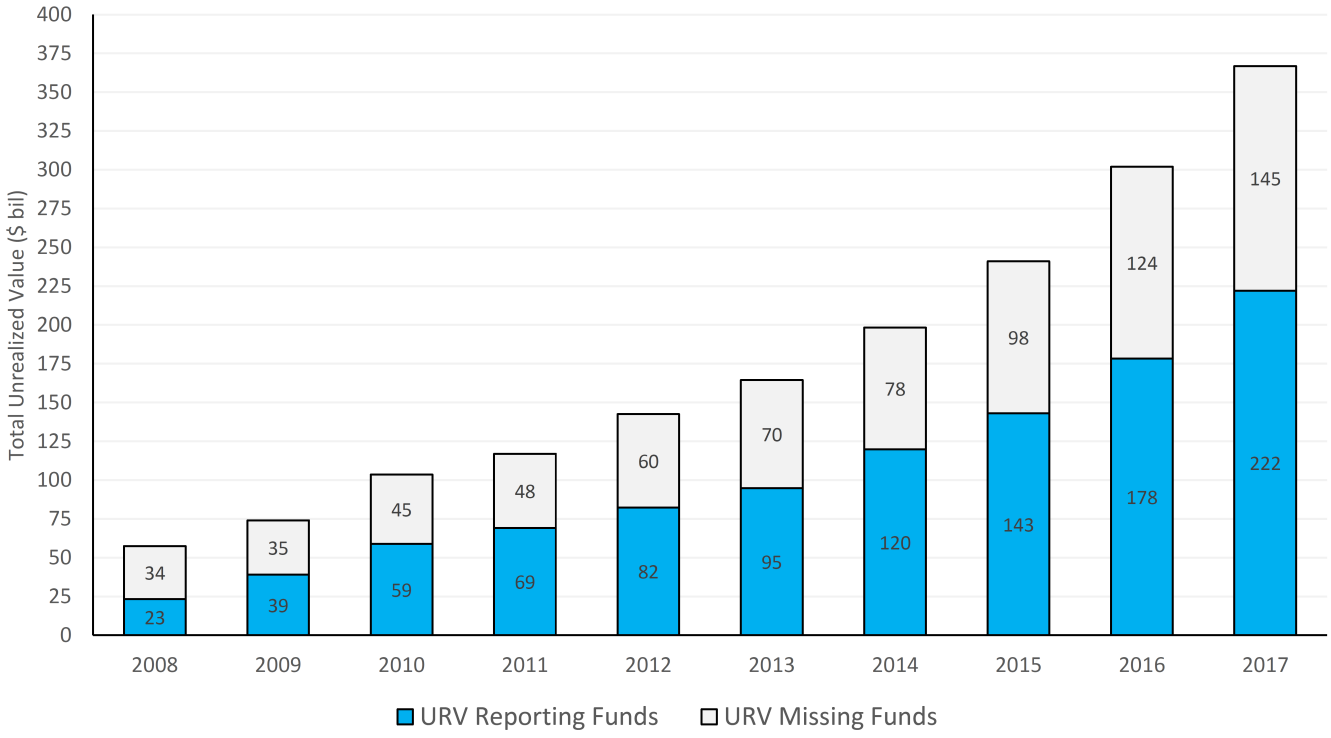


Figure 3: Institutional Investors and Investment Approach

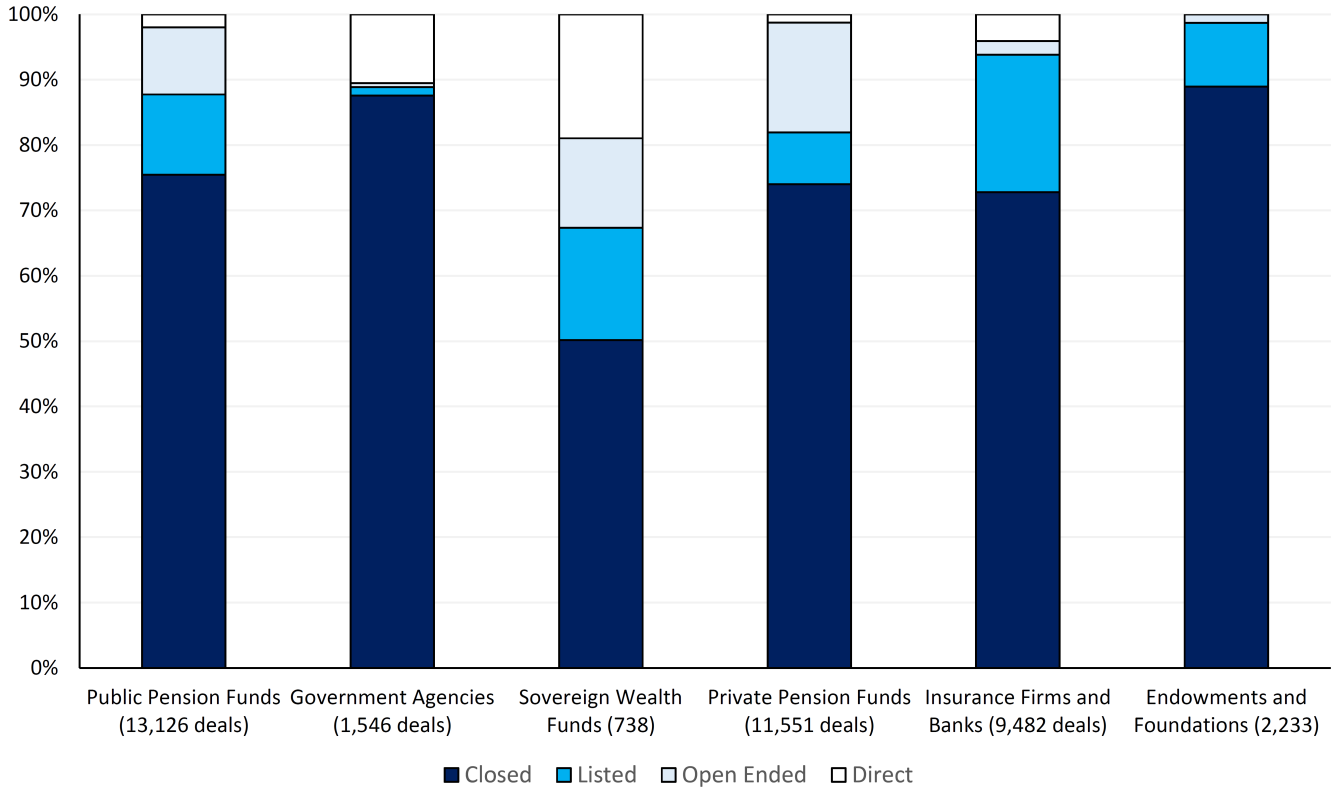


Figure 4: Institutional Investors and Industry of the Deal

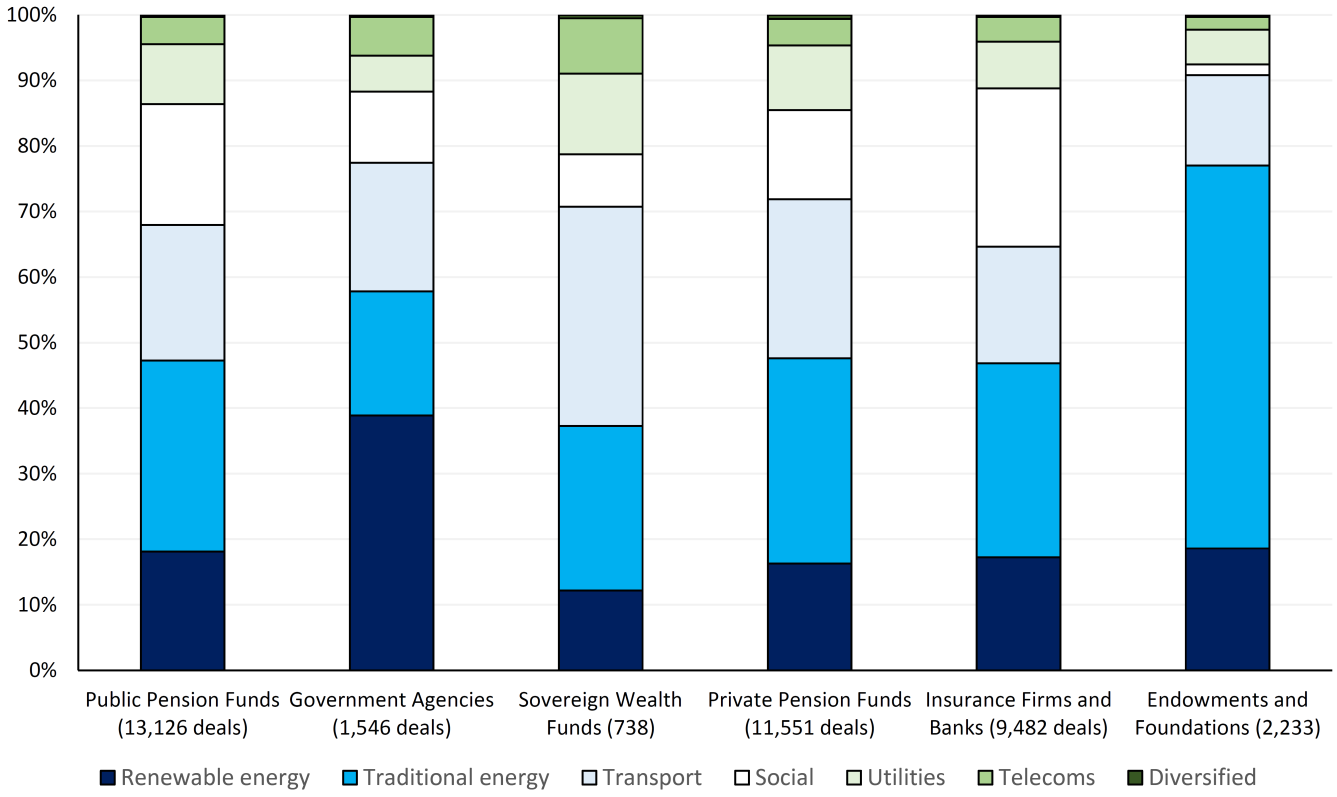
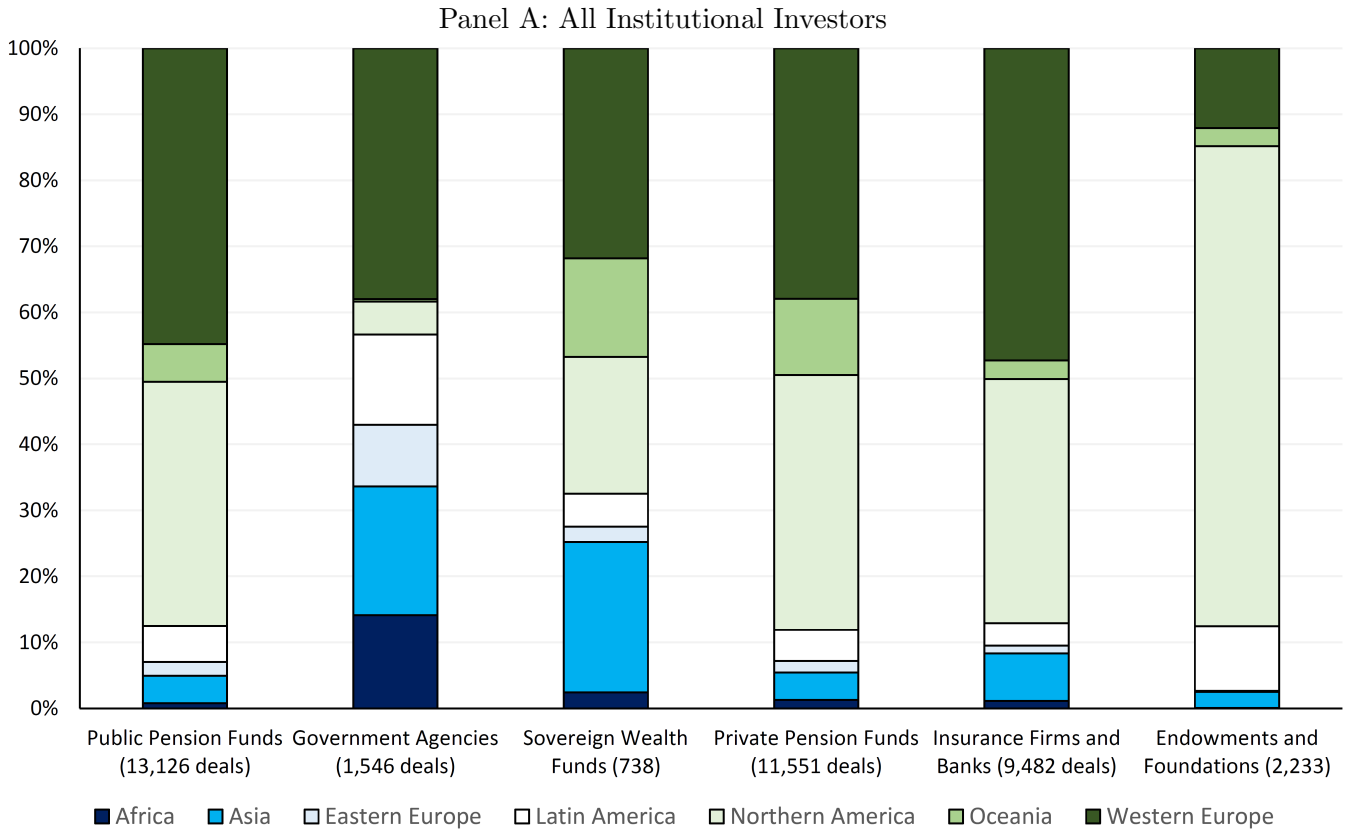


Figure 5: Institutional Investors and Regional Location of the Deal



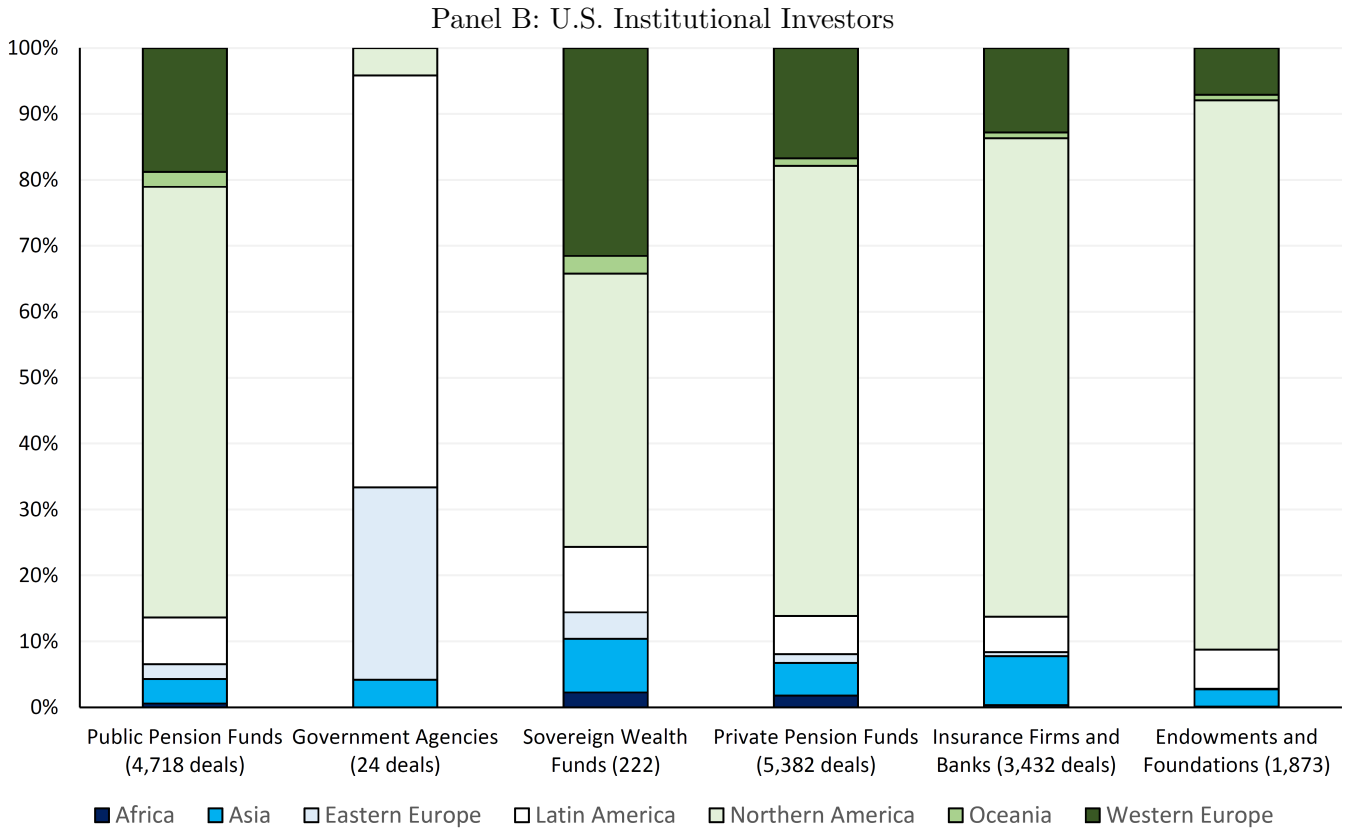
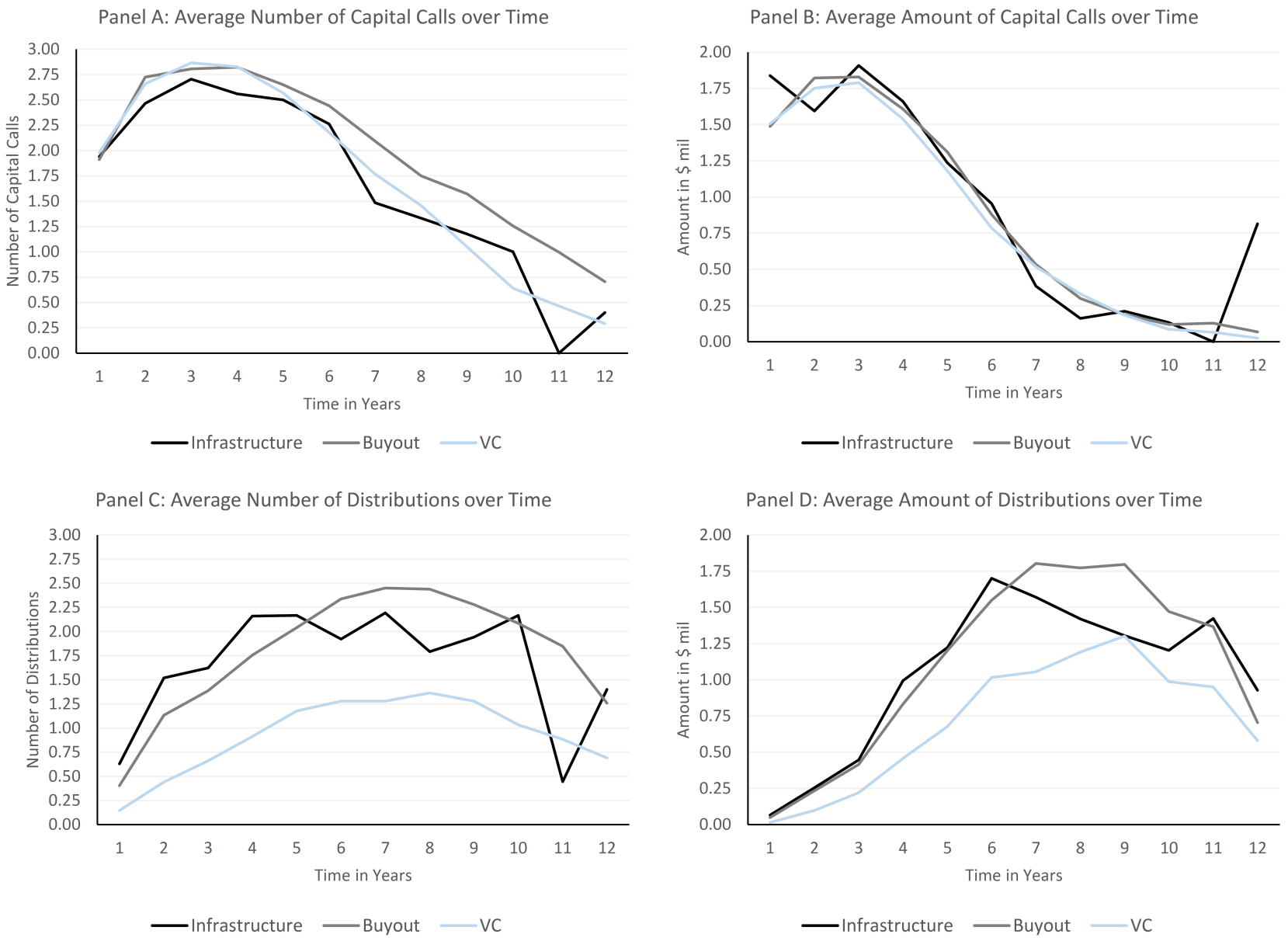


Figure 6: Comparison of the Cashflows of Infrastructure Funds with Buyout and VC Funds



Online Appendix:

The Subsidy to Infrastructure as an Asset Class

September 2018

Appendix 1: Statements of U.S. Public Pension Funds about Infrastructure

California State Teachers' Retirement System 2017 CAFR: "Short-term results for the Infrastructure Portfolio are not particularly significant, as performance expectations will be better measured over the long term as investments mature and achieve their full cash flow potential. The Infrastructure Portfolio has begun to enter a more mature phase and is beginning to achieve greater cash flow potential."

Iowa Public Employees' Retirement System 2017 CAFR: "Private real assets investments include direct equity investments in commercial real estate properties, or investment in partnerships or funds that invest in real estate and other real assets including, but not limited to, farmland, timberland, or infrastructure. The purpose of investing in private real assets is to provide income, diversification, and inflation protection." Iowa PERS 2017 Private Markets Investment Policy: "Given their stable cash flow and low variability of revenue, infrastructure assets can support more debt. For this reason, infrastructure investments may utilize up to 65 percent debt at the fund level and will be expected to use no more than 70 percent on any given asset. These limits will be reviewed on a case by case basis and determination of the debt level will be dependent on the investment type and risk characteristics of the investment."

New York State Common Retirement Fund 2017 CAFR: "Currently, most of our activity [in real assets] is focused on infrastructure transactions, given the size and risk profile of the opportunity set. Real asset investments offer exposure to varied return sources, including capital appreciation and cash flow from income. The diversified approach reduces realized volatility and allows the portfolio to benefit from long-term growth investment themes. These themes, such as the global growth in protein-based diets, will play out over multiple economic cycles. These investments will have a longer duration and an implicit focus on sustainable practices."

Oregon Public Employees Retirement System 2017 CAFR: "Alternative Equity investments seek to provide diversification and inflation hedging characteristics to the Fund and include investments with a focus on infrastructure and natural resources."

Pennsylvania State Employees' Retirement System 2017 CAFR: "Natural Resources/Infrastructure differ from real estate in that they focus on other real assets other than real estate, but maintain the characteristics of collateralization by hard assets and income-producing potential."

Employees' Retirement System of the State of Rhode Island 2017 CAFR: "Infrastructure – These four funds provide inflation-protection and current income to the portfolio through investments in facilities and services required for an economy to function including electricity production and distribution, pipelines, sewers and waste management, airports, roads, bridges, ports, railroads, telephone and cable networks, and hospitals."

Employees Retirement System of Texas 2017 CAFR: "The Systems private infrastructure investments are in large-scale public systems, services and facilities that are necessary for economic activity. These types of relatively illiquid investments are often made in essential services with high barriers to entry and predictable cash flows and have expected life from ten to twelve years, with the option of one to three-year extension."

Washington State Department of Retirement Systems 2017 CAFR: "Tangible Assets [includes Infrastructure]: This includes 40 limited liability structures and funds. The primary goals of the tangible asset portfolio are to generate a long-term sustainable and stable income stream as well as generate appreciation at least commensurate with inflation."

Table IA.1: Robustness: Exiting a Deal and Investor Type

Robustness check of Table 2: We control for other investor types instead of public pension funds.

This table presents results of a survival analysis using Cox proportional hazard model. The event of interest is a sale transaction that results in a full (not partial) exit of an equity position in an infrastructure asset. We present the hazard ratios. *Private PF* is an indicator variable for private pension funds. *Insurance firms and banks* and *Endowments and foundations* are indicators for these institutional investors. *Government agency* and *Sovereign wealth funds* are indicators for these two types of public institutional investors. We control for the natural logarithm of LP AUM and year of first infrastructure investment. *#Funds* measures the number of investments in infrastructure funds by investor. *Direct deal* is an indicator variable for direct investments in infrastructure deals. *Concession* is an indicator variable equal to one if an investor enters a concession deal with the government. *Greenfield* and *Brownfield* are indicators for project stage (the omitted category is secondary stage). *Home deal* is an indicator for deals located in the same country (state) as the investor. *#Investors* counts the total number of investors in the same deal (multiple LPs investing through the same infrastructure fund are not counted multiple times). *Investment stake* measures the investment stake of the infrastructure fund through which the LPs accessed the deal. *Total Stake* is the total stake of all investors in the deal. We control for LP country, deal industry, and deal region fixed effects. We cluster standard errors by investor, fund, or asset. We report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private PF	1.174**	1.192**	1.179**	1.170**	1.149**	1.139*	1.139	1.139***
	[0.085]	[0.085]	[0.081]	[0.079]	[0.079]	[0.079]	[0.090]	[0.041]
Insurance firms and banks	1.050	1.057	1.062	1.074	1.080	1.069	1.075	1.069
	[0.092]	[0.089]	[0.087]	[0.083]	[0.087]	[0.084]	[0.125]	[0.057]
Endowments and foundations	1.594***	1.563***	1.464***	1.465***	1.592***	1.602***	1.588***	1.602***
	[0.159]	[0.155]	[0.143]	[0.143]	[0.156]	[0.151]	[0.206]	[0.140]
Government agencies	1.234	1.020	1.196	1.250	1.429	1.458	1.178	1.458***
	[0.445]	[0.329]	[0.422]	[0.434]	[0.454]	[0.486]	[0.368]	[0.194]
Sovereign wealth funds	1.369*	1.162	1.349*	1.313	1.163	1.283	1.125	1.283**
	[0.236]	[0.200]	[0.238]	[0.237]	[0.253]	[0.249]	[0.270]	[0.158]
Log Investor Size	1.054**	1.057**	1.051**	1.046**	1.046**	1.047**	1.046**	1.047***
	[0.023]	[0.023]	[0.023]	[0.021]	[0.022]	[0.022]	[0.023]	[0.010]
Year first infra	0.987**	0.993	0.993	0.991	0.995	0.992	0.994	0.992
	[0.007]	[0.006]	[0.006]	[0.006]	[0.007]	[0.007]	[0.014]	[0.007]
#Funds	1.001	1.002	1.001	1.001	1.000	0.999	0.999	0.999
	[0.006]	[0.006]	[0.006]	[0.005]	[0.006]	[0.006]	[0.006]	[0.003]
Direct deal	0.718*	0.675**	0.734	0.745	0.923	0.762		0.762**
	[0.136]	[0.128]	[0.142]	[0.137]	[0.258]	[0.141]		[0.100]
Concession				2.085***	2.921***	2.436***	2.487***	2.436***
				[0.145]	[0.222]	[0.172]	[0.569]	[0.429]
Greenfield				0.742***	0.677***	0.662***	0.663**	0.662***
				[0.036]	[0.036]	[0.035]	[0.124]	[0.087]
Brownfield				0.618***	0.535***	0.550***	0.545***	0.550***
				[0.028]	[0.028]	[0.027]	[0.103]	[0.084]
Home Deal				0.749***	0.736***	0.770***	0.771*	0.770***
				[0.066]	[0.067]	[0.068]	[0.113]	[0.066]
#Investors					0.922***	0.942***	0.947	0.942
					[0.014]	[0.012]	[0.048]	[0.053]
Investment Stake					0.822***			
					[0.050]			
Total Stake						0.986	0.975	0.986
						[0.061]	[0.237]	[0.189]
LP country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Deal region FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Deal industry FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Investor	Investor	Investor	Investor	Investor	Investor	Fund	Asset
Observations	38,671	38,671	38,671	38,407	30,942	33,608	32,637	33,608

Table IA.2: Robustness: Exiting a Deal and Investor Type (Only Closed Funds)

Robustness check of Table 2: We analyze only the subsample of deals accessed through closed funds.

This table presents results of a survival analysis using Cox proportional hazard model. The event of interest is a sale transaction that results in a full (not partial) exit of an equity position in an infrastructure asset. We present the hazard ratios. *U.S. Public PF* and *Non U.S. Public PF* are indicator variables for U.S. and non U.S. public pension funds. *Government agency* and *Sovereign wealth funds* are indicators for these two types of public institutional investors. We control for the natural logarithm of LP AUM and year of first infrastructure investment. *#Funds* measures the number of investments in infrastructure funds by investor. *Direct deal* is an indicator variable for direct investments in infrastructure deals. *Concession* is an indicator variable equal to one if an investor enters a concession deal with the government. *Greenfield* and *Brownfield* are indicators for project stage (the omitted category is secondary stage). *Home deal* is an indicator for deals located in the same country (state) as the investor. *#Investors* counts the total number of investors in the same deal (multiple LPs investing through the same infrastructure fund are not counted multiple times). *Investment stake* measures the investment stake of the infrastructure fund through which the LPs accessed the deal. *Total Stake* is the total stake of all investors in the deal. We control for LP country, deal industry, and deal region fixed effects. We cluster standard errors by investor, fund, or asset. We report standard errors in brackets. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
U.S. Public PF	0.816***	0.866**	0.812***	0.814***	0.857**	0.870**	0.870	0.870**
	[0.055]	[0.058]	[0.054]	[0.054]	[0.053]	[0.055]	[0.099]	[0.061]
Non U.S. Public PF	0.894	0.819**	0.895	0.897	0.877*	0.872*	0.872	0.872***
	[0.067]	[0.064]	[0.069]	[0.069]	[0.063]	[0.064]	[0.097]	[0.040]
Government agencies	1.026	0.726	1.014	1.069	1.268	1.241	1.241	1.241*
	[0.262]	[0.154]	[0.259]	[0.275]	[0.319]	[0.305]	[0.308]	[0.140]
Sovereign wealth funds	1.023	0.753*	1.011	0.995	0.967	0.952	0.952	0.952
	[0.133]	[0.114]	[0.144]	[0.151]	[0.159]	[0.176]	[0.209]	[0.125]
Log Investor Size	1.008	1.004	1.007	1.004	0.994	0.996	0.996	0.996
	[0.017]	[0.017]	[0.017]	[0.016]	[0.015]	[0.015]	[0.016]	[0.008]
Year first infra	0.977***	0.985***	0.981***	0.979***	0.975***	0.973***	0.973***	0.973***
	[0.006]	[0.006]	[0.006]	[0.006]	[0.005]	[0.005]	[0.007]	[0.005]
#Funds	0.995	0.998	0.995	0.995	0.991*	0.991*	0.991*	0.991***
	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.005]	[0.002]
Concession				2.082***	2.842***	2.278***	2.278***	2.278***
				[0.141]	[0.222]	[0.163]	[0.516]	[0.487]
Greenfield				0.656***	0.539***	0.548***	0.548***	0.548***
				[0.033]	[0.027]	[0.028]	[0.102]	[0.077]
Brownfield				0.576***	0.485***	0.505***	0.505***	0.505***
				[0.027]	[0.026]	[0.026]	[0.101]	[0.084]
Home Deal				0.848*	0.813**	0.863*	0.863	0.863*
				[0.076]	[0.075]	[0.076]	[0.108]	[0.066]
#Investors					0.976	0.973**	0.973	0.973
					[0.017]	[0.014]	[0.057]	[0.062]
Investment Stake					0.845***			
					[0.053]			
Total Stake						0.983	0.983	0.983
						[0.069]	[0.262]	[0.199]
LP country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Deal region FE	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Deal industry FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Investor	Investor	Investor	Investor	Investor	Investor	Fund	Asset
Observations	29,068	29,068	29,068	28,807	22,541	24,458	24,458	24,458

Figure IA.1: Comparison of the Cashflows of Infrastructure Funds with Buyout and VC Funds (Matched Subsamples)

