EDHEC
Infrastructure &
Private Assets
Research Institute

Submission to the Department of Work and Pensions (DWP) Call for Evidence: Options for Defined Benefit schemes: a call for evidence
5 September 2023

Noël Amenc, Frédéric Blanc-Brude, Abhishek Gupta

Executive Summary

The Department for Work and Pensions has issued a call for evidence as to whether defined benefit (DB) schemes could benefit from increasing investments in productive finance, including infrastructure. In this response, we argue that DB pension plans in the UK should abstain from investing in infrastructure, unless they are able to do so with enough information about risk and the true market value of these investments.

Of course, infrastructure can offer very attractive investment characteristics for DB funds: the latest research conducted by EDHEC shows that unlisted infrastructure equity and debt can play very useful roles in the portfolio of a defined DB plan. Their fixed term and high distribution profile confers on them a bond-like quality, while retaining equity-like features. The long-term and contracted nature of most infrastructure businesses also enables them to raise significant amounts of debt, in the form of non-recourse loans (project finance) and bonds that are characterised by low credit risk levels and typically attractive spreads.

As we show in this response, infrastructure has the potential to improve both sides of the balance sheet: by diversifying the portfolio and improving the risk-adjusted returns of a plan's performance-seeking portfolio, while contributing to its liability hedging objectives, thanks to the interest rate sensitivity of infrastructure equity and the yield pick-up of infrastructure debt compared to corporate bonds of the same credit quality and duration. In mature funds, infrastructure can also be a contributor to cash-flow driven strategies.

That said, investors face significant hurdles to invest in infrastructure in a manner that is in line with their prudential and fiduciary responsibilities. The main stumbling block preventing the widespread development of infrastructure investment amongst DB plans in the UK is the type and quality of data available to investors in such assets has been remarkably poor and unreliable. The tendency to rely on contributed appraisal data, which is common in private markets, and not on information that accurately represents the risks of the asset class, masks the true characteristics of these investments, and precludes any rational decision-making process when it comes to investing in infrastructure.

In our response, we show that while on aggregate infrastructure has a lower volatility than its public counterparts, there have also been multiple cases of infrastructure companies going bankrupt or face significant write downs. Robust data enables an investor to be aware of these risks and, more importantly, manage them in a timely manner. As long as fair value and risk are not properly measured, UK DB plans will continue to either not invest in infrastructure or fail to invest wisely and face the consequences of not managing the risks, as the recent episode of the multi-billion-pound loss faced by Thames Water investors,

some of which are UK pension plans, illustrates.

With poor quality data, UK DB plans also face the risk of mistreatment of pension rights. The annuity guarantees or lump sum calculations based on incorrect data can lead to an unfair valuation of pension rights and distort the benefits received by the pensioners. In the same way, fair valuation of all private assets, including infrastructure, is an important issue in the area of pension fund consolidations or buy-outs.

However, in recent years, there have been major advancements in the quality of the data available to the investors and regulators. As a result, it is possible to do much better both in terms of valuations, but also financial and climate risk measurements. Robust data will also allow a fair consolidation of funds which won't depend on the methodological choices used by the individual funds.

We therefore think that there is now nothing to prevent the adoption of serious infrastructure valuation practices that use the right "comparables" to estimate the risk premium and therefore the right discount rates to use in infrastructure valuation. In the same way, relevant market indices for this class of investment enable pension fund capital to be allocated efficiently and the risk of this allocation to be managed.

In this context, it seems important to us that The Pensions Regulator should set up best practice rules and require pension funds to show that they have a serious investment process for this asset class, which should not remain marginal in institutional investors' allocations due to its macro and microeconomic benefits.

De facto, we believe the idea of the infrastructure asset class being "too small to be important and deserve attention" is depriving pensioners of the many benefits of this asset class, and it is an excellent thing that this additional knowledge of risks can enable us to emerge from this negative and restrictive status.

Table of Contents

About Us

The EDHEC Infrastructure & Private Assets Research Institute is a research centre of the EDHEC Business School, one of the best ranked business schools for its programs and research in finance. The institute was created in 2016 with the support of the business school and several key seed partners, including the government of Singapore, Natixis and Meridiam, to spearhead new research in the asset pricing and credit risk of private infrastructure investments.

Thanks to this work, an industry initiative was created in 2019 to contribute even more actively to the development of the infrastructure asset class. Our corporate entity, Scientific Infra and Private Assets Ltd is an ESMA-regulated provider of market indices, benchmarks and valuation analytics for investors in unlisted infrastructure equity and private debt, including the widely used infra300® index. The infraMetrics® platform already provides robust and granular data to investors representing USD400bn of infrastructure AUM (YE2022) as well as prudential regulators and public policy bodies.

In 2020, the institute launched a major new project on the measurement and benchmarking of climate risks and the social acceptability of infrastructure investments. After three years of development, several key research results a major data collection effort, we now publish climate and social risk data in infraMetrics®, alongside our indices and analytics since Q1 2023.

Having achieved market recognition for infrastructure investment benchmarks, EDHECinfra was also renamed “EDHEC Infrastructure & Private Assets Research Institute” to reflect a new ambition for our work, with a focus on private equity and debt. privateMetrics, a new platform, will launch in 2023 and provide asset valuation tools and market indices for investors in private companies worldwide. While developing an indexing and benchmarking business, the institute continues to develop new research, including new work on the uses of machine learning to process text, accounting and geographic data and create new data on private markets. We are also regularly involved in regulatory and policy matters by providing free access to our unique data to prudential regulators and policy-setting bodies or government departments needing information on the procurement of infrastructure projects, in particular the cost of capital of private investors and the financial risks they face.

The EDHEC Infrastructure and Private Assets Research Institute is also supported in its endeavours by an international advisory board consisting of senior executives from the investment world. Since its creation, EDHEC Infrastructure and Private Assets Institute has published more than 50 academic research papers. Our data is also frequently used by the industry to produce research including by the Boston Consulting Group, BlackRock, Ares Management, PGIM, CBRE and many more. Research at EDHEC is both “for business” and “for good”: it has both commercial and social value.

Authors

Noël Amenc is an Associate Professor of Finance at EDHEC Business School, Director of Scientific Infra & Private Assets, and Senior Advisor to Scientific Beta, of which he was the founding CEO. Within EDHEC Business School, he is also Affiliate Member of the EDHEC Risk Climate Impact Institute. Prior to joining EDHEC Business School as founding director of EDHEC-Risk Institute, he was the Director of Research of Misys Asset Management Systems. He has published extensively in finance journals and contributed to four books on quantitative equity management, portfolio management, and alternative investments. He is a member of the editorial board of the *Journal of Portfolio Management*, associate editor of the *Journal of Alternative Investments*, and member of the advisory board of the *Journal of Index Investing*. He is also a member of the Finance Research Council of the Monetary Authority of Singapore. He was formerly a member of the Consultative Working Group of the European Securities and Markets Authority (ESMA) Financial Innovation Standing Committee and of the Scientific Advisory Council of the AMF (French financial regulatory authority). He holds graduate degrees in economics, finance and management and a PhD in finance.

Frédéric Blanc-Brude is the founding Director of EDHEC Infrastructure & Private Assets Research Institute, a dedicated research unit at EDHEC developing a unique body of applied research on private investment since 2016. He is also the CEO of Scientific Infra & Private Assets, a provider of unlisted investment equity and debt index data and analytics since 2019.
He joined EDHEC in 2012 after 10 years of private sector experience in the infrastructure finance field, and direct involvement in more than USD6bn of transactions. His research work focuses on asset pricing and the stochastic modelling of cash flows. He has published papers in economics and finance journals, recently co-authored a book on the valuation of unlisted infrastructure equity and debt investments. He is also a member of the editorial board of the *Journal of Alternative Investments* and a regular contributor to the work on long-term investment of the G20, EIOPA, IAIS and other regulatory bodies. He also represents EDHEC on the Advisory Board of the Global Infrastructure Facility of the World Bank and on the Blue Dot Network Executive Consultation Group. He holds graduate degrees from the London School of Economics, the Sorbonne, and Sciences Po Paris and a PhD in Finance (King's College).

Abhishek Gupta is an Associate Director at the EDHEC Infrastructure & Private Assets Institute and the Head of infraMetrics Product Development. He has more than 10 years of experience in asset management and alternative investments including stints at Goldman Sachs and Partners Group. He holds a Masters of Science in Financial Engineering from Nanyang Business School and a Bachelor of Technology from the Indian Institute of Technology.

Objectives of the Call and our Contribution

This document is a response to a call for evidence launched by the Department for Work and Pensions (DWP) in July 2023. The objective of the DWP document is to gather evidence as to whether defined benefit (DB) schemes can benefit from increasing their investments in productive finance, including infrastructure, while maintaining appropriate security of the pension benefits promised and meeting the other DB obligations.

The DWP has invited responses from stakeholders who can offer an informed perspective on how DB schemes engage with productive finance in practice and how that could change. As an independent academic institute and a regulated data provider, EDHEC*infra* is submitting this document as evidence supporting higher investment in infrastructure from DB pension schemes.

Having conducted more than seven years of research in this asset class, we know that infrastructure is an attractive asset class, both in terms of its risk-adjusted returns and its role as a diversifier to a portfolio primarily made up of stocks and bonds. A higher allocation to these investments can be used to construct more efficient portfolios, be it for a young scheme in accumulation phase or a mature scheme in decumulation phase.

In this document, we provide evidence on the usefulness of the infrastructure asset class in DB pension fund allocations. We also look at the shortcomings and limitations of these allocations due to data challenges. As with any investment, there are risks to investing in infrastructure and we will discuss them from the DB scheme perspective. Finally, as the DWP is also considering consolidation of funds, we also address the questions posed specifically by the consolidation.

Infrastructure investments (equity and debt) can play very useful roles in the portfolio of a DB pension plan

Infrastructure investments, which are common across the UK, consist of equity and debt investments in private (unlisted) companies that operate assets providing infrastructure services as defined in the TICCS classification of infrastructure companies. Infrastructure companies typically own outright, or have the right to operate, one or several large physical assets that are also immobile and single use. Their ability to operate these assets as a business is typically linked to a long-term contract or a licence granted by a public authority or sometimes a private counterparty.

It follows that these assets require a long time to repay their original investment and often have a fixed life (the concession contract term) which can be extended but otherwise gives the investment a fixed-term nature. In addition, the high upfront sunk costs required to develop infrastructure assets mean that they must generate significant free cash flow to repay investors over time. Indeed, research shows that infrastructure companies have very high dividend distribution levels compared with otherwise comparable private firms (Tan & Whittaker, 2020). The fixed term and high distribution profile of many infrastructure equity investments thus confers on them a bond-like quality, while retaining equity-like features (investors are the residual claimant).

Finally, the long-term and contracted nature of most infrastructure businesses enables them to raise significant amounts of debt, partly on the bond market but mostly in the form of non-recourse loans (so-called project finance). Privately placed infrastructure debt represents the most significant part of this asset class by size and is characterised by low credit risk levels and typically attractive spreads.

These characteristics are likely to play a useful role in the allocation of a pension fund. We return to these points below, after briefly describing the risk management framework of DB pension plans within which infrastructure could play a role.

DB financial investment management has the principal objectives of:

a) managing the plan's fundings ratio i.e., the ratio of the present value of its assets to that of its liabilities; and
b) controlling the volatility of this ratio, which is an indication of the plan's continued ability to service plan members.

Of course, proper liability hedging is done under the constraint of contributions, and it involves minimising these contributions for a targeted level of pensions. This dual goal of minimising contributions and hedging liabilities has given rise to an organisation of investment management that makes a distinction between two

"funds": one aiming to achieve the best absolute risk-adjusted performance, the Performance-Seeking Portfolio (PSP) which is typically not well-correlated with the liabilities of the plan, and one designed to manage the risk in the liabilities of the fund, the Liability-Hedging Portfolio (LHP).

The PSP can be designed to produce a level of performance above the cost of the liabilities, and therefore of their hedging by the LHP, and thereby contribute to a reduction in the plan's funding effort. In turn, the volatility of the funding ratio results from choosing the risky assets that make up the PSP in order to reduce the pension fund's required level of new funding.

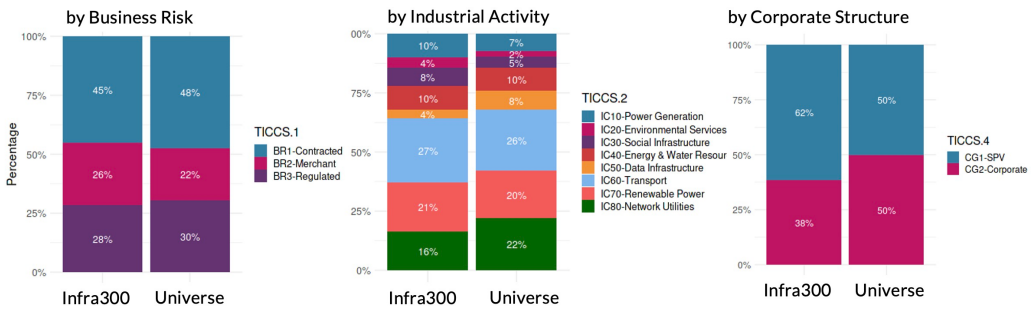
This fund separation approach is a key aspect of modern risk management for pension plans and highlights the multiple roles that infrastructure investments can play in DB plans. Indeed, the nature of infrastructure investments enables investors to benefit from both performance-seeking enhancements and liability-hedging benefits. We discuss these two points below, as well as the ability of infrastructure investments to generate income and/or to match cash flows.

Unlisted infrastructure equity in a performance-seeking portfolio

The goal of a PSP is to achieve the highest Sharpe ratio, i.e., the highest expected return per unit of risk. In other words, for a given level of risk, the best PSP is the combination of risky assets that obtains the highest return. In this context, investments offering an attractive Sharpe ratio to begin with should be of interest and even more so when return correlations with other asset classes in the portfolio are imperfect, thus reducing total portfolio risk and risk-adjusted returns.

The unlisted equity possesses these characteristics. In Table 1, we show the historical performance figures of unlisted infrastructure equity, represented by the infra300 index which tracks 300 infrastructure investments worldwide, and compare them with publicly traded equities. The infra300 is representative of the global infrastructure investment market since it is designed to match the weight of the unlisted infrastructure equity universe by TICCS® segments, namely Business Risk, Industrial Activity, and Corporate Structure, as shown in Figure 1.

Figure 1: The Historical Performance Figures of Unlisted Infrastructure Equity



The three panels show the investible universe (rhs) vs infra300® (lhs) weights by business risk, industrial activity and corporate structure according to TICCS®.

It important to note that these numbers are directly comparable because the infra300 index is calculated using a monthly updated assessment of its constituents' fair market value. This takes into account the full evolution of interest rates, the risk premium of the market for these types of assets (which is re-estimated monthly using observable secondary transactions) and any changes in the future cashflows of these firms. Hence, the level of volatility reported for the infrastructure asset are much higher than private appraisals might suggest but also much more realistic (we return to data issues in the next section). As shown in table 1, on a 10-year basis the risk of unlisted infrastructure is approximately 120bp lower than listed equities.

Over the past 10 years, infrastructure equity has outperformed publicly traded equities, delivering higher returns with a lower level of volatility, and leading to a Sharpe Ratio that is around 300bp higher on a 10-year basis. Table 1 also shows that that there is a similar difference of risk-adjusted profile between other asset classes at different investment horizons.

Table 2 shows the return correlations between unlisted infrastructure equity and traditional asset classes: it confirms that in the case of equities correlations are imperfect and quite low, while they are higher for bonds due to the income-driven nature of infrastructure assets and their resulting sensibility to interest rates. This *duration* of infrastructure equity investments is the result of their bond-like nature.

Correlation with listed equities total returns is low, which is to be expected given the large difference in cash yield (table 3) between the two. Since the total return is made of the price return and the cash yield, but most of the correlation between the two asset classes arises from the movement of the discount rate i.e., the price return, the larger cash yield of infrastructure companies tends to create a 'buffer' between the total return series. In effect, recent research shows that the correlation between infrastructure and equity returns is time-varying and increases significantly during times of market stress (Blanc-Brude, 2022). However, the level of correlation remains limited even in such periods, Meanwhile the correlation of infrastructure valuations with bonds is higher and remains so over time even though it has been shown to decrease in periods of market stress by the same research.

A recent study (Amenc, et al., 2021) on the desirable level of strategic allocation towards infrastructure equity and debt in a multi-asset class PSP with investments in 10 asset classes including stocks, bonds and other alternatives found that a typical investor could wish hold an allocation of up to 10% in infrastructure in their performance-seeking portfolio in order to achieve a maximal improvement in the Sharpe ratio. The paper also showed that under-funded, return-seeking plans, with a higher minimum return target for their portfolio, would allocate more to infrastructure equity, whereas better funded or more risk-averse investors, who aim to limit risk, would have a higher allocation to infrastructure debt.

Finally, introducing infrastructure equity to a PSP not only results in a more efficient portfolio, but can also serve a secondary purpose: it offers a hedge

against interest rate risk and reduces the need for explicit hedging, whether this involves a physical portfolio of bonds, a derivatives strategy or both.

Table 1: Performance of unlisted infrastructure equity (infra300 index) vs public equities (MSCI World index)

	Annualised return			Annualised volatility			Sharpe Ratio*		
	10-year	5-year	3-year	10-year	5-year	3-year	10-year	5-year	3-year
infra300	12.07%	9.53%	12.36%	10.57%	10.41%	10.47%	1.14	0.92	1.18
MSCI World	9.87%	8.56%	11.92%	11.81%	14.73%	12.56%	0.84	0.58	0.95

Source: infraMetrics®, Refinitiv. Based on monthly data as of 30 June 2023. *Assuming Rf=0

Table 2: Correlation coefficients of total returns (Local Currency) unlisted infrastructure equity (infra300 index) public equities (MSCI World index) and public bonds (FTSE World Broad Investment Grade Index)

	FTSE World IG Bond	MSCI World	infra300
FTSE World IG Bond	1.00	0.18	0.61
MSCI World	0.18	1.00	0.11
infra300	0.61	0.11	1.00

Source: infraMetrics®, Refinitiv. Based on monthly data from 2008-2023 as of 30 June 2023.

Table 3: Price and income return components of the unlisted infrastructure equity (infra300 index) and public equities (MSCI World index)

	Price Return			Income return		
	2020	2021	2022	2020	2021	2022
infra300	-9.19%	7.47%	-4.18%	7.33%	8.68%	9.97%
MSCI World	8.36%	21.78%	-19.13%	2.34%	2.20%	1.78%

Source: infraMetrics®, Refinitiv. Based on monthly data as of 30 June 2023.

This is due to the bond-like nature of infrastructure equity investments already highlighted above: these assets can have a (modified) duration of up to 15 years, and a positive convexity of c.40-150 due to their long investment horizon. By comparison, the S&P U.S. Treasury Bond Index has a duration of 5.2 years and a convexity of 0.69, according to infraMetrics. However, these interest rate hedging characteristics vary between types of infrastructure companies and activities, as shown in table 4, and need to be well-understood by investors. These characteristics imply that infrastructure investments can be a powerful hedge against the interest rate risk and, ultimately, help create a PSP that has a better correlation with liabilities.

Table 4: Average Duration of infrastructure companies by TICCS industrial activities

Industrial Activity	Avg Duration
Global infrastructure	6.87
Power Generation ex-Renewables	5.31
Social Infrastructure	6.15
Energy and Water Resources	8.06
Transport	7.61
Renewable Power	6.21
Network Utilities	7.95

Source: infraMetrics® as of 30 June 2023

As a result, a DB scheme that employs a cash-only investment strategy, with no leverage, can use its infrastructure equity allocation in the PSP to reduce the decorrelation between the PSP and the liabilities and reduce its dependency on and therefore its allocation to the liability-hedging portfolio. This partial correlation, if it is stable, therefore allows the level of contribution to be optimised for an identical level of volatility. On the other hand, a Liability-Driven Investment (LDI) strategy which relies on derivatives to hedge the interest rate risk can use infrastructure equity for this purpose and reduce the leverage of the portfolio, in turn reducing the risk.

Furthermore, in the case of mature funds, where the contributions are limited and do not cover pension payments, the risk management challenge is not only to improve the risk-exposure matching. Ideally, mature funds should also be able to meet their liabilities without having to liquidate assets, and therefore being subject to the price volatility potentially generated by liquidating assets. In this context, infrastructure equity, which pays much more stable dividends than public equities, would again be a positive addition; it would contribute both to an improvement in the risk-adjusted performance of the PSP and also to the liquidity of the plan from a cashflow-driven investing (CDI) perspective.

Private infrastructure debt in a liability-hedging portfolio

A LHP is not designed to fund the cost of the liabilities but to hedge their risk. It is common practice among pension plans to use government and corporate bonds to hedge their liabilities as they are both exposed to interest rate risk.

However, the role of infrastructure debt in the construction of liability-hedging portfolios can be even more significant.

Tables 5 and 6 show the risk/return profile and the total return correlations of investment grade bonds and private infrastructure debt. Public IG Bonds are represented by the FTSE World Broad Investment Grade Bond Index including government and corporate debt which makes this index a comprehensive representation of the global investment-grade universe. Private debt is represented by the infra300 Debt Index which tracks the performance of the most recent senior debt instruments issued by the constituents of the infra300® unlisted infrastructure equity index described above.

We see that infrastructure debt has a high correlation with public bonds (0.74 which is statistically significant at the 99% level) but also offers a superior performance with a lower risk level. As a result, the 10-year Sharpe ratio of infrastructure debt (0.73) is superior to that IG bonds (0.29). Infrastructure debt can have a duration of three to 12 years and a yield of 3-6%, on par with equivalent investment grade corporate bonds. But it also has a low probability of default and high recovery rates; as a result, the average expected loss is lower than 1% for investment grade private infrastructure debt. Table7shows the credit risk metrics of probability of default, loss-given default, and expected loss in the private infrastructure investment grade debt universe by maturity of the underlying loans. Thus, infrastructure debt can be a valuable addition in the LHP of a DB scheme portfolio: it would not only hedge as effectively against interest rate risk as public bonds, since it has comparable duration and credit quality, but would also contribute to the risk-adjusted return objective of the plan as indicated by its better Sharpe ratio.

Table 5: Performance of private infrastructure debt (infra300 Debt index) vs public bonds (FTSE World Broad Investment Grade Index)

	Annualised return			Annualised volatility			Sharpe Ratio		
	10-year	5-year	3-year	10-year	5-year	3-year	10-year	5-year	3-year
infra300 Debt	3.40%	0.76%	-2.71%	4.66%	5.08%	5.41%	0.73	0.15	n/r*
FTSE World IG Bond	1.22%	-0.40%	-4.48%	4.17%	5.19%	5.27%	0.29	n/r*	n/r*

* not relevant

Source: infraMetrics®, Refinitiv. Based on monthly data as of 30 June 2023. *Assuming Rf=0

Table 6: Correlation of private infrastructure debt (infra300 Debt index) compared against public equities (MSCI World index) and public bonds (FTSE World Broad Investment Grade Index)

	FTSE World IG Bond	MSCI World	infra300 Debt
FTSE World IG Bond	1.00	0.18	0.74
MSCI World	0.18	1.00	0.03
infra300 Debt	0.74	0.03	1.00

Source: infraMetrics®, Refinitiv. Based on monthly data from 2008 to 2023 as of 30 June 2023.

Table 7: Credit risk metrics in investment grade private infrastructure debt by maturity of the underlying loan instruments

	0-5 years	5-10 years	10-15 years	15+ years
Probability of default	0.9%	0.7%	0.6%	0.5%
Loss Given Default	12.0%	11.8%	9.1%	10.7%
Expected Loss	0.4%	0.4%	0.3%	0.3%

Source: infraMetrics® as of 31 March 2022

Infrastructure assets as a source of liquidity

Beyond the management of their funding ratio, DB schemes reaching the decumulation phase need to manage solvency and liquidity risks, so they are able to make pension payments in a timely manner.

Infrastructure debt is of course an income generating asset and can contribute to this objective since it is typically of high credit quality. Moreover, infrastructure equity pays stable dividends: the infra300 index exhibits a very persistent cash yield of 7-8% per annum over the last 20 years (appendix C). In comparison, the dividend yield of public equities is much lower at 2% per annum (table 3). This is due to the economic characteristics of infrastructure companies highlighted above: infrastructure businesses generate significant free cash and have limited re-investment needs. The dividend volatility of infrastructure equity investments is also typically low.

Drawing on these characteristics, a recent research paper by (Blanc-Brude & Shen, 2022) shows that adding infrastructure to a pension fund portfolio can indeed improve the cash flow and income generation potential of the PSP significantly, thus making an illiquid asset an effective source of liquidity for the plan.

Hence, both infrastructure equity and debt can contribute to a cash-flow driven strategy and support the objective to generate income for the plan, while improving the risk-adjusted returns of the PSP and maintaining the liability hedging properties of the LHP, all the while relying less on derivatives in the context of LDI strategies.

If infrastructure investment is such a good match for DB plans, why is it not more commonly found in pensions plans in the UK? **While infrastructure clearly have a lot to bring to many plans, there is a major hurdle: the type and quality of data on such assets available to investors has historically been remarkably poor and unreliable.**

Increasing pension plan allocations to illiquid asset like infrastructure does not make sense without good quality data on returns and risks

Reported private asset valuations are often wrong, making basic risk management impossible

Private infrastructure valuations are typically based on so-called “appraisals”: a process which consists of updating the previous period's net asset value (NAV) to adjust for changes in the financial conditions of the company and the market. In the case of infrastructure companies, such valuations are conducted using the so-called income method, as described in the IFRS 13 norm: future dividends or debt service payments are discounted at the appropriate discount rate to compute the net present value of the asset, also known as the NAV.

In principle, these NAV computations should comply with the following principles:

- The “future” cash flows should be the “expected” cash flows in the statistical sense; i.e., since cash flows are risky and their future value is uncertain, the best description of these future flows is a statistical distribution and its expected mean value.

- The discount rate used should incorporate, in the words of IFRS 13, the “latest” market information, namely a combination of risk-free rate of interest a.k.a. the time value of money and a risk premium, representing the market price of risk at the time of valuation. This calls for two important comments:

    - If the asset is long-lived, which infrastructure is, the correct risk-free rate is best embodied by a term structure spanning the expected life of the investment. Given the multi-decade time horizon of infrastructure investments, it should be immediately clear that the use of a full-term structure of interest rates implies a certain variability of the NAV. Indeed, as mentioned above, infrastructure can be expected to have bond-like characteristics, including a certain exposure to interest rate risk.

    - Regarding the risk premium, still following IFRS 13, the correct value should be the latest market price of risk given the risk of the future cash flows of the company. Since these risks value from one firm to the other (e.g., some have contracted revenues, some do not) a different risk premium should be computed for each firm that captures their exposure to these risks and the price that the market is willing to bear on that date to be exposed to them.

However, there is a long list of additional issues with the way NAV are computed for unlisted infrastructure companies. In 2022, EDHECinfra researchers conducted a series of semi-structured interviews with 12 individuals working in the field infrastructure asset valuation at prominent accounting firms and asset managers in the City of London. The stylised findings of these interviews are as follows:

- The future dividends used to compute NAVs are not statistical constructs based on the likelihood of revenues or free cash flows but a "base case" which may reflect positive or negative biases. For instance, numerous transportation projects are financed on the basis of over-optimistic traffic forecasts a.k.a. the optimism bias ((Blanc-Brude, et al., 2018), (Buhl, et al., 2006)). More recently, renewable energy projects have been financed on the basis of optimistic subsidy forecasts (which were then reversed). Examples abound of the limitations of the uncertainty of future cash flows in infrastructure businesses, but these are often not addressed in the forecasting of future dividends, which remains a static exercise.

- The manager's fund target IRR is often used as the discount rate to compute a NAV for unlisted infrastructure equity investment.

  This practice is very odd. It implies either that fund managers have set a target return to represent an implicit risk level, or that they can select assets that are so homogenous that they all have the exact same risk profile, implying the exact same discount rate. It also implies that this fixed number corresponds to the market price of risk at all times. This is clearly impossible to achieve in a market like unlisted infrastructure which is characterised by highly heterogenous assets, the demand for which (and therefore the market price of risk of which) has changed considerably in the past two decades.

  Instead, this practice suggests that a completely ad hoc discount rate is used to arrive as a NAV that embodies (by design) the target return of the fund, ensuring that it is met. In some cases, this practice may be akin to fraud.

- Risk-free rates used are always a moving average of short-term interest rates.

  This practice is extremely common and consists of ignoring the long-term nature of infrastructure investments and their potential exposure to interest rate risk. This is in direct contradiction with IFRS 13. It also leads to so-called "smoothing" of the reported NAVs which typically change very little over time as a result (we return to this phenomenon and the illusions created by NAV "unsmoothing" techniques below).

  The direct result of this practice is to ignore the duration of infrastructure cash flows and therefore their potential use in an integrated risk management framework, as described above. Moreover, the smoothing of NAVs precludes any measure of risk and therefore of return correlations

or extreme price variations; in other words, smoothing NAVs prevents any risk management. Clearly, this is not helping pension plans to invest in unlisted infrastructure.

- Some valuation firms use the Capital Asset Pricing Model (CAPM) to estimate risk premia i.e., the equity risk premium come from the listed equity market.

  Large accounting firms (but not all) fall in this category. Formally speaking, this is an improvement on the use of completely ad hoc numbers. But while this practice can at least be considered to follow a well-known theoretical framework, it poses a number of issues:

  - The CAPM is an important part of the development of modern finance theory: it states that the return of an investment can be explained by a linear combination of the market return (risk-free rate plus equity risk premia) with the asset correlation with this market (the asset market beta). However, the CAPM has been disproved numerous times in the academic literature (Fama & French 2004, Ross 1977, Elbannan 2015). In a nutshell, a single factor model fails to convincingly explain the variance of prices and equity returns. Instead, multiple systematic factors risk factors can be shown to proxy the risks and drive the valuation of equities much more accurately e.g., famously the value factor, the profit factor, etc.

  - When applying CAPM to unlisted infrastructure, auditors use, once again, a smoothed estimate of the market risk premium (see for instance: KPMG market risk premium report[1]) which, along with the bad interest rate assumptions mentioned above, creates further smoothing. Furthermore, they usually estimate the market beta of unlisted infrastructure companies using a listed market proxy, implying that a representative listed proxy of unlisted infrastructure exists. However, this is not the case. First, listed infrastructure companies are few and many been delisted in recent years. Second, a number of academic publications (Amenc et al 2017, Blanc-Brude et al 2016) have shown that the various listed infrastructure indices that exist do not capture the dynamic of private markets at all and are, in fact, perfectly correlated with listed equities as a whole. This leaves auditors with a bad proxy of the market beta of unlisted infrastructure.

  The result of this practice is to mis-represent the market price of risk of unlisted infrastructure investments and to further smooth NAVs and prevent any viable risk management by investors.

- Sometimes asset maturities are extended in order to keep the NAV constant and offset the impact of higher discount rates.

This practice was mentioned by one interviewee. In some circumstances, even smoothed discount rates have to be adjusted to reflect large changes in base rates, usually the result of changes in monetary policy. The practice of extending the horizon of the investment in an ad hoc manner in order to keep the NAV at the same level is not only in contradiction with IFRS 13 but also, if no other justification can be given, akin to fraud i.e., a wilful misrepresentation of the value of the asset.

- A "proprietary database of recent transactions" is used to "market check" the valuations.

  As well as using the income method, valuers can compare the resulting appraisals with recent transactions or 'comparables' using the so-called "market method" i.e., comparing price multiples such as Enterprise Value-to-Ebitda or Price-to-Sales.

  The issue here is the robustness of such statistics. In recent surveys of seminar and webinar participants, EDHECinfra asked practitioners how many "comparable transactions" they felt comfortable with to make such an assessment (which in reality it most probably is not) randomly drawing 10 data points for a data distribution to estimate its mean or quartile values leads to very poor and unreliable estimates , see Appendix B).

  In fact, given the heterogeneity and uniqueness of infrastructure companies, which practitioners are quick to acknowledge, the notion that a sufficient number of truly comparable transactions that took place in the recent past can be observed is fanciful at best. Since IFRS requires using data for current valuation date, even if comparable transactions can be observed, say, one year earlier, market conditions must have changed in the meantime and this data cannot be used as a direct proxy of current prices.

  There is a solution to this fundamental problem of data paucity in private asset valuation. It consists of applying finance theory to model and price the risk factors that are common to all assets and that explain observable market prices, and to use these to "shadow price" assets today. It is a much more accurate assessment than using recent transaction prices directly because it removes the idiosyncratic noise of individual cases and can be produced at scale. We return to this below.

- The choice of valuation methodology and the resulting NAVs changes for the same asset from on manager to another.

  Investors (limited partners) exposed to the same assets via two or more fund structures often find that the reported NAVs are not the same for that same investment. This confirms the ad hoc nature of the methods employed in many cases and the unreliable nature of valuations that are reported: of the two different NAVs that one pension funds receives for the same asset (from two fund managers), at least one must be false. Any LP invested in the same fund also receives a false NAV. It is in fact quite likely that both NAVs are false.

> In the end, the arbitrary nature of the inputs used to value private assets like infrastructure is obvious. Some professionals do not hesitate to call the "risk premium' they include into the discount rate the "fudge factor".

Generally speaking, there is a tendency amongst valuers and fund managers to avoid updating discount rates and to keep asset NAVs as stable as possible from the moment the investment has been made, regardless of the evolution of the market and of interest rates. One pension fund interviewed by EDHECinfra mentioned an infrastructure asset invested trough a fund that kept the exact same NAV for five years in a row.

Of course, smooth returns series lead to underestimating risk and correlations with other asset classes as shown in table 8: an appraisal-based index of infrastructure fund returns is found to have no statistically significant correlation with either stocks or bonds. This data is useless to estimate return co-variance between asset classes.

Table 8: Correlation of appraisal-based index (Preqin index) compared against public equities (MSCI World index) and public bonds (FTSE World Broad Investment Grade Index)

	Preqin Index	Equity	Bonds
Preqin Index	1.00	-0.06	-0.26
Equity	-0.06	1.00	0.30
Bonds	-0.26	0.30	1.00

Source: Preqin, Refinitiv. Based on quarterly data from 2008 to 2023 as of 31 March 2023 (the latest available from Preqin).

Furthermore, it should be noted that the common practice of using a mathematical technique called "unsmoothing" to remove the serial correlation in appraisal-based returns, does not really change the nature of the problem. Several such techniques exist and they all give different results! The choice of unsmoothing methods, key parameters and the number of relevant lags have a significant impact on the resulting "volatility". Unsmoothing methods are purely statistical and do not rely on the economic fundamentals that drive the variance of unlisted asset prices. While unsmoothing does change the data, it does not improve it. There is no reason to believe that risk measures derived using such techniques have anything to do with the actual risk inherent in the asset class. Unsmoothing appraisals is just another blind guess or an opportunity to manipulate the data.

Finally, appraisals are reported at best on a quarterly basis but are really only the object of a fundamental analysis conducted once a year, when auditors produce the company's financial accounts. This seasonality in the appraisal data has been shown in previous research (Bianchi et al 2017): appraisals only really change once a year, or when managers raise a new fund (Jenkinson et al 2013). Not only are appraisals infrequently reviewed, they are made available to investors in private funds with a lag of several quarters, making any appreciation of the state of the private asset portfolio relative to other asset classes impossible. With low frequency, stale and lagged data, it is hard for investors to understand the characteristics of the investments they have made and to assess their risks.

Thames Water: far from a unique case of risks that are poorly perceived by investors

These practices must also be put into a market context: for a relatively long period of time, with falling interest rates and high demand i.e., a falling risk premium, the fair market value of unlisted infrastructure asset increased steadily. Keeping assets undervalued for the entire holding period enables managers to show a surprise "bump" in the valuation on exit and to secure their carry, while highlighting their purported ability to select the best assets.

In a different rate environment, these incentives are reversed, and many private assets are now overvalued, as confirmed by recent industry surveys (Preqin Investor Outlook[1]), but it remains the case that reported private asset values are not representative of market prices and that these practices render any attempt at risk management impossible for investors.

However, it must also be acknowledged that keeping NAVs as smooth as possible is not only the result of bad or flawed valuation practices but also that of what the literature calls "the demand for smoothness" expressed by some investors in illiquid assets. Indeed, in interviews, fund managers are quick to mention that the CIO of a pension plan values the fact that the private part of their portfolio is not volatile. This of course leads to a lower volatility of the funding ratio but not for the right reasons.

For instance, the decisions made by the UK University Superannuation Scheme (USS) to invest in Thames Water, the London water utility, suggest that the plan was unaware of the level of risk and of the true value of the company. Over the past several years, USS invested several times in the famed utility, each time at higher reported valuations. In March 2022, it increased its stake and also reported a higher value for its existing investment, aligning the appraisal of its c.20% stake with that of OMERS, the majority shareholder, a Canadian DB pension plan. However, in December 2022, OMERS suddenly marked down the value of this investment by 28% (Financial Times, July 2023). In effect, the company is crippled with multiple layers of debt and faces rising costs including debt servicing costs that indexed on inflation. USS now has to recognise the same loss. Many stakeholders seemed surprised by the size of this loss in value. After all, it seems unlikely that a large water utility could lose almost one third of its value in less than nine months... However, this is not what happened. The owners of Thames Water recognised a large loss in December 2022 when in fact the company had been getting riskier and losing value for a decade! (a forthcoming publication by Blanc-Brude & Whitaker develops this case in more details).

When computing the fair market value of Thames Water using a more adequate methodology that captures the impact of cash flows, rates and the cost of risk, a different picture than the one presented by appraisals appears (we return to this methodology below). As shown in table 9, the trends in both Thames Water's cost of capital and volatility should have been warnings of the operator's financial difficulties. Table 9 also shows that Thames Water was always riskier than its peers, i.e., other regulated utilities. Under different periods of private management, the value of the firm, e.g., its price-to-sales ratio decreased steadily,

while that of other utilities increased. But these risks and their impact on the true market value of Thames Water were not recognised by its owners, who remained blinded by the stale valuations reported by their auditor.

Nor is Thames Water an isolated case. Table 10 provides several other examples of the materialisation of extreme financial risks in the infrastructure asset class. In each case, the risk of these assets (their volatility) was higher than that of global infrastructure (infra300 index) but also of the sector to which they belonged. Impairments and defaults had become more likely as the true risk increased. Investors eventually suffered large losses. Of course, most infrastructure investments do not suffer large impairments or defaults, but these examples are a good illustration of the fact that for pension funds to ignore risk (the demand for smoothness) can only be a short term and, in the end, delusional approach. Instead, they need better data to measure the fair value and the volatility of unlisted infrastructure equity and debt.

One can add that the additional risks created by climate change for infrastructure investments add another layer of complexity to this issue: infrastructure companies are large carbon emitters in some cases, and also exposed to significant physical risks, like flooding and storms. Our survey of valuers confirmed that these risks are thoroughly ignored by current appraisals methodologies of private assets (we also return to this below).

It should be highlighted that such limitations, and sometimes apparent disregard for accurate asset valuations, have direct implications for the valuation of pension rights and the distortion of benefits between pensioners. They can lead to under or over-valuation of assets when determining annuity guarantees or calculating lump sums, which in both cases are non-revisable, even in the case of revaluation of the assets.

Table 9: Risk & Valuation Metrics for Thames Water Utilities, Global Utilities and the infra300® market index

Date	Segment	Volatility*	Value-at-Risk**	Median Price/Sales	Median EV/EBITDA
2013	Thames Water	18.9%	-33.1%	3.73	10.30
	Global Regulated Utilities	13.4%	-11.3%	2.22	8.92
	infra300	8.3%	-1.2%	2.19	9.69
2017	Thames Water	38.6%	-68.1%	1.77	8.13
	Global Regulated Utilities	13.8%	-11.1%	2.44	12.33
	infra300	8.8%	-3.0%	2.62	11.83
2020	Thames Water	38.0%	-63.0%	1.94	8.45
	Global Regulated Utilities	13.0%	-8.5%	2.42	11.69
	infra300	8.6%	-1.7%	2.79	12.00
Q1 2023	Thames Water	37.9%	-64.5%	1.54	7.69
	Global Regulated Utilities	12.9%	-12.7%	2.06	12.81
	infra300	10.4%	-7.0%	2.93	11.66

Source: infraMetrics. *Standard deviation of monthly returns over a historical 10-year period. **Gaussian value-at-risk at 97.5% confidence interval.

Table 10: Impairments, Defaults and Related Volatility of Infrastructure Projects

Company	Sector	Country	Event Detail	Value Before the Event (USD)	Price After the Event (USD)	Loss of Value	Volatility Before the Event		
							Company	Segment	infra300
Bluewaters Power Station	Coal-fired power	Australia	Default in 2012	87,929,231	63,280,539	-28%	21.2%	10.9%	10.3%
Line 9 Metro Arganda	Urban mass transit	Spain	Impairment in 2020	51,568,739	33,186,324	-36%	21.8%	13.1%	8.9%
A-70 Circunvalacion de Alicante	Motorway	Spain	Default in 2012	25,195,207	-	-100%	21.6%	9.9%	6.6%
Nottingham Express Transit	Urban light rail	UK	Default in 2018	474,227,049	340,903,055	-28%	27.4%	11.2%	8.3%
Robin Hood Airport Doncaster Sheffield	Airport	UK	Impairment in 2013	182,580,630	53,902,406	-70%	21.5%	13.8%	10.3%

Source: infraMetrics. The segments used to qualify the business risk are those determined in the TICCS framewok and representative of the sector and operational risk of the infrastructure investment in quetion. Volatility is calculated over periods of two years prior to the occurrence of the event affecting the infrastructure investment under conside ration.

Pension plans need quantified, robust and market-based risk metrics to invest in illiquid assets with confidence and at scale.

So far, we have shown that unlisted infrastructure presents all the characteristics of a very useful asset class for DB plans but also that the current state of the data used in private markets makes it almost impossible to harvest these benefits. Instead, investors are left with information that fails to represent the value of their holding, or the risks of their investment strategy, and precludes any serious risk management, including any use of infrastructure investments in an ALM context. We have shown that this state of affairs is the result of poor valuation and reporting practices and sometimes of the complicit demand for smoothness of the plans themselves.

However, the history of the development of any alternative asset class tends to follow a path from being small and opaque to growing into a sufficiently prominent type of financial asset that new research and innovation take place to better understand its characteristics, market dynamics, and its role in the portfolio of investors.

Three major evolutions have taken place in recent years that make the infrastructure asset class better understood and allow investors to measure and manage the risks of their infrastructure exposure:

1. The creation of a taxonomy of infrastructure companies allowing a proper mapping of the risks by segment and benchmarking of the asset class.
2. The development of a mark-to-market approach allowing high-frequency and robust asset valuations to be produced.
3. The creation of a body of knowledge about the exposure of infrastructure assets to climate risks and their integration in a forward-looking risk framework.

TICCS

The Infrastructure Company Classification Standard[1] (TICCS®) was created by EDHEC*infra* to provide investors with a frame of reference to approach the asset class. It is a common classification standard that focuses on organising individual infrastructure companies into business risk, activity, corporate structure and geo-economic buckets. While it aims to categorise companies based on their *prima facie* characteristics, it focuses on groupings that are related to risk the riskiness of the investment. As a result, TICCS segments are useful to value infrastructure investment since they capture common characteristics.

TICCS offers an alternative to investment categories that are inherited from the private equity and real-estate universe e.g., “Core” or “Core+” which are not

consensus and therefore may not be the most informative when trying to group infrastructure investments and create benchmarks.

Today, TICCS is used by numerous investors including some of the largest asset managers in the world. TICCS is also reviewed biennially and the market consensus about TICCS is guaranteed by an independent review committee chaired by the Royal Institute of Chartered Surveyors and which includes a dozen major investors, managers and standard setters.

Thank to this consensus approach it is possible to define objectively the type of infrastructure investments to which a plan is exposed to wants to be exposed e.g., contracted renewable and social infrastructure projects, and to design the adequate risk and return benchmark.

Marking infrequently traded, heterogenous assets to market is possible

Once infrastructure companies are organised into clear buckets, they can be priced on a regular basis by transforming recent transactions into a series of risk premia that are common to all investments.

For example, say a road project needs to be valued today. There may not be many recent transactions that are sufficiently comparable to this specific project. Roads do not trade very frequently and they can have different characteristics e.g., some have contracted revenues like PFI roads in the UK, while others have merchant revenues (tolls). However, these assets and all other infrastructure companies share a number of key risk factors that are priced in each transaction: for example the size (Total Assets) or the profitability of the company are common proxies of the risk of the investment. If the impact of these factors on the valuation of the asset are both independent and measurable statistically, then these individual risk premia can be used to produce a calculate the total risk premium for any infrastructure company on the same date.

Thus, the scientific asset pricing of infrastructure companies can be based on statistically robust risk factors that correspond to their observable financial characteristics. While each infrastructure investment is different, they are all exposed to these same risk factors, only in different quantities. This process is summarised in appendix A.

As well as computing the latest risk premium for individual firms, given their individual exposures to each risk factor, it is possible to use a full-term structure of risk-free rate to build the discount factors that are used to discount future dividends. For instance, valuating an off-shore wind energy project in the UK with an economic life of 25 years requires using a 25-year term structure of gilt yields to which the relevant risk premium is added to discount each future dividend back to the valuation date.

Finally, a statistical model of future dividends uses a large database of historical data about infrastructure companies to take into account their financial structure, age, lifecycle and business model. Out-of-sample precision for such cash flow models is typically within 3%.

We have shown in several publications that a combination of TICCS® segmentation and risk factor exposures enables investors to estimate the fair market value for any infrastructure investment with a high degree of precision: once the asset does trade, the predicted price is typically very close. Table 11 compares more than 250 reported infrastructure investment transaction values against the predicted values in infraMetrics. On aggregate, the errors are less than 1%, and the 10th and 90th percentile error is less than 5%.

Table 11: Distribution of estimation errors in the valuation of infrastructure transactions

10% quantile	25% quantile	Median	Mean	75% quantile	90% quantile
-5.00%	-1.95%	-0.22%	-0.55%	1.64%	3.85%

Source: infraMetrics

Thus, it is possible to largely improve the current state of valuations and reporting that characterises investment in private assets like infrastructure by UK pension plans and to address many of the issues described earlier: as we showed in the first part of this response, when fair value and risk are measured adequately, the investment profile of infrastructure companies is revealed to be highly attractive to DB plans. But as long as fair value and risk are not measured, as described in the second part of our response, UK DB plans will continue to either not invest in infrastructure or fail to invest wisely and face the consequences of not managing the risks they are taking.

Integrating Climate Risks

In the context of their decisions to invest in infrastructure, pension plans, like other investors, need to take climate risks into account. Indeed, their liabilities typically stretch far into the future, and their assets will thus necessarily be exposed to climate risks.

Will the world and the UK follow a decarbonisation pathway which implies significant transition risks for investors in infrastructure, including the costs of decarbonisation, that of carbon taxes, potential changes of consumer preferences e.g., air travel, etc? Conversely, in the absence of decarbonisation, physical risks are expected to increase significantly and could lead to the partial or complete destruction of certain infrastructure assets, even before 2050. Moreover, physical risk can be expected to increase capital and operating costs and to

These questions have been addressed in very recent research published by EDHEC*infra*.

- A first finding of this research is that a disorderly climate transition represents a risk of at least USD600bn for investors in infrastructure worldwide by 2050 i.e. about one quarter of the current market value of all privately invested infrastructure in the 27 most active markets (Amenc, et al., 2023).

- A second finding is that, in the absence of an energy transition, the cost of physical risks will double by 2050 and that in extreme cases, investors with most exposed assets may experience large losses of more than half of the portfolio value (Amenc, et al., 2023). This level of extreme risk is explained by the high level of concentration of infrastructure portfolios in direct investments from investors (10 projects on average) and their managers (20 projects on average) and by the lack of knowledge, and therefore lack of integration, of the veritable exposures to physical infrastructure climate risk.

Such results require two types of data: first a robust asset pricing framework like the one described above, as well as asset-level climate risk exposure data, either in the form of carbon emission estimates or physical risk exposures to flood, high heat etc. These two inputs can be jointly used in the context of existing climate scenarios e.g., NGFS and produce estimates of the financial losses that climate change can create for investors in these assets. Certainly, these risks should not be ignored, and DB schemes need to have an accurate picture of their baseline valuations to estimate and manage the climate risks. A summary of these research findings can also be found in Appendix D of this document.

Thus, it is possible to vastly improve on what currently exists both in terms of valuations and financial and non-financial risk measurements. Achieving this level of scientific methods and transparency will be a steppingstone on the path towards a more sophisticated and more beneficial to current and future pensioners private asset classes.

The consolidation of DB plans requires consistency of private asset valuations

The DWP is also considering options for DB schemes to be consolidated. This process is the opportunity to implement the reforms and transformations that will address the issues described above and bring UK pensions into a modern future.

Elsewhere in the world, pension investors are already asking these same questions and advancing new rules to address them. From Denmark to Australia to some of the largest Canadian plans, numerous investors have adopted better reporting practices and use modern asset pricing methods to better understand and manage the risks of their investments in infrastructure.

Consolidation is the opportunity for DB plans to be managed and regulated in a much more prudent manner with a focus on transparency and reporting.

A key issue when it comes to this consolidation and unlisted private assets like infrastructure then is the prerequisite to obtain precise and consistent valuation estimates of the private assets in the individual DB pension portfolios. As we know already and discussed above, most private asset NAVs in UK plans are not genuinely marked to market and even the same assets can have different marks.

A focus must be given to the quality of methodologies and data and to the independence of the valuations. Ultimately if these valuations depend on methodological choices made by individual funds, then there is a risk of unfair consolidation of the assets.

Conclusion

The DWP issued a call for evidence to understand if a larger investment in infrastructure can be beneficial for DB schemes and at the same time allow the pensions to limit the risk and volatility.

In this document, we showed that there exists sufficient evidence that both infrastructure equity and debt can be useful additions to a DB pension's portfolio. They have an attractive risk-return profile and can act as a portfolio diversifier. They can contribute to a cash-flow driven strategy and support the objective to generate income for the plan, while improving the risk-adjusted returns of the performance-seeking portfolio and maintaining its liability hedging properties.

But there is a major stumbling block preventing this development from taking place: the type and quality of data available to investors in such assets has been remarkably poor and unreliable. The tendency to rely on contributed appraisal data, which is common in private markets, and not on information that accurately represents the risks of the asset class, masks the true characteristics of these investments, and precludes any rational decision-making process when it comes to investing in infrastructure.

We showed that while on aggregate infrastructure has a lower volatility than its public counterparts, there have also been multiple cases of infrastructure companies going bankrupt or face significant write downs. Robust data enables an investor to be aware of these risks and, more importantly, manage them in a timely manner. As long as fair value and risk are not properly measured, UK DB plans will continue to either not invest in infrastructure or fail to invest wisely and face the consequences of not managing the risks.

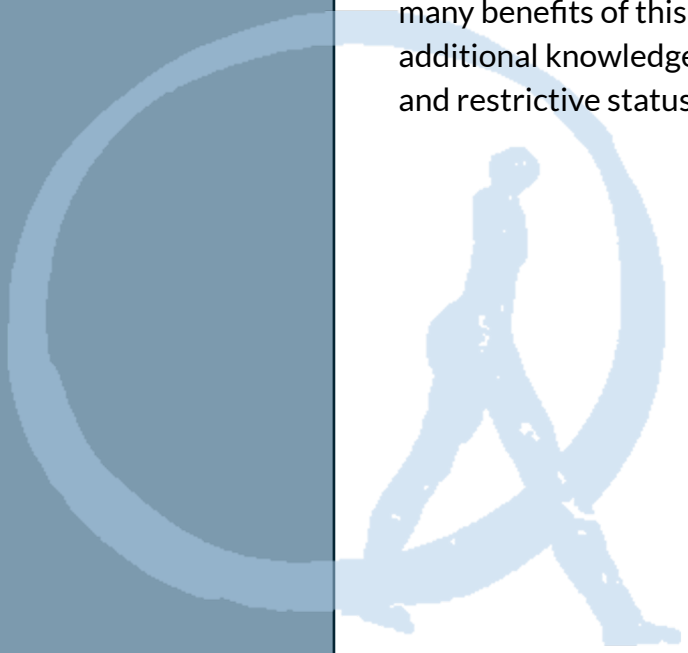
With poor quality data, UK DB plans also face the risk of mistreatment of pension rights. The annuity guarantees or lump sum calculations based on incorrect data can lead to an unfair valuation of pension rights and distort the benefits received by the pensioners. In the same way, fair valuation of all private assets, including infrastructure, is an important issue in the area of pension fund consolidations or buy-outs.

However, in recent years, there have been major advancements in the quality of the data available to the investors and regulators. As a result, it is possible to do much better both in terms of valuations, but also financial and climate risk measurements. Robust data will also allow a fair consolidation of funds which won't depend on the methodological choices used by the individual funds.

We therefore think that there is now nothing to prevent the adoption of serious infrastructure valuation practices that use the right comparables to estimate the risk premium and therefore the right discount rates to use in infrastructure valuation. In the same way, relevant market indices for this class of investment enable pension fund capital to be allocated efficiently and the risk of this allocation to be managed.

In this context, it seems important to us that The Pensions Regulator should set up best practice rules and require pension funds to show that they have a serious investment process for this asset class, which should not remain marginal in institutional investors' allocations due to its macro and microeconomic benefits.

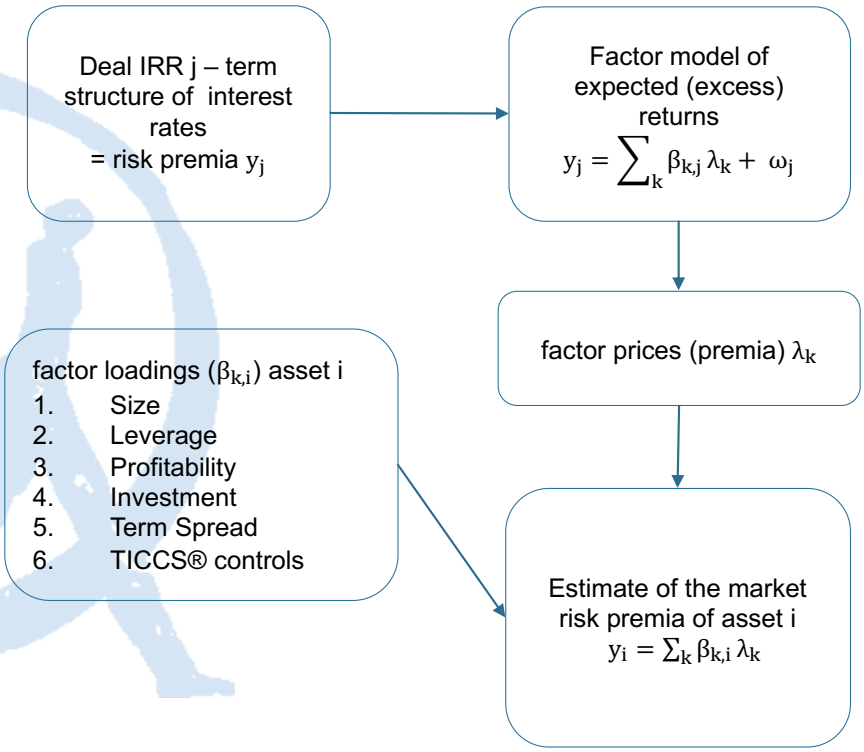
De facto, we believe the idea of the infrastructure asset class being "too small to be important and deserve attention" is depriving pensioners of the many benefits of this asset class, and it is an excellent thing that this additional knowledge of risks can enable us to emerge from this negative and restrictive status.



Appendices

APPENDIX A: EDHEC*infra* valuation methodology

- We observe expected returns in new secondary market transaction, each quarter
- We estimate the impact of a limited set of risk factors on expected returns
- Each deal corresponds to the same risk factor exposures, only in different quantities (β)
- The market price of each risk factor is the same for all firms (λ)
- Once we know the price of each risk premium, we can apply it to any untraded company because it is exposed to the same factors



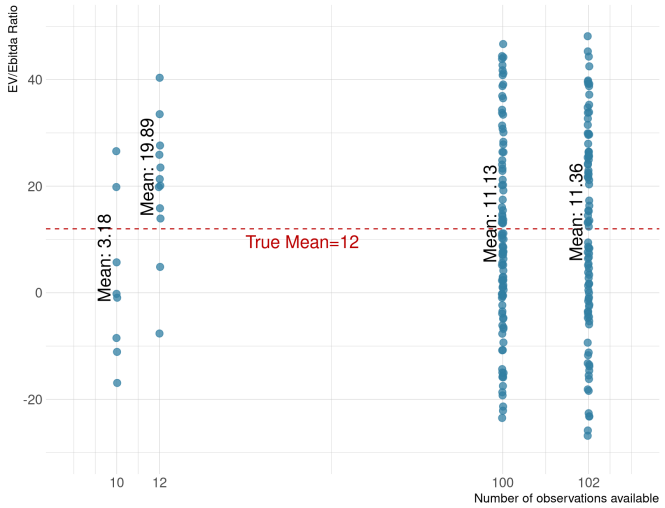
APPENDIX B: Appropriate and robust number of comparable transactions

1. EDHEC*infra* surveyed its seminar and webinar participants from the investment industry on how many "comparable transactions" they felt comfortable to make a valuation assessment. Majority of the participants said 10 transactions are enough to make a valuation assessment.

Number of transactions	Survey responses
5	19%
10	53%
50	19%
100	8%

2. An illustration of a statistically robust set of comparable transactions:
    a. Let's say we want to make investment that has a true market EV/Ebitda of 12x **on average**, but that can vary between -50x (negative Ebitda) to +100x between deals for many different, asset-specific reasons.
    b. We don't know the true average market value, but we try to find out by looking at some "recent transactions"
    c. We can assume that the EV/Ebitda ratio is normally distributed and draw random sample datapoints

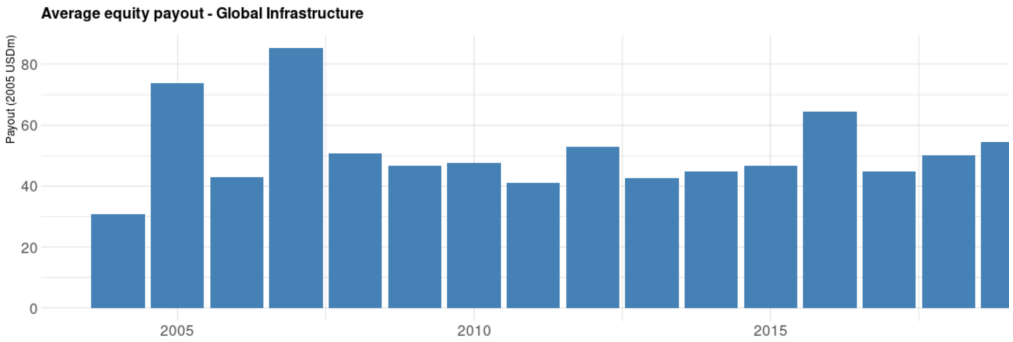
    Mean calculation of the sample with draws of 10, 12, 100, and 102 datapoints



    d. If we can only observe ten randomly selected "recent transactions", we get a very imprecise estimate of the true value of the market.
    e. If we observe just **two** more randomly selected transactions, we get can get a completely different picture.
    f. If we can observer a larger sample of 100 recent deals selected randomly, we still don't find the true market value (11.13x), but we get a lot closer to where the market is really at.
    g. And if we again observe **two** more (102) randomly selected datapoints, our estimate is not very different that with 100 deals.
    h. The size of the error between observing a dozen deals and observing 100+ deals is several orders of magnitude larger for the small sample.
    i. Robustness is not achieved by adding 'a few more data points'; it requires a minimum amount of data, below which comparables are meaningless, and above which more data makes less of a difference.

APPENDIX C: Stable dividends in unlisted infrastructure equity investments

- Average annual dividend per year, across 500+ infrastructure firms globally



- While the dividends in unlisted infrastructure companies individually can be quite erratic, on aggregate, the dividends are stable at USD40m-60m per annum.

APPENDIX D: Summary of EDHEC Research Paper "It's getting physical" Published in September 2023 (url)

This paper shows that the physical risks created by climate change are not limited to a distant future for investors in infrastructure, some of whom could well lose more than 50% of the value of their portfolio to physical climate risk before 2050 in the event of runaway climate change. Moreover, the average investor will also lose twice as much to extreme weather, mostly in OECD countries, compared to a low carbon scenario.

The numbers are significant: over the past two decades, institutional investors have increasingly allocated capital to private, mostly unlisted, infrastructure companies like toll roads, airports, power plants and pipelines. infraMetrics tracks a universe representing approximately USD4.1 trillion of enterprise value and USD2.2 trillion of market capitalisation at current market prices in 25 key markets.

Floods and storms are the most common types of climate-related events, but extreme temperature events are also on the rise as global warming increasing their frequency and intensity. If climate change speeds up, these trends are also forecast to become more frequent and more severe. Using a very granular database of asset-level physical risk estimates and financial data, we find that the impact of runaway Climate Change on the value of infrastructure investments before 2050 is significant. We also find that if no serious measures are taken, financial losses from physical risk (which are never zero) would be twice as high than in a low carbon scenario, for all investors.

In this note, we describe our approach to measure baseline physical risks (today) and how physical risks would materialise from that baseline in different climate scenarios in terms of their impact on cash flows and discount rates at the asset

level. We also look at how physical risks, despite being asset specific, are not easily diversified for most investors, some of whom could have a high concentration of such risks in their portfolios.

Our research shows that the cost of physical risks within the "Current Policies" scenario represents, on average, 4.4% of the total NAV of the assets in our reference database by 2050. The average maximum loss is -27% and we see that the effect of extreme climate events is negative across all sectors, impacting the NAV of transport (-10% on average with a maximum of -97%) and the energy and water resources sector (-7% on average, with a maximum of -40%).

Moreover, most investors in infrastructure hold a few individual assets and therefore have potentially high concentration in physical risks. Investors who hold direct stakes in infrastructure assets, be they fund managers or asset owners, usually have fewer than 20 investments. The average asset owner typically has fewer than 10 direct stakes. As such, when an investor finds themselves exposed to the riskiest assets in the same portfolio, losses can mount to 27% in the orderly transition scenario and to 54% in the "Hot House" scenario.

2050 is still 30 years away and past the investment horizon of investment funds, but many are now exposed to much longer-term investments. Moreover, the next generation of funds will pick up the same assets.

Climate change risks are already material for a number of investors in infrastructure assets even if these are located in developed economies. This challenges the intuition of many investors that these risks would impact first and foremost the poorer populations of the global south. Instead, the reverse is true: more value will be destroyed in places where more valuable assets exist. It should also be noted that our loss estimates can be considered very conservative in the light of the very limited impact of physical risk on the economy implied by the scenario used by the Network for Greening of the Financial System (NGFS). A 'too little, too late' scenario, by which emissions keep rising and climate change happens faster, would show a rapidly decreasing value of infrastructure assets due to their loss of future revenues, itself the result of a less active economy, mostly due to chronic heat.

This focus on the materiality of the physical risks allows climate risk to be seen not solely as the result of a public policy decision but as a reality that, without action from all stakeholders, including governments, will have a very significant impact on the value of investments.

References

• Amenc, N., Blanc-Brude, F., & Gupta, A. (2021). Strategic Asset Allocation with Unlisted Infrastructure, EDHECinfra white paper.
• Amenc, N., Blanc-Brude, F., Chreng, A., & Tran, C. (2017). The Rise of "Fake Infra": The Unregulated Growth of Listed Infrastructure and the Dangers It Poses to the Future of Infrastructure Investing, EDHECinfra white paper.
• Amenc, N., Blanc-Brude, F., Gupta, A., Jayles, B., Manocha, N., & Marcelo, D. (2023). It's getting physical, EDHECinfra Inframetrics white paper.
• Amenc, N., Blanc-Brude, F., Gupta, A., Jayles, B., Marcelo, D., & Orminski, J. (2023). Highway to Hell: Climate Risks will cost hundreds of billions to investors in infrastructure before 2050, EDHECinfra Inframetrics white paper.
• Bianchi, R., Drew, M., & Whittaker, T. (2017). Unlisted Infrastructure: Biases in Appraisal-Based Valuations?, EDHECinfra white paper.
• Blanc-Brude, F. (2022). Is Infrastructure Shockproof? The Resilience of Infrastructure Equity Investments During Market Downturns, 2000-2022, EDHECinfra Inframetrics white paper.
• Blanc-Brude, F., & Shen, J. (2022). Building Portfolios with Infrastructure. Performance, Cash Flows & Portfolio Allocation, EDHECinfra Inframetrics white paper.
• Blanc-Brude, F., Moraleja, S. G., & Whittaker, T. (2018). Take the Next Exit – A Case Study of Road Investments Gone Wrong, Spain, 1998-2018, EDHECinfra white paper.
• Blanc-Brude, F., Whittaker, T., & Wilde, S. (2016). Searching for a Listed Infrastructure Asset Class, EDHECinfra white paper.
• Buhl, S., Flyvbjerg, B., & Skamris, M. (2006). Inaccuracy in Traffic Forecasts, Transport Reviews 26(1): 1-24.
• Elbannan, M. A. (2015). The capital asset pricing model: an overview of the theory, Journal of Economics and Finance 7(1): 216-228.
• Fama, E., & French, K. (2004). The capital asset pricing model: Theory and evidence, Journal of Economic Perspectives (18)3: 25-46.
• Jenkinson, T., Sousa, M., & Stucke, R. (2013). How Fair are the Valuations of Private Equity Funds, available at SSRN 2229547.
• OECD. (2021). Annual Survey of Large Pension Funds and Public Pension Reserve Funds: Report on pension funds' long-term investments, OECD, available at https://www.oecd.org/finance/private-pensions/survey-large-pension-funds.htm.
• Ross, S. (1977). The Capital Asset Pricing Model (CAPM), Short-Sale Restrictions and Related Issues, The Journal of Finance (1): 177-183.
• Tan, R., & Whittaker, T. (2020). Anatomy of a Cash Cow: An In-Depth Look at the Financial Characteristics of Infrastructure Companies, EDHECinfra white paper.