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RESEARCH INSIGHTS

EDHEC BUSINESS SCHOOL

EDHEC*infra* & Private Assets

Contents

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Introduction

I am delighted to introduce the infrastructure investment special issue of the EDHEC*Infra* & Private Assets Research Institute supplement to Investment & Pensions Europe. Here we present the results of our most recent investigations with the aim of providing institutional investors with an academic research perspective on some of the most pressing issues facing them today.

Our first two articles delve into the field of environmental, social and governance risks, and the implications these hold for the investment community. In the first, we explore the practical challenges of using the EU Taxonomy for Sustainable Activities to assess the sustainability of the infrastructure asset class and conclude that, while the taxonomy marks a significant step, it does not provide comprehensive insights. In the second, we develop Social Risk Sector Ratings and conduct a case study to examine how social acceptance on the sector level affects social risk levels for water companies in the UK. Significantly, our analysis shows that acceptance levels align with sector trends and reveals statistically significant relationships between sector sentiment and company support.

Our next two papers look at the investment implications of climate risk for global infrastructure. We first explore the substantial financial risks posed by climate change to infrastructure investments, which include both physical risks from extreme weather events and transition risks related to the shift towards greener technologies. We then present the findings of a survey of the international investment community which revealed that they are concerned and lack data regarding the physical climate risks overhanging the sector. These risks could be huge and could wipe as much as 54% off the value of portfolios. Concerned investors say they have little confidence in the advice and data they are receiving.

Our final two articles present some of our latest research insights into infrastructure investment portfolio construction and risk management. The penultimate piece reveals how investors in Thames Water could have learned about the entity's risk and likely market value much earlier had they compared its characteristics to market and peer group data. A straightforward comparative analysis would have signalled a high-risk, low-return profile that should have raised numerous red flags. Our final paper looks at the challenging goal of achieving diversification in unlisted infrastructure investments, given their pronounced illiquidity. We show that a 'Smart Infra' approach, focusing on diversifying factor risks, makes broad diversification feasible even given these hurdles.

We wish you an enjoyable read and extend our warmest thanks to IPE for their collaboration on the supplement.

Frédéric Blanc-Brude, Founding Director, EDHEC*Infra* & Private Assets Research Institute

Using taxonomies to qualify the sustainability of infrastructure investments

Nishtha Manocha, Senior Research Engineer, EDHEC*Infra* & Private Assets Research Institute; **Rob Arnold**, Sustainability Research Director, EDHEC-Risk Climate Impact Institute

The EU Taxonomy is the first global effort to address environmental sustainability and to provide a robust framework for classifying economic activities based on their environmental impact.

In this study, we explore the practical challenges of using the taxonomy to assess the sustainability of the infrastructure asset class.

We conclude that, while it marks a significant step in identifying sustainable economic activities, it does not provide comprehensive insights for the infrastructure asset class.

We recognise the need for deeper insights into asset-level actions and strategies that can bridge the gap between eligibility and alignment with the EU Taxonomy's sustainability criteria.

Introduction

This study explores the practical challenges of using the EU Taxonomy for Sustainable Activities to assess the sustainability of the infrastructure asset class. It concludes that, while the EU Taxonomy marks a significant step in identifying sustainable economic activities, it does not provide comprehensive insights for the infrastructure asset class. By mapping the EU Taxonomy to the infrastructure asset class using TICCS, we address how green taxonomies can be applied to infrastructure sustainability assessments. We also propose key improvements to enhance the applicability of such green taxonomies in identifying and promoting the transition to a low carbon economy.

We also use the suggested mapping as a framework to assess the sustainability of the European infrastructure asset class under the EU Taxonomy. We find that $1.5trn of the European infrastructure asset class (in the European Economic Area and UK) by size is likely to qualify as sustainable under the EU Taxonomy, while about $20bn of assets by size is likely to have no sustainable characteristics and could be stranded in the transition to a low-carbon economy. Additionally, more than $215bn of infrastructure is not aligned with the taxonomy's current description of sustainability.[1]

The role of sustainable taxonomies

The EU Taxonomy is the first global effort to address environmental sustainability and to provide a robust framework for classifying economic activities based on their environmental impact. The primary objective of the EU Taxonomy is to assist investors in discerning sustainable investment opportunities while preventing the misrepresentation of sustainability. Furthermore, the EU Taxonomy seeks to streamline investments aimed at transitioning towards a sustainable, low-carbon economy. Consequently, it holds significant sway over the perception and strategic approach to assets within the European Union, including infrastructure assets and financial products based on them.

Classifying an infrastructure asset as sustainable is likely to confer several advantages on it. Sustainable investments qualify for public sector financial incentives, such as cash grants, soft loans and tax incentives, as well as increased access to private sector loans that may have more favourable terms than the market standard. A sustainable classification may also signify that the asset is aligned with long-term climate policy objectives that enable the transition to a low-carbon economy, thus making it attractive to long-term investors during the transition to a low-carbon economy.

Assets that fail to qualify as sustainable in the EU Taxonomy will be ineligible for participation in EU green finance programmes. Ineligibility may arise from underlying technology or geographic location, an inability to shift away from greenhouse gas-emitting processes or difficulties in complying with regulatory requirements, hindering the collective transition to a low-carbon economy.

A framework for using the EU Taxonomy to identify sustainable infrastructure investments

The EU Taxonomy is a classification system established by the EU to identify environmentally sustainable economic

1 Visit https://publishing.edhecinfra.com/papers/2023_taxonomies_sustainability_infrastructure_investments.pdf for a more in-depth study of the topics discussed here.

activities, supporting the region's transition to a greener and more sustainable economy. This framework presents a list of sustainable economic activities across various sectors, including infrastructure-related activities such as the generation of energy through bioenergy, geothermal sources, hydropower and more.

Investors face a significant challenge when evaluating the eligibility and alignment of their investments with the EU Taxonomy, particularly at the individual company level. This is because the EU Taxonomy is structured as a list of activities and currently there is no framework that identifies the activities of an infrastructure company and subsequently maps it to those of the EU Taxonomy. Further, infrastructure companies have complex and diversified business operations which may engage in a mix of sustainable and unsustainable activities. For example, mapping the activities of a company in the transport or energy sector to the EU Taxonomy is a complex and challenging task. These sectors encompass a wide array of operations, from traditional fossil fuel-based activities to renewable energy generation, electric mobility and sustainable transportation. The sheer diversity of activities within these sectors makes it difficult to isolate and categorise them accurately. Moreover, many companies in these sectors have interconnected processes that further complicate the classification. For instance, an energy company may simultaneously operate conventional power plants and generate electricity from renewable sources.

This study addresses one of the most significant problems in this context: mapping the infrastructure asset class, classified by TICCS, to the activities of the EU Taxonomy.

Currently, there are numerous large asset owners and asset managers using TICCS for strategic asset allocation, portfolio construction and performance attribution. The mapping of TICCS to the EU Taxonomy outlined in this paper serves as a valuable resource for these infrastructure investors, providing them with a systematic approach to understanding the sustainability and associated investment risks within their infrastructure portfolio. Using the TICCS classification as a starting point, infrastructure investors can identify potential EU Taxonomy-eligible investments, positioning themselves a step ahead in meeting broader EU Taxonomy-aligned reporting requirements.

Taxonomy eligibility is an assessment of whether an economic activity has a set of corresponding criteria in the taxonomy to be assessed against – in other words, whether the activity is in the scope of the taxonomy to begin with. To be considered aligned, an economic activity must meet specific technical screening criteria showing that it contributes to at least one of the taxonomy's six objectives and also 'do no significant harm' (DNSH) to any other objective; and meets the minimum safeguards. This study focuses on assessing only the eligibility of infrastructure subclasses to the EU Taxonomy.

Methodology: mapping TICCS to the EU taxonomy

The economic activities of the EU taxonomy are themselves derived using NACE as their basis. The European Commission maps the EU Taxonomy activities against the NACE classification system, and for each sustainable activity provides the corresponding NACE codes.

The first step in this exercise is to identify the primary activity of each infrastructure asset subclass and map it to the NACE classification system. This mapping focuses on the main activity rather than all possible activities of any given asset subclass. Considering the main activity instead of all sub-activities ensures that the sustainability assessment is centred around the primary function of the asset.

Using the NACE codes associated with the main activity of an asset subclass as a bridge, we determine whether a TICCS asset subclass was consistent with activities classified as sustainable within the EU Taxonomy, specifically focusing on the objectives of climate change mitigation and climate change adaptation. Through this process, we facilitated the mapping of TICCS asset subclasses to the specific activities outlined in the EU Taxonomy, enabling a clear understanding of the sustainability eligibility of these subclasses.

The EU Taxonomy is a list of sustainable activities, but it is not a list of unsustainable ones – ie, not being in the list of the activities identified by the EU Taxonomy does not mean that these excluded activities and associated asset classes are unsustainable. The asset classes that are not eligible for the EU Taxonomy thus cover a range of assets, from those that are unsustainable, such as fossil fuel power plants, to those that are inherently green, such as parks.

To get a clearer picture of the (in) eligibility of the infrastructure asset class with the EU taxonomy, an additional step of discretionary categorisation was carried out in this study, wherein we re-classified the ineligible asset classes into:

Low-carbon assets: These assets have minimal adverse sustainability impacts but are not explicitly classified as sustainable by the EU Taxonomy. Examples include public parks and gardens. These assets are re-classified as eligible.

Supporting assets: These assets support and facilitate sustainable activities but do not primarily align with EU Taxonomy criteria. Examples include infrastructure for natural gas distribution. These assets are classified as ineligible.

Potentially stranded assets: Assets like coal and oil are at risk of devaluation due to evolving climate policies and market changes. Gas is considered eligible for transition activities. These assets are classified as ineligible.

Ambiguous assets: Assets with activities that might be sustainable but do not directly align with the EU Taxonomy, such as social infrastructure implementing renewable energy systems. These assets are classified as ineligible.

The final mapping that categorises each TICCS asset subclass under the taxonomy is presented in the study.

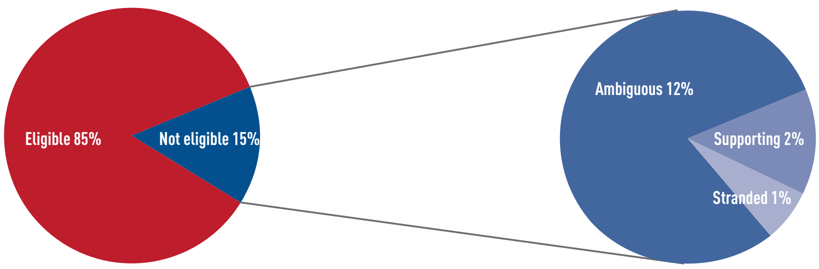
Case study: how sustainable is the European infrastructure asset class?

Using the mapping presented above, this study classifies about 5,300 companies of the EDHEC*infra* European universe (European Economic Area and the UK) as eligible or not under the activities listed as sustainable by the EU Taxonomy.

The 15% of companies that do not qualify as sustainable in this study constitute approximately $275bn worth of infrastructure investments in Europe. Among these, about $20bn of assets by size have no sustainable characteristics and would likely be stranded in the transition to a low-carbon economy. More than $215bn of infrastructure is not aligned with the EU Taxonomy's definition of sustainability as is. While these assets are not explicitly classified as sustainable and are categorised as unaligned to the EU Taxonomy, they could potentially be decarbonised with technological interventions and in the future could meet the requirements of the EU Taxonomy. The remaining $40bn assets do not explicitly align with the EU Taxonomy's definition of sustainability but have activities that support other eligible activities. This distribution is presented in figure 1.

Notably, the power sector stands out as a substantial contributor to this high level of compliance. This phenomenon can be largely attributed to the substantial

1. Eligibility of EDHEC*infra* European assets for the EU Taxonomy by asset value



Note: Eligible assets include both those initially designated as eligible and those that have been recategorised as low-carbon assets.

investments made in renewable energy assets across Europe, driven by various incentives and regulations, such as the EU's Renewable Energy Directive.

In the development of the EU Taxonomy, there was considerable debate on the inclusion of nuclear and gas (classified as non-renewable power infrastructure in TICCS) activities, reflecting the intricate task of balancing energy security and sustainability in energy mixes within EU member states. Key concerns centred on the sustainability of nuclear and gas, due to associated greenhouse gas emissions, and the management of radioactive waste. Despite objections from various stakeholders, including environmental groups and European Parliament members, gas and nuclear were eventually added to the taxonomy as transition activities, acknowledging the absence of readily available low-carbon alternatives. This study finds that excluding gas and nuclear assets (gas and nuclear power plants and gas pipelines) led to a notable decline in eligible assets, from 85% to 80%, with approximately $80bn worth of assets becoming ineligible. The share of stranded assets increases significantly, from $20bn to $100bn. This underscores the taxonomy's sensitivity to technology inclusion/exclusion and emphasises the crucial role of regulators in shaping sustainable infrastructure practices.

This study, by delineating the activities of each infrastructure industry subclass and identifying their overlap with the EU Taxonomy, contributes to the initial step of determining the eligibility of an investment to the EU Taxonomy. This step is crucial for infrastructure investors seeking to incorporate sustainability considerations into their portfolios, providing a foundation for further evaluation and decision-making.

The way forward

The categorisation of an asset class as eligible for the EU Taxonomy, as demonstrated in this study, does not make it automatically aligned with the taxonomy. The qualification merely signifies eligibility for further scrutiny against the 'substantial contribution' and 'do no significant harm' criteria outlined by the EU Taxonomy.

While the study contributes to the initial step of determining eligibility by delineating the activities of each infrastructure industry subclass and identifying their overlap with the EU Taxonomy, it does not offer additional insights on how aligned eligible assets are or how can ineligible assets improve processes to improve their sustainability performance in the future. This result leaves investors without enough information on the risks they face when it comes to alignment (and resilience). For instance, if airports can, in principle, be green, what can a specific airport do in practice and how much will it cost? This highlights a knowledge gap that, could potentially serve as a guide for the sustainability roadmap of any given infrastructure company.

The premise that alignment is possible is implicit in the taxonomy's structure. However, answering this question forms the basis for a more comprehensive investigation, recognising the need for deeper insights into asset-level actions and strategies that can bridge the gap between eligibility and alignment with the EU Taxonomy's sustainability criteria. Addressing this knowledge gap is essential for understanding the practical steps and transitions required for aligning infrastructure assets with the objectives of initiatives like the EU Taxonomy. This knowledge will be instrumental both for asset owners to understand practical approaches to improving sustainability and for investors in identifying sustainable investments, guiding the allocation of funding and investments toward the goal of transitioning to a low-carbon economy, and facilitating the broader sustainability objectives.

A new research initiative at the Scientific Infrastrcture & Private Assets Research Institute is building a body of knowledge on the most impactful asset-level strategies, their effectiveness, and associated costs, available to infrastructure assets to decarbonise and improve climate resilience. This intentional approach enables a focused examination of practical, asset-level interventions within the current technological landscape.

Social risk indexing and rating for infrastructure investors

The case of the UK water sector

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This article summarises the findings of a new paper[1] in which we develop Social Risk Sector Ratings and conduct a case study to examine how social acceptance on the sector level affects social risk levels for water companies in the UK.

We find that the private water sector in the UK suffers from a poor reputation, facing significant social and political backlash.

Significantly, our analysis shows that acceptance levels align with sector trends and reveals statistically significant relationships between sector sentiment and company support.

These findings illustrate the importance of understanding sector effects in managing social risks and highlight the varying degrees to which individual companies are influenced by sector-level sentiment.

Introduction

Infrastructure investments have significant positive impacts on economies and societies, but they also pose real or perceived negative impacts. As a result, the social acceptance of infrastructure projects is material for investors and can create significant risks and consequences.

Recent examples highlight the challenges and consequences of social risks in infrastructure investments:

In the UK, widespread protests against sewage spills by water companies led to regulatory changes in April 2023, removing the fine cap and more than doubling pollution fines for the first half of 2023 compared to 2022 (Segal [2023]).

In France, a court ordered the dismantling of wind turbines near Montpellier following resident protests about noise and environmental concerns, including a study showing bird deaths (Jenkinson [2023]).

In the US, landowners in Iowa leveraged the upcoming 2024 presidential election to block a carbon pipeline project to protect their property and agriculture industry (Frankel and Tabet [2023]).

In Germany, coal-mining projects have always faced strong opposition and protests that required expensive clearances, increasing costs and delaying projects (DW [2023]).

These cases illustrate the dynamic relationship between infrastructure assets and societal reactions. Social risks can lead to project delays, increased costs, regulatory changes and long-term reputational damage, making them financially material for companies. To manage these social risks, it is essential to identify which risks are controllable.

Social risks at the asset level comprise two components. The *systematic component* relates to the market, country or sector and includes factors such as industry reputation, public perception and regulations. This component can be assessed but not directly controlled by the investor. The *idiosyncratic component* is specific to the company or asset and can be influenced by actions that improve public perception.

In this research, we apply Natural Language Processing (NLP) techniques and sentiment analysis to measure the systematic part of social risk using news and social media data. Our results indicate that the systematic component accounts for 60-70% of total social risk. This means that only 30-40% of a company's social acceptance is directly controllable. Therefore, once an investor selects a market or sector, more than half of the social risk is predetermined due to its systematic nature. Asset and investment managers can use our systematic social risk assessments to a) estimate risks at the asset level and b) compare and manage social risks at the portfolio level.

Social acceptance indices

Social acceptance is a critical indicator of social impact and potential financial risks for infrastructure developers and investors. It involves understanding the factors that influence public support for different sectors to identify material risk factors.

Research around social acceptance is interdisciplinary and varies in definition. It describes the positive outcome of an acceptability process at a specific

1 See https://publishing.edhecinfra.com/papers/2024_Social_Risk_Indexing.pdf for the full paper.

point in time, which means social acceptance can change as perceptions and circumstances evolve (Busse and Siebert [2018]). Wüstenhagen, Wolsink and Bürer (2007) categorise social acceptance into three types: socio-political acceptance (public approval of policies and new technologies), community acceptance (those directly affected by infrastructure siting decisions) and market acceptance (reflected in consumer demand and investment in new technologies and infrastructure). Achieving social acceptance requires aligning stakeholder interests and maintaining a social licence to operate, an informal 'social contract' granting consent for project development and operation (Vauban Infrastructure Partners [2022]). Without this, project costs and development times can increase, and projects can face delays or cancellations.

We developed three social acceptance metrics (see figure 1) to monitor impacts and risks across various infrastructure asset groups on a regional level, currently covering:

- 23 sector groups following Scientific Infra's TICCS classification (Scientific Infrastructure & Private Assets Research Institute [2022]);
- in five countries (US, UK, Canada, Australia and New Zealand);
- over a period of more than 10 years.

The metrics provide valuable insights into public sentiment and potential risks, helping to navigate the complex landscape of infrastructure development and investment.

1. Social acceptance metrics

Social Support Index

The Social Support Index measures the average level of public acceptance for specific infrastructure asset classes on a scale from 0 to 100, with 100 indicating full social support. This index combines sentiment from news coverage and social media discourse to provide insights into public support trends over time across different sectors and countries. By comparing sectors or countries and analysing trends, investors can understand the public's acceptance levels and make informed decisions.

Social Consensus Index

The Social Consensus Index assesses the level of agreement within the public by measuring sentiment polarisation. This index ranges from 0 to 100, with higher values indicating greater consensus and stability in public acceptance. It captures the variance in sentiment scores to determine how unified or divided public opinion is regarding specific infrastructure projects. A higher consensus suggests more stable public acceptance and support (or lack thereof).

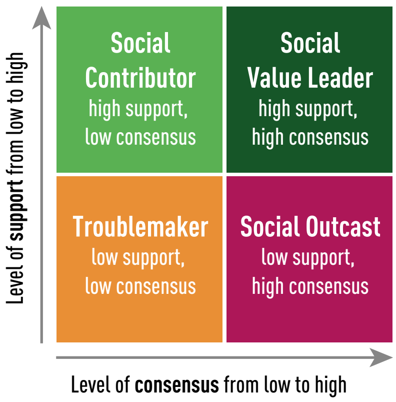
Social Attention Trend

The Social Attention Trend tracks the focus on selected topics in news coverage and social media discussions. This metric highlights the proportion of ESG-related topics being covered, indicating which issues are becoming salient and thus potential material risk factors. Increased attention to a particular issue suggests that it is becoming more significant in public discourse, which can impact the social acceptance of related projects.*

* To identify the salient social impact and risk factors, we followed the ESG Taxonomy (Manocha, Marcelo and Blanc-Brude [2022]) to develop an ESG Dictionary (Orminski and Shen [2023]). This dictionary successfully detects 20 social impact and risk factors in textual data related to the general public (eg, human health, pollution, socio-economic factors), customer service (quality, availability and affordability of services), the workforce (eg, working conditions, payment, safety, labour rights) and regulatory risks.

2. Style boxes representing four types of sectors based on their level of social support and consensus

Social Contributor: Strongly supported but widely debated sectors
Social Value Leader: Sectors with high support from most members of the public
Troublemaker: Unsupported and widely debated sectors
Social Outcast: Sectors with low support from most members of the public



Social risk sector rating

Scientific Infra's Social Risk Sector Ratings analyse the relationship between the Social Support Index and the Social Consensus Index across various sector groups. These ratings are visualised using style boxes, which are divided based on the global cross-sector median values of the Social Support and Social Consensus indices from 2018 to 2023.

The style boxes categorise sectors into four quadrants, representing different levels of social acceptance and associated risks (see figure 2).

To provide more detailed insights and track changes in social acceptance, the ratings focus on three specific results – *latest quarter*, *yearly changes* and *trend indicator* (see figures 3 and 4 for definitions, and for the global and UK ratings, respectively).

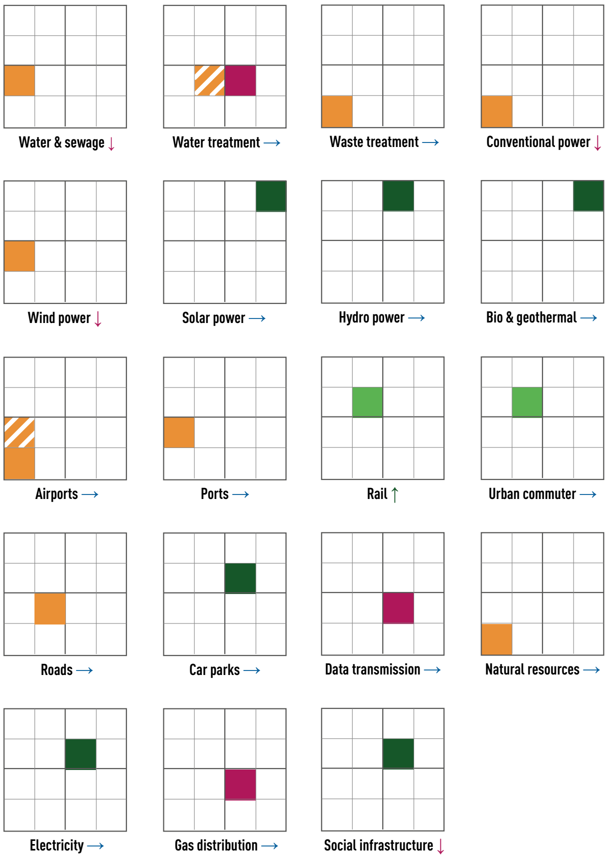
The Social Risk Sector Ratings show that globally, climate-focused sectors like renewable energy are more respected than polluting ones. However, wind power is less favoured due to environmental and noise concerns, except in the UK, where it enjoys robust support due to effective policies and geographical advantages. In contrast, the UK's transport sector, specifically rail and urban commuter services, faces dissatisfaction due to delays and high costs. Understanding these nuances helps investors align with socially accepted sectors, mitigate risks, and make informed decisions that align with societal values.

Use case: the water and sewage sector in the UK

A sector becoming increasingly controversial

Since the Water Act of 1989 privatised the UK's water and sewage sector, the focus has shifted from infrastructure development to efficiency, private investments and service quality despite maintaining a monopolistic structure. The regulator Ofwat oversees the sector, but despite regulatory efforts, customer complaints

3. Global Social Risk Sector Rating, year-end 2023



Latest quarter:
The style boxes are split into quartiles of the Social Support and Social Consensus indices. The highlighted square shows the average social acceptance for the most recent quarter (Q3 2023).

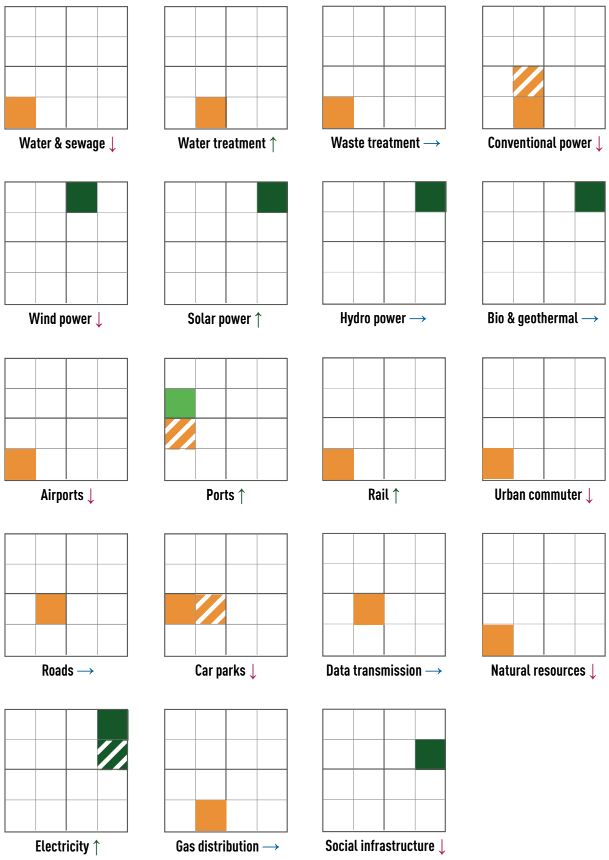
- Social contributor
- Social value leader
- Troublemaker
- Social outcast

Yearly changes:
If a sector has shifted between quartiles over the past year, the style boxes highlight these changes wth a patterned shade for the same quarter from the previous year (Q3 2022).

- Social contributor
- Social value leader
- Troublemaker
- Social outcast

Trend indicator:
A trend indicator shows the development of the Social Support Index compared to the same period a year ago, indicating whether support has increased (> +1% ↑), decreased (< −1% ↓) or remained unchanged (−1% > +1% →). The trend indicator focuses solely on the level of support, not consensus.

4. UK Social Risk Sector Rating, year-end 2023



and rising water bills have persisted. While early privatisation saw infrastructure and environmental improvements, controversy grew over high executive salaries and prioritising of dividends over long-term investment, leading to substantial debt since the 1990s.

Additionally, public support has plummeted due to the sector's failure to meet leakage targets and manage ageing infrastructure, exacerbated by frequent sewage overflows into rivers and seas, sometimes illegally. In 2023, following major public protests, the regulator removed the £250,000 fine cap, significantly increasing pollution fines (Plimmer [2023]).

Despite water companies' pledges to invest £10bn in infrastructure, environmentalists and customers fearing higher bills remain sceptical. The situation has reignited discussions on renationalisation to ensure stable prices and transparency, with some advocating the government's reacquisition of water services.

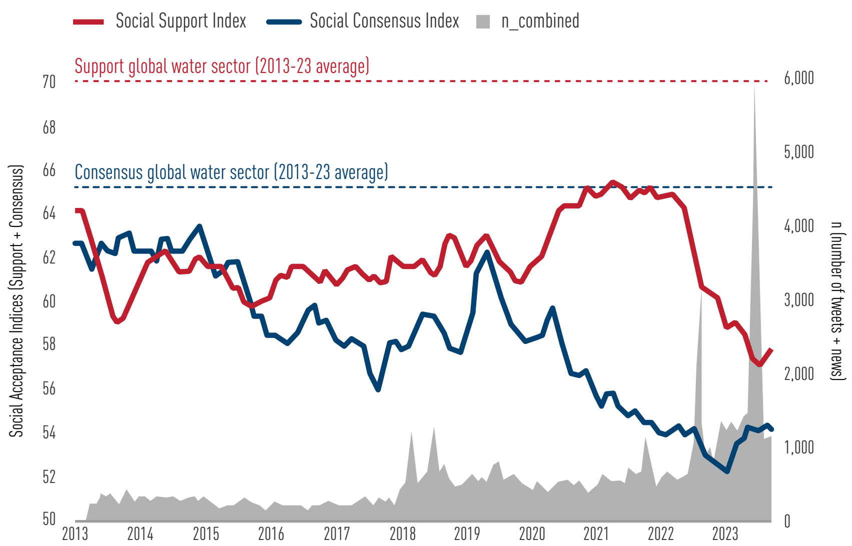
What do the social acceptance indices reveal?

The above review reveals that the private water sector in the UK suffers from a poor reputation, facing significant social and political backlash. The social acceptance indices show a steep decline in public support for the UK's water and sewage sector since 2020, reaching a new low by July 2023 (see figure 5). This support level is significantly lower than the sector's global average (red dotted line in figure 5) as well as the average support for other infrastructure sectors within the UK.

Public discourse around the UK water sector remains slightly polarised, with increased opposing discussions between 2019 and 2023, for example, on issues like public versus private ownership. However, the latest sewage scandal and its impact on the environment and human health have led to a more aligned public discourse, with people agreeing on the low support. Overall, news coverage tends to show higher consensus on environmental issues, while discussions on social media are more polarising, particularly regarding ownership debates.

Public dissatisfaction, combined with high consensus, can trigger regulatory risks. Low social support likely prompted the UK government to remove the pollution fine cap in April 2023, leading to higher fines and increased pressure on water companies. Continuous low support could further push discussions on renationalisation. Understanding the social factors behind these sentiments is crucial for a full risk assessment.

5. Social Support Index and Social Consensus Index for the UK water sector



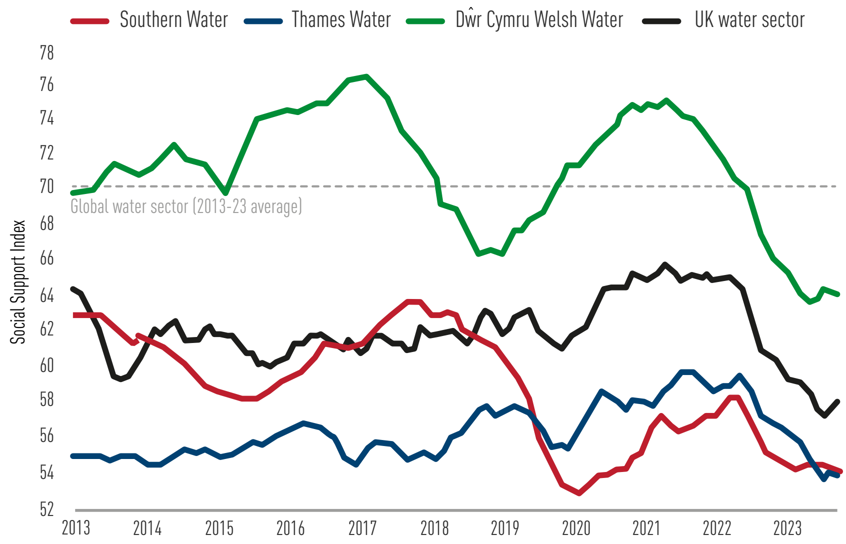
Notes: The left axis represents the Social Support and the Social Consensus indices in comparison to the global water sector (dotted lines). The right axis provides the number of tweets and news articles for each month (grey area).

How do the sector results affect individual companies?

To further understand the implications of sector-level social acceptance on individual companies, we examined how these sector-level results translate into social risk factors at the company level. Accordingly, we explored the social acceptance indices for specific companies to gain insights into the systematic component of social support. We compared Thames Water, Southern Water and Dŵr Cymru Welsh Water, all private monopolies in their regions, to see how sector-level support (or the lack thereof) affects them.

Our analysis shows that acceptance levels of these companies align with sector trends (see figure 6). Furthermore, regression analyses reveal statistically significant relationships between sector

6. Acceptance levels of three UK water companies align with sector trends



Notes: The chart shows the Social Support Index for the UK water sector (black line) in comparison to the support for Dŵr Cymru Welsh Water (green line), Southern Water (red line) and Thames Water (blue line).

sentiment and company support, with coefficients ranging from 0.26 to 1.24, indicating varying impacts (see figure 7).

Southern Water (red line in figure 6) experienced a sharp decline in support following a £90m fine for premature wastewater spills, resulting in the lowest support among UK water companies. Its coefficient of 0.26 (the lowest across all companies) suggests a modest yet significant relationship between sector and company level sentiment, highlighting the potential for improving its idiosyncratic component independently.

Dŵr Cymru Welsh Water (green line in figure 6), a not-for-profit company, enjoys the highest support due to its unique structure and the reinvestment of profits for public benefit, despite sharp declines in support during 2017-18 and recent challenges. In contrast to Southern Water, its coefficient of 1.24 shows a strong correlation with sector-level social support, indicating limited control over social support levels.

Thames Water (blue line in figure 6), the UK's largest water company, consistently shows the lowest support. Financial concerns, legal issues and significant debt contribute to its vulnerable state. Its coefficient of 0.68 suggests a moderate impact of sector sentiment on the company's support level.

These findings illustrate the importance of understanding sector effects in managing social risks and highlight the varying degrees to which individual companies are influenced by sector-level sentiment. The UK water sector's issues with pollution, transparency and financial mismanagement highlight the importance of managing systemic social risks within ESG frameworks. Approximately 70% of these risks are beyond direct control but can be managed within investment decisions. Understanding and monitoring public sentiment can help anticipate regulatory changes and manage social risks. The ongoing dissatisfaction among consumers, coupled with potential government actions like renationalisation, underscores the critical link between social acceptance, financial materiality, and public policy.

7. Effect of the UK water sector on the social acceptance of three UK water companies

	Thames Water	Southern Water	Dŵr Cymru Welsh Water
UK water sector	0.678** (0.037)	0.265* (0.095)	1.236** (0.059)
Constant	1.242** (0.154)	2.940** (0.394)	-0.867** (0.244)
Observations	68	68	68
R^2	0.778	0.036	0.774

Note: Standard errors in parentheses. **p < .001, *p <.01

Methodology

Where does the data come from?
The data comes from two types of sources: 1) local and international news articles provide insights into public concerns and 2) the social media discourse on X (formerly Twitter) reflects people's unfiltered opinions. Both data sources are filtered for English-language content related to various infrastructure sectors and ESG topics according to Scientific Infra's TICCS and ESG Dictionaries (Orminski and Shen [2023]). The sentiment from these articles and tweets is used to gauge public social acceptance.

How do you measure sentiment?
Sentiment in news articles and social media discourse is measured using a lexicographic approach, applying the VADER dictionary (Hutto and Gilbert [2014]). The dictionary classifies words as positive, neutral or negative, and assigns a polarity score from -1 to +1. The VADER dictionary is particularly suited to social media data. Accordingly, we added an additional step for news articles building a 'Ground Truth' dataset to improve the accuracy of our analysis (Shen and Whittaker [2023]).

Are your results valid?
The validity of the Social Support Index was tested against other public opinion measures, especially in the US and the UK, using representative panel surveys. Although the Social Support Index may show different levels compared to survey results, both sources follow the same trend (for more details, see Orminski and Shen [2023]). This alignment indicates that the Social Support Index provides a valid representation of public support.

More details on our methodology and all results of the Social Risk Rating can be found in the full paper. See https://publishing.edhecinfra.com/papers/2024_Social_Risk_Indexing.pdf

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Computing extreme climate value for infrastructure investments

Asset pricing applied to NGFS Phase 4 and Oxford Economics scenarios to measuring climate risks at the asset level

Bertrand Jayles, Senior Sustainability Data Scientist, EDHEC*Infra* & Private Assets Research Institute; **Jianyong Shen**, Senior Research Engineer and Deputy Lead of Research & Development, EDHEC*Infra* & Private Assets Research Institute

The research paper[1] explores the substantial financial risks posed by climate change to infrastructure investments.

These risks include both physical risks from extreme weather events and transition risks related to the shift towards greener technologies.

The paper introduces a novel methodology to estimate these risks using economic and climate scenarios developed by the Network for Greening the Financial System (NGFS) and Oxford Economics.

By incorporating financial and macroeconomic variables to project future cash flows and discount rates, the methodology provides a comprehensive tool for assessing climate risks in infrastructure investments.

Introduction to climate risks in infrastructure

Infrastructure assets are essential to the functioning of modern society, providing critical services such as transportation, energy, water and communication. These assets are designed to endure specific climate conditions but are now facing increased vulnerability due to climate change. The impact of climate change on infrastructure is multifaceted, involving both immediate and long-term consequences.

Extreme weather events, such as floods, hurricanes, heatwaves and wildfires, pose direct physical risks to infrastructure. These events can cause substantial damage, leading to immediate financial losses and necessitating costly repairs and maintenance. For instance, the severe flooding in north-eastern Italy in 2023 resulted in extensive damage and high repair costs, highlighting the financial burden of such events on infrastructure investments.

Beyond physical damage, climate change also introduces transition risks. These risks are associated with the economic and regulatory changes required to shift towards a low-carbon economy. Transition risks include costs related to compliance with new regulations, investments in cleaner technologies and potential changes in market demand. As governments and organisations worldwide implement policies to mitigate climate change, infrastructure investments must adapt to these evolving conditions.

Institutional efforts to manage climate risks

Recognising the importance of addressing climate risks, several organisations have developed tools and frameworks to help financial institutions manage climate-related financial risks. One of the key initiatives in this area is the Network for Greening the Financial System (NGFS), established in 2017 by a group of central banks and supervisors. The NGFS has created a set of climate scenarios designed to assist financial institutions in evaluating and managing climate risks. These scenarios provide plausible future pathways, incorporating various climate mitigation strategies and their potential economic impacts.

Building on the foundation laid by NGFS, Oxford Economics has developed additional climate scenarios that complement the NGFS scenarios. These scenarios enhance the robustness of climate risk assessments by addressing some limitations in the NGFS scenarios and offering a broader range of potential future outcomes. By combining the insights from NGFS and Oxford Economics, the paper presents a comprehensive approach to understanding and managing climate risks in infrastructure investments.

1 Computing Extreme Climate Value for Infrastructure Investments. See https://publishing.edhecinfra.com/papers/2024_computing_extreme_climate_value_for_infra_investments_research_paper.pdf

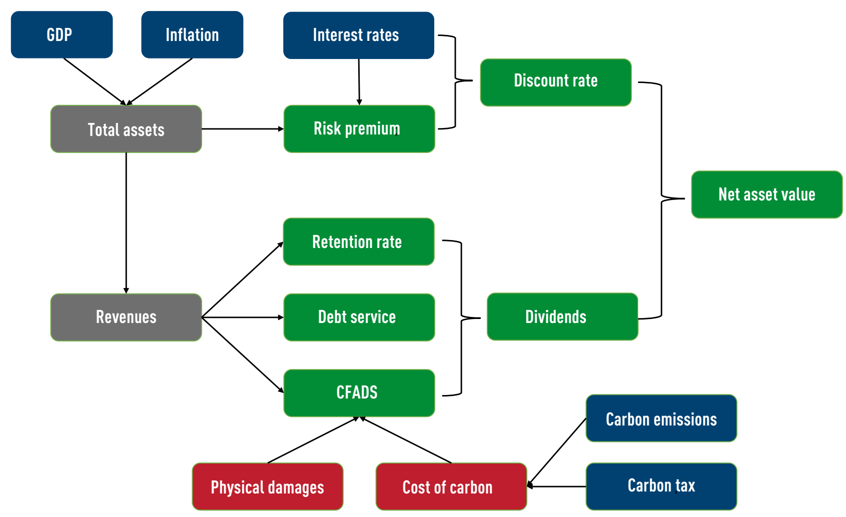
Methodology for estimating climate risks

The paper's proposed methodology employs a discounted cash flow (DCF) approach to estimate the value of infrastructure companies under different climate scenarios. The DCF approach is widely used in financial analysis to value investments by projecting future cash flows and discounting them to present value. It is particularly suitable for long-term investments such as infrastructure, where future cash flows can be significantly impacted by climate change.

The model integrates financial and macroeconomic data to project future cash flows and discount rates. Key financial variables include the revenues and size of the business. They are influenced by macroeconomic variables such as GDP, inflation and interest rates, which capture the broader economic impacts of climate change. Climate-related factors such as carbon pricing, regulatory compliance costs (carbon taxes) and physical damage also have a direct impact of cash flows.

Our cash flow models are based on historical data from a broad sample of infrastructure companies across more than 20 countries worldwide and all sectors as defined per TICCS. In addition to historical financial data, the model incorporates data on carbon emissions and physical risks. Carbon emissions data is essential for understanding the exposure of infrastructure companies to transition risks, as policies aimed at reducing emissions can significantly impact their operations. Physical risk data, on the other hand, helps to quantify the direct impact of extreme weather events on infrastructure assets. By integrating both types of data, the model provides a comprehensive assessment of climate risks. Figure 1 illustrates and summarises the climate risk model.

1. Schematic illustration of the climate risk model



Notes: The macroeconomic variables taken from NGFS and Oxford Economics, are highlighted in blue, while asset level variables (carbon cost and physical damage) are highlighted in red. The financial variables that are used as inputs of the Scientific Infra & Private Assets Research Institute's asset pricing model are highlighted in grey, while the output variables of the asset pricing model are highlighted in green.

Climate scenarios and their implications

Climate scenarios are critical for understanding the potential future impacts of climate change on infrastructure investments. These scenarios provide insights into how different pathways of climate change might affect economic and financial variables. The NGFS scenarios, widely used in the financial industry, offer plausible future macroeconomic and climate pathways. These scenarios include various climate mitigation strategies, ranging from aggressive action to limited or no action, and their corresponding economic impacts.

Oxford Economics scenarios complement the NGFS scenarios by providing additional perspectives and addressing some limitations. In particular, the NGFS scenarios seem overly optimistic regarding the reduction of carbon emissions in coming years (all scenarios but one reach negative emissions before 2050 in the Remind-Magpie integrated assessment model) and regarding the economic impact of a rise in mean temperature (GDP grows almost at the same pace in all scenarios). By contrast, Oxford Economics offers scenarios where countries fail to reduce their emissions and thereby to mitigate climate change. As a consequence, physical risks in these scenarios have a very material impact on the economy before 2050, which sounds like a more realistic 'business-as-usual' case. These scenarios enhance the robustness of the analysis by offering a broader range of potential future outcomes. By combining insights from both sets of scenarios, the paper presents a comprehensive view of the possible impacts of climate change on infrastructure investments.

Despite their importance in assessing the impact of climate change on the financial sector, current climate scenarios have limitations that hinder their practical utility. The primary limitation is the inability to assign probabilities to these scenarios. Since they are based on a limited number of narratives without measures of uncertainty or likelihood, it can lead to the incorrect perception that these scenarios represent the most likely futures or that all scenarios are equally probable. Additionally, relying on just a few scenarios with potentially questionable assumptions is somewhat restrictive. However, despite these drawbacks, climate scenarios still provide a valuable basis for estimating climate-related risks for both academia and the financial industry.

In the financial analysis of climate risks that follows, we retain three scenarios from NGFS and Oxford Economics (each), one from each scenario category:

Orderly Transition scenario: the world starts aligning immediately with the Paris Agreement in order to mitigate climate change without abrupt transition shocks.

Disorderly Transition scenario: the world starts aligning in the next decade (2030), thereby applying heavy tax shocks but still mitigating climate change.

No Transition scenario: no actions are taken to mitigate climate change; the climate thus becomes much wilder.

Impact of climate risks on financial performance

The infra300 index, representing a global sample of infrastructure companies, is used in the model to assess the impact of climate risks on a diversified portfolio of infrastructure assets. This index includes companies from various sectors, such as energy, transportation, water and communication, providing a representative sample for the analysis. By using the infra300 index, the model can evaluate the effects of climate risks on different types of infrastructure investments, offering insights into the resilience and vulnerability of various sectors.

The results show that the costs associated with climate risks are significantly higher in the scenario where physical risks are predominant, ie, in the No Transition scenario. In this scenario, the absence of effective climate policies leads to severe physical damage due to elevated carbon emissions and a rise in temperature. Conversely, in the Orderly Transition scenario, where climate policies are implemented systematically and early, the climate costs are the lowest due to reduced physical damage and efficient adaptation measures.

To quantify these impacts, we defined several key metrics of climate risks:

Climate cost: This metric includes expected losses from physical damage and costs associated with carbon taxes. The analysis shows that climate costs are particularly high in the No Transition scenario due to extensive physical damage and unmitigated carbon emissions. In contrast, the Orderly Transition scenario results in the lowest climate costs.

EBITDA-at-risk: This metric measures the impact of carbon costs on a company's earnings before interest, tax, depreciation and amortisation (EBITDA). It serves as a proxy for transition risks. The results indicate that in the No Transition scenario, EBITDA-at-risk remains low due to minimal carbon taxes. However, in the Orderly and Disorderly scenarios, EBITDA-at-risk initially spikes with the introduction of carbon taxes but eventually decreases as companies reduce their emissions and adapt to the new regulatory environment.

Carbon intensity per revenue: This metric reflects a company's carbon efficiency relative to its revenue. The findings suggest that stringent climate policies incentivise companies to lower their carbon intensity, thereby enhancing their sustainability over time.

Net asset value (NAV): The NAV computations for infrastructure portfolios reveal significant variations across different scenarios. In the No Transition scenario, severe physical risks and associated costs lead to a notable decline in NAV. On the other hand, scenarios involving transitions, particularly orderly ones, show more favourable NAV trajectories, highlighting the financial benefits of proactive climate action.

Additionally, we introduce metrics of extreme climate risk, which measure the potential losses that can be expected if actions to mitigate climate change are taken late or not taken at all:

Late alignment risk: This metric assesses the combined effects of physical and transition risks if climate policies are implemented late. The results show that delayed action, while still costly, is less damaging than no action at all.

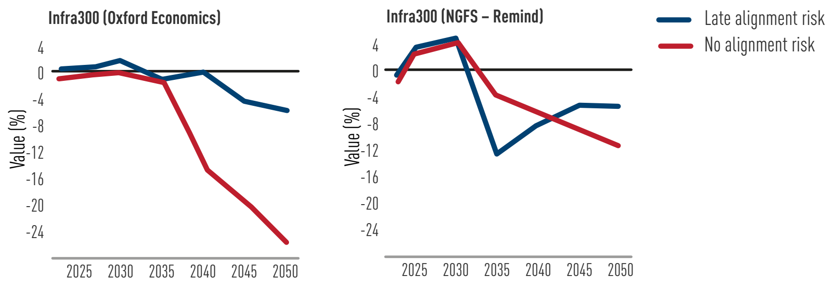
No alignment risk: This metric measures the consequences of failing to mitigate climate change altogether. The findings indicate that potential losses due to not aligning at all are approximately six times higher than the potential losses due to aligning late.

Extreme transition risk: This metric measures the potential losses that are purely due to carbon emissions in the Disorderly Transition scenario. Since this scenario has the highest transition risks, we add an 'extreme' label to it.

Extreme physical risk: This metric measures the potential losses purely due to potential physical damage in the No Transition scenario. Since this scenario has the highest physical risks, we add an 'extreme' label to it. We find that in 2050, the potential losses due to physical risks in the No Transition scenario are more than 10 times higher than the potential losses due to transition risks in the Disorderly Transition scenario.

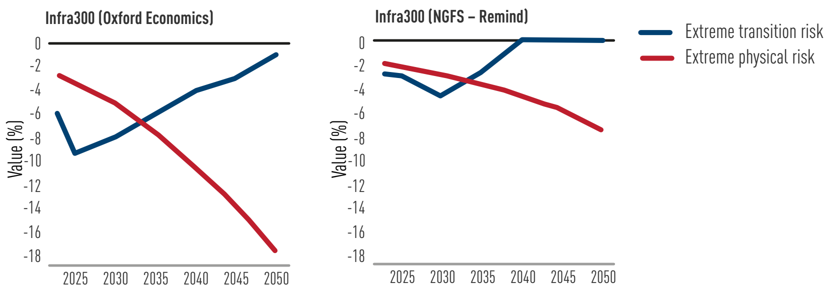
These four metrics are presented in figures 2 and 3.

2. Estimations until 2050 of the late alignment and no alignment risk metrics



Note: The charts show the average over the infra300 index for both NGFS and Oxford Economics.

3. Estimations until 2050 of the extreme transition and physical risk metrics



Note: The charts show the average over the infra300 index for both NGFS and Oxford Economics.

Conclusion

Our research paper provides a comprehensive analysis of the financial risks posed by climate change to infrastructure investments. The novel methodology developed in the paper offers a robust framework for assessing these risks, integrating climate scenarios and economic data to project future cash flows and discount rates. By leveraging the insights from the NGFS and Oxford Economics scenarios, the model provides valuable guidance for investors, helping them to navigate the uncertainties posed by climate change.

Our findings emphasise the critical importance of incorporating climate risks into infrastructure investment decisions. Physical and transition risks can indeed significantly impact the financial performance of infrastructure assets, and the costs associated with inaction are substantial. Indeed, our results demonstrate that the costs of climate risks are substantially higher in scenarios with severe physical risks. Proactive climate policies and investments in greener technologies are essential for mitigating these risks and ensuring the long-term resilience and sustainability of infrastructure assets.

Overall, the paper makes a compelling case for the importance of considering climate risks in infrastructure investments, offering a comprehensive tool for managing these risks and making more informed decisions in the face of a changing climate.

Physical climate risk survey:

Those in the infrastructure investment industry are concerned and lack data

Noël Amenc, Director, EDHEC*Infra* & Private Assets Research Institute, Affiliate Member, EDHEC-Risk Climate Impact Institute; **Frédéric Blanc-Brude**, Founding Director, EDHEC*Infra* & Private Assets Research Institute; **Alice James**, Writer, EDHEC*Infra* & Private Assets Research Institute

These risks could be huge, and investors have no certainty on how they will affect global infrastructure.

Physical risks could wipe as much as 54% off the value of portfolios.

Concerned investors say they have little confidence in the advice and data they are receiving.

Two-thirds of those polled had carried out no evaluation of this physical risk themselves.

The risk: it's real, but we can't measure it

Investors and other industry professionals are concerned about physical climate risk and believe that they have almost no idea how it will affect unlisted infrastructure assets; that's the clear message they delivered when we surveyed them on their views regarding the risks to the asset class and whether they feel the advice and information they are getting is sufficient or even reliable.

This survey was conducted among investors and other professionals invited to a presentation of our latest research paper1 on 27 September 2023. Key takeaways from the survey, which polled 70 professionals including managers with more than $2trn under management, are as follows:

97% of investors polled believe physical climate risk is significant.

Some 76% believe it will have a medium or high effect on their infrastructure investments.

However, only 16% think we actually know how it will impact these assets.

76% also stated that the climate scenarios used by financial institutions to evaluate transition risk to infrastructure are inadequate for the assessment of physical climate risk.

That said, some three quarters said that our research had helped them to better assess these risks and their potential impact.

The survey also revealed that some two-thirds of those polled had carried out no evaluation of this physical risk themselves.

In very concrete terms, this survey confirms that despite the importance attributed to physical climate risk, investors and managers are not in a position to estimate its impact on their own portfolio. This inability is all the more concerning because investor portfolios, being highly concentrated, can be very strongly exposed to physical climate risk without awareness of this. This lack of knowledge of risks raises important questions for the risk management and solvency measurement of insurance companies and pension funds, especially considering that institutional asset owners are increasingly investing in private assets, notably unlisted infrastructure.

This survey also raises the question of the right information and the management of climate risks and their financial consequences for long-term investors in infrastructure.

The research: physical risks could wipe as much as 54% off the value of portfolios

In August 2023, we published a new research paper, 'It's getting physical', which revealed that an investor could incur losses of 54% on the value of their unlisted infrastructure portfolio due to both the realisation of climate risks before 2050 and the high level of concentration of institutional investor portfolios. This estimation was produced using the EDHEC Infrastructure & Private Assets Research Institute database of financial and extra-financial database on unlisted infrastructure, the largest in the world today. The energy transition and the alignment of economies bring a cost to private investors, but so does climate change! Importantly, however, our research also showed that if the relevant stakeholders could only organise the transition towards a decarbonised economy today, extreme losses could be reduced by half.

The findings reveal 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, and beyond this extreme loss, it should be stressed that the average investor will also lose twice as much to extreme weather, which corresponds to a current policy scenario, mostly in OECD countries, compared to a low carbon scenario.

On 27 September 2023 at 9am BST we held a webinar where we presented the

1 See https://publishing.edhecinfra.com/papers/2024-01_physical%7C_climate_risk_survey.pdf

findings of the paper to investment professionals globally.[2] Following this, we polled our invited audience for their views on some of the key questions regarding their views and practices regarding physical climate risk management for unlisted infrastructure assets.

Some 261 members of the investment community tuned in. (It is worth noting when scheduling live online events that time zones mean you can broadly favour Europe, the Americas or Asia. This webinar was scheduled to appeal to European attendees and thereafter the US. Full details are in the Appendix.)

The responses: concerned investors say they need better data

We posed seven questions to those invited to our webinar. Some of these required simple yes/no answers, some were more nuanced and several offered the opportunity for a narrative response. Details of each are given below, plus a selection of the written responses submitted.

Question 1: Is physical climate risk something you consider to be significant?

Yes: 68 (97%)
No: 2 (3%)

Unsurprisingly, and perhaps reassuringly, our cohort was almost unanimous on this front, with 68/70 (or 97%) stating that physical climate risk is something that they do consider significant. Indeed, it is perhaps most concerning that there are two respondents who still believe that they are not. In our recent paper, we showed that such risks are already material for a number of infrastructure assets even if these are generally located in developed economies; eg, the UN Office for Disaster Risk Reduction reported that the number of major flood events already more than doubled between 2000 and 2019, while the incidence of storms grew by 40% during the same period.

Question 2: What impact do you believe physical climate risk will have on your infrastructure investments?

High impact: 23 (33%)
Medium impact: 30 (43%)
Low impact: 13 (19%)
Other: 4 (6%)

Our respondents gave a slightly more mixed response to this question, but overall 76% stated that they anticipated physical climate risk having a medium or high impact on their infrastructure investments (see figure 1). The fact that we see such a broad spread between the responses highlights the impossibility of quantifying future damages armed with only the limited data on both effects and policy responses that we have today.

Perhaps the most interesting takeaway from the responses to this question is that close to a fifth of the polled sample of industry professionals are confident that their investments are reasonably secure; the answers to question 1 suggest that this is not because they are blasé about climate change; it may be that they think that their particular investments have been selected in the belief that they are less vulnerable.

There was no particular pattern to those stating they saw low impact: they were quite evenly scattered geographically. That said, those considering the potential impact would be small were overwhelmingly from the UK and Germany (see figure 2); however, these were also the largest categories of responders, and the sample size is small.

Question 3: Do you believe that the current state of knowledge on physical climate risk allows the value, or at least the relative size, of its impact on infrastructure investments to be genuinely measured?

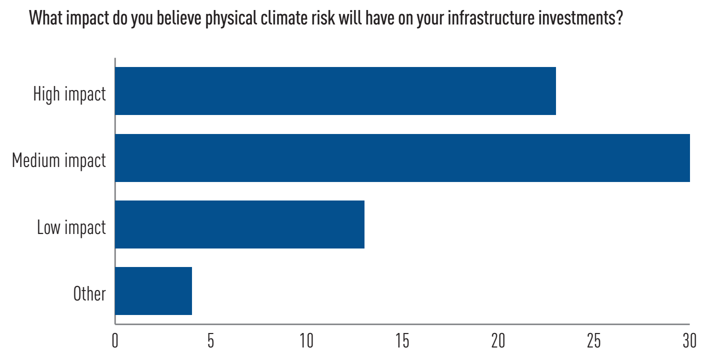
Yes: 11 (16%)
No: 16 (23%)
Somewhat: 38 (54%)
Not sure: 5 (7%)

Responses to this question were more nuanced, but the overall message is one of a lack of confidence in our current ability to gauge the magnitude of climate risk impact on the asset class (see figure 3). Just 16% believe we currently have the tools to get it right.

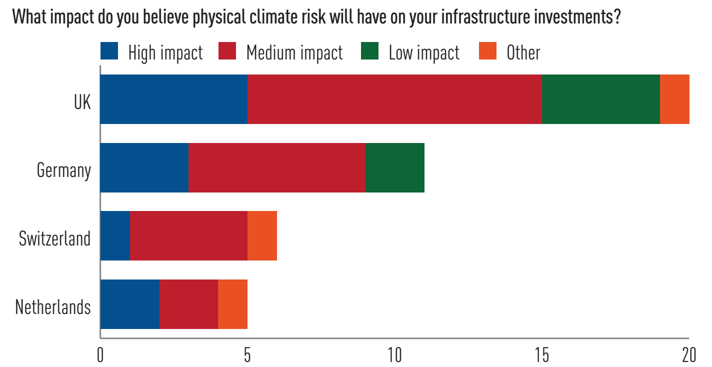
That said, more than half do believe we are part of the way there, which is encouraging but suggests that research will have to improve substantially to reassure the investment community that they have all the data needed on the potential magnitude of climate risk impact.

In terms of clustering geographically, UK

1. It's tough to quantify future damage armed with limited data



2. Those seeing low impact were mostly from the UK and Germany

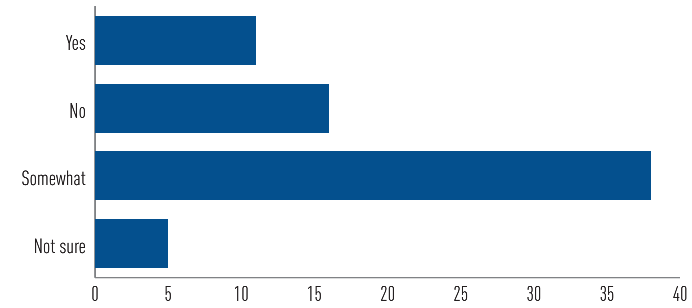


Note: This graph shows the geographical distribution of responses from the UK, Germany, Switzerland and the Netherlands. Together these accounted for 40 of the 70 respondents.

2 For our next event, which will take place in Chicago on 17 October 2024, please see here: https://scientificinfra.com/private-asset-day/

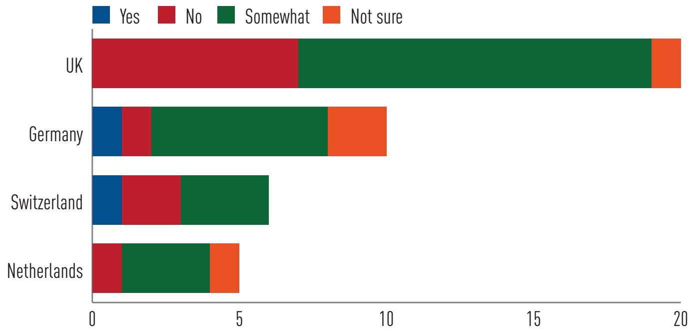
3. There's little confidence that we have the tools to get things right

Do you believe that the current state of knowledge on physical climate risk allows the value, or at least the relative size, of its impact on infrastructure investments to be genuinely measured?



4. UK responders were the most negative

Do you believe that the current state of knowledge on physical climate risk allows the value, or at least the relative size, of its impact on infrastructure investments to be genuinely measured?



Note: This graph shows the geographical distribution of responses from the UK, Germany, Switzerland and the Netherlands. Together these accounted for 40 of the 70 respondents.

responders were the most negative, casting seven out of the 16 'no' votes (see figure 4). That said, the sample size is small.

Question 4: Has the research carried out by the EDHEC Infrastructure & Private Assets Research Institute allowed you to assess this risk and its impact better? Yes/No? Please explain why.

Yes: 40 (75%)
No: 13 (25%)

We regularly poll our clients and those in the wider community for their views on key developments within the industry, the challenges they face and how we are helping them in this space. As such, it is reassuring that some 75% of respondents stated that our research is helping them to understand the climate risks that threaten investments in this field and their impacts.

Below is a selection of the narrative responses:

With nil background I was persuaded by EDHEC's methodological approach. You really have to get granular, and it's difficult to diversify away from the risk.

Yes, investment into infrastructure will continue within multi-asset funds, but we need to be aware of the ever-changing material risks associated.

This whole body of work will evolve, and it is really important to look at physical risk sooner rather than later.

Helpful perspectives on the methodology and data needed to try to predict climate risk and value at risk to a given asset under a given scenario.

I learned that it is important to consider the probable impact of physical risks and to be as precise as possible in its estimation. We would assign the asset manager to initiate an analysis.

It allows us to consider that physical risks could eventually be higher than estimated.

Question 5: Have you implemented an evaluation of this physical risk yourself?

Yes: 24 (34%)
No: 46 (66%)

Two thirds of respondents have carried out no evaluation of physical climate risks themselves. This response serves to highlight just how dependent professionals in the industry are on the advice and data available from researchers and consultants. It is clear that this lack of real evaluation of the climate risk to which investors' assets are exposed heightens the risk to which these assets are exposed, because these same investors have highly concentrated investments in assets whose exposure to potentially very high risks is not measured.

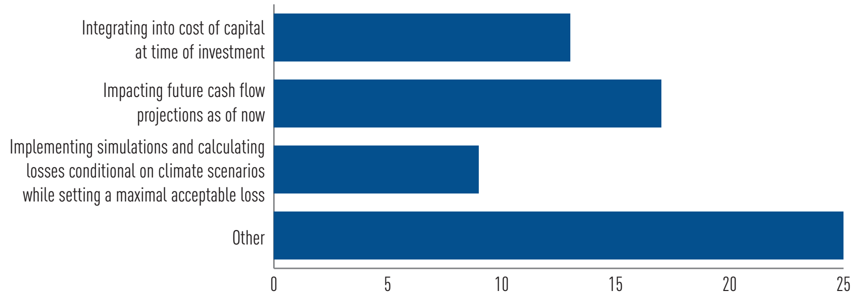
Question 6: Do you integrate this risk into your investment process? If so, how?

By integrating it into the cost of capital at the time of the investment: 13 (20%)
By impacting the future cash flow projections as of now: 17 (27%)
By implementing simulations and by calculating losses conditional on climate scenarios while setting a maximal acceptable loss: 9 (14%)
Other (please specify below): 25 (39%)

The replies to this question show how very varied approaches to incorporating risk can be – even when considering a single class of risks on a single asset class within a highly regulated industry (see figure 5). Responses were spread across the four options, with 25 saying they use a different approach to integrate physical

5. Approaches to incorporating risk varied greatly

Do you integrate this risk into your investment process? If so, how?



climate risk into their investment process, 17 favouring impacting the future cash flow projections as of now, 13 integrating it into the cost of capital at the time of the investment and nine by implementing simulations and by calculating losses conditional on climate scenarios while setting a maximal acceptable loss.

The 'Other' option refers essentially to investors who do not have a quantified or formal approach to assessing climate risk in the investment process. It should be noted that even when the investments have a process that integrates this risk, the inadequacy of the assessment of the reality of this risk makes this integration questionable (see figure 6).

Question 7: Specifically for infrastructure, do you believe that the climate scenarios used by financial institutions to evaluate transition risk are adequate for the assessment of physical climate risk?

Yes: 11 (24%)
No: 35 (76%)

Once again, the answers to this question reveal industry professionals' frustration with the data that is available to them (see figure 7). More than three quarters do not think that the climate scenarios used by financial institutions to evaluate transition risk are adequate for the assessment of physical climate risk.

Below is a selection of the narrative response to this final question:

No – definitely not. There are some huge concerns around the present state of scenarios ... but fortunately, further work is ongoing to develop better scenarios.

Not ideal but is probably a good way to think about it. Otherwise you will have a separate set of scenarios for transition risk and a separate set of scenarios for physical risk. And can't combine risks.

I suspect the risk is currently understated and reflective of experience rather than potential futures.

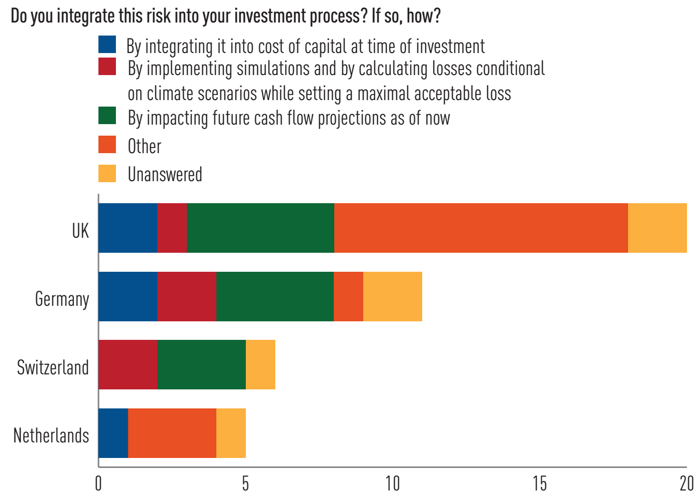
No, because current models run on regression of historical data and climate change might bring us a completely unknown future scenario.

No, they are present and in development but insufficient or inadequate. Right now we apply full risk methodology with no regards for the project specificities, it needs to be tailored by sector.

Yes because these scenarios exist and allow to share a common understanding.

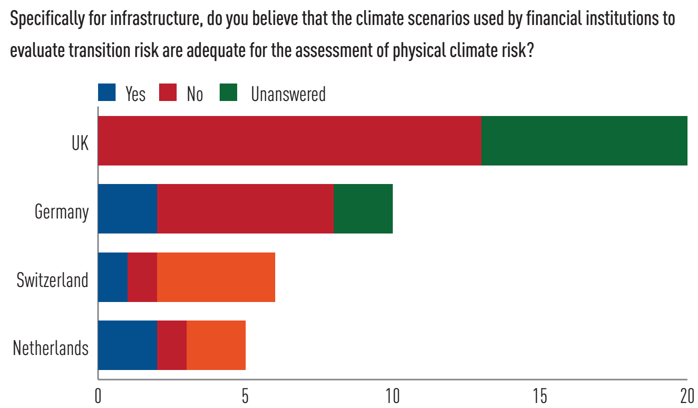
These responses are generally consistent with our research and with the importance of going beyond the NGFS scenarios to estimate physical climate risk.

6. Effective integration at an early stage



Note: This graph shows the geographical distribution of responses from the UK, Germany, Switzerland and the Netherlands. Together these accounted for 40 of the 70 respondents.

7. Few see climate scenarios as adequate for climate risk assessment



Note: This graph shows the geographical distribution of responses from the UK, Germany, Switzerland and the Netherlands. Together these accounted for 40 of the 70 respondents.

The EDHEC Infrastructure & Private Assets Research Institute is improving on the macro- level understanding of physical risk, which consists of a national-level damage function impacting the productivity of factors, by estimating very granular physical risk exposures at the asset level (down to a 30-metre resolution) for floods, storms and heat. This technology combined asset-level characteristics, eg, types of physical assets, with the most recent assessment of physical hazards and state-of- the-art, hazard and activity-specific damage functions. The result is a refined estimate of the physical damage at risk (PDaR) for a given hazard return period today, which can serve as the basis for asset-level physical risk exposures in different scenarios.

Conclusions

Our survey reveals that industry professionals have much pessimism about the data they are being given regarding physical climate risk, considering it to be both incomplete and unreliable. They have doubts about the models being used, and they want more and better research.

Responses to the seven questions highlight the following:

Responders overwhelmingly consider that physical climate risk is something significant.

Expectations of its impact vary hugely, but most believe it will have a medium or high impact on their infrastructure investments.

They display a lack of confidence in our current ability to gauge the magnitude of climate risk impact on the asset class. Very few believe we currently have the tools to get it right.

Most say that our research is helping them to understand how these risks threaten investments in this field and their potential impacts.

Most have carried out no evaluation of physical climate risks themselves.

Almost all integrate consideration of these risks into their investment process, though in many different ways, and most of those who do not do so yet say they plan to.

Most believe that the climate scenarios used by financial institutions to evaluate transition risk are inadequate for the assessment of physical climate risk.

This high level of risk shows the importance of implementing more ambitious policies to cope with climate change. The energy transition and the alignment of economies bring a cost to private investors, but so does climate change! Importantly, however, our research also showed that if the relevant stakeholders could only organise the transition towards a decarbonised economy today, extreme losses could be reduced by half.

And our research has shown that investors are right to be concerned and to question the calibre of the data that they are receiving. On the one hand, runaway climate change could lead to losses as large as half of the portfolio of some investors because of physical damage; on the other, a delayed transition, even if it achieved decarbonisation, would create a gigantic price and interest rate shock and could wipe out as much as $600bn of infrastructure asset value for the same investors.

The climate impacts and risks to infrastructure assets are a key point of focus but investors often lack the full picture of their level of impact or exposure. And they are incorporating them into their strategies in many different ways. Moreover, physical risk estimates are often simplified to a ‘point on a map’ estimation and do not take into account the granularity of the terrain or the type of damage that different hazards can cause to an asset.

Proper integration of climate risks requires an evaluation of the impact of these risks, which, the survey shows, has been insufficiently developed. It is clear that given the level of concentration of the portfolios, and therefore of the potential concentration in the riskiest assets, proper knowledge of these risks and their consequences is essential. The results of the survey show that this is unfortunately not the case currently.

Appendix: breakdown of webinar attendees

Some 261 industry professionals tuned in to our webinar. The full results are as follows:

Nature	Attended
Asset managers	97
Asset owners	51
Consultants	42
Banks	21
Regulators	9
Others	41
Total	**261**

Location	Attended
UK	66
France	42
Switzerland	25
Germany	23
US	17
Netherlands	16
Australia	10
Luxembourg	8
Singapore	7
Denmark	5
Hong Kong	5
Norway	5
Japan	4
Ireland	3
Sweden	3
Austria	2
Canada	2
China	2
Finland	2
Iceland	2
Italy	2
South Africa	2
Andorra	1
Croatia	1
Kenya	1
Morocco	1
Parked	1
Portugal	1
Spain	1
Vietnam	1
Total	**261**

Low tide: benchmarking risks in infrastructure investments

What the data showed about Thames Water

Frédéric Blanc-Brude, Founding Director, EDHEC*Infra* & Private Assets Research Institute; **Abhishek Gupta**, Associate Director, EDHEC*Infra* & Private Assets Research Institute; **Tim Whittaker**, Research Director and Head of Data Collection, EDHEC*Infra* & Private Assets Research Institute

In this paper, we ask what investors in Thames Water could have learned about the entity's risk and likely market value had they compared its characteristics to market and peer group data.

We show that a straightforward comparative analysis would have signalled a high- risk, low-return profile that should have raised numerous red flags.

The company's incentives were twisted by an extremely low regulatory weighted average cost of capital; as a response, previous investors extracted the maximum amount of cash as fast as possible, creating a huge debt pile.

Its exposure to key risk factors had been high, and rising, for a significant period of time, pointing to a likely loss in value that was not recognised for years.

Thames Water's dramatic impairment was entirely predictable

A large water and wastewater utility like Thames Water epitomises the 'stable and predictable' cash flows that investors are attracted by in the infrastructure asset class. Yet, in December 2022, the value of this investment was impaired by almost 30%, an abrupt and unexpected loss of approximately £1.5bn (the company was previously valued at about £5bn by its owners) for investors including UK, Japanese and Canadian pension plans. Only nine months earlier, in March 2022, some investors were still increasing the valuations of their stakes.

Yet a straightforward comparative analysis reveals the emergence of a high-risk, low-return profile that should have raised numerous red flags and prompted long-term investors seeking a 'boring' investment to reconsider. For a large water utility to lose so much value so fast, the investment must in fact have been mispriced for several years leading up to the impairment. Our own assessment is that its value had indeed been decreasing for years and will likely decline more from the current reported valuation.

Without this analysis, investors fell prey to a form of self-referencing or 'absolute thinking' that unfortunately remains very common in infrastructure investment: it's about the one asset, not the market or peers. This narrow vision can obscure the big picture and the role played by market dynamics – ie, the systematic drivers of the fair market value of private infrastructure companies. Because infrastructure assets are large and illiquid, once invested, it can be hard not to 'fall in love with your position' since it is difficult to change easily or quickly. But taken in isolation, a single asset is often more of a story than a hard quantitative assessment.

We argue that benchmarking the key characteristics of the asset would have allowed a much better understanding of its risk profile. Taking a relative view requires representative and robust information to build benchmarks and point of reference to which the risks and performance of infrastructure assets can be compared. When this information is available, investors can better understand the kind of investments they have made, because they can compare them to the right benchmark. In this article, we use such a database of financial data for similar and comparable investments and examine the difference between robust but representative benchmarks and the data available for Thames Water and its holding company Kemble Water.[1]

Most infrastructure assets are in some ways unique and will differ from the average in their sector or country. However, when compared with a large and robust sample, any large differences from the benchmark provide indication of not only how unique an infrastructure company is, but also of how confident (or worried) investors should be about its ability to deliver 'stable and predictable cash flows'. The difference between an

1 For an in depth version of the research presented here, please go to: https://publishing.edhecinfra.com/papers/2024_low_tide_research_paper.pdf

investment's characteristics and its benchmark does not necessarily signal problems, but it is something that investors should be able to understand and explain; and, yes, in some cases it can be a red flag.

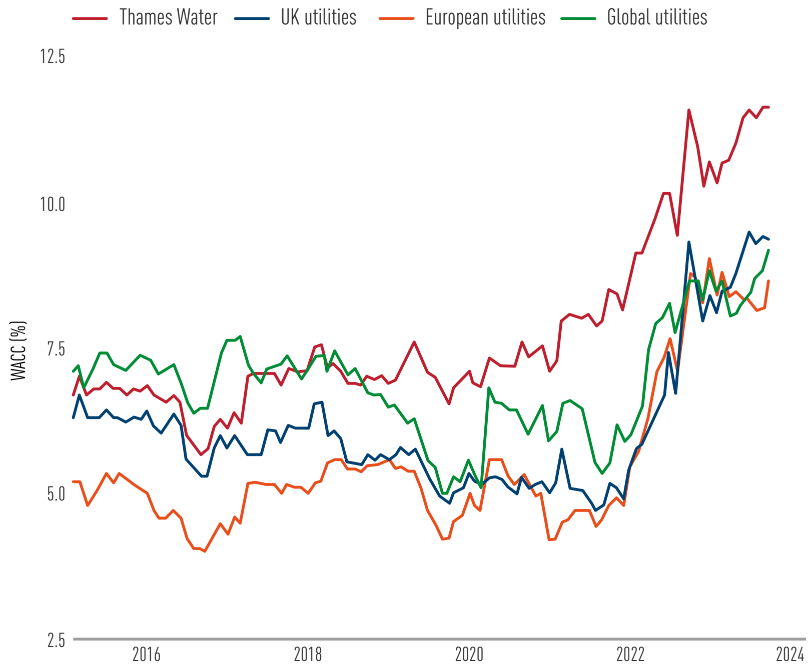
There are three red flags that investors could have considered long before Thames Water had to be brutally impaired at the end of 2022. Had these been identified up front, they could have provided a cause for remedial action or a revaluation of the asset much earlier on.

Red flag 1: the regulated cost of capital

Toxic incentives meant that Thames Water wasn't a 'normal' utility

The company should not have been expected to behave 'normally' as its incentives were twisted by an extremely low regulatory weighted average cost of capital (WACC) that could only logically push it to take on too much risk to achieve the level of returns required by the market. While this is true of the whole sector, the gap between Thames Water's market WACC and its regulated version is the largest of all of its peers (figure 1).

1. Weighted average cost of capital for Thames Water and peer groups



Source: infraMetrics, pre-tax, nominal

Thames Water is one of 17 regulated water and sewage companies in the UK. They are to a large extent natural monopolies and need to be regulated to minimise the welfare impact of monopolistic behaviour. For a monopoly such as a water company, it is rational and profit maximising to underinvest in its asset and to overcharge its customers, irrespective of whether it is publicly or privately owned. For these reasons, regulatory oversight is required and aims to have the firm maintain or improve the quality and quantity of service, while limiting the cost to the consumer.

In England and Wales, this is achieved through incentive regulation by Ofwat (the Office of Water Services). The regulator aims to promote productive efficiency by setting tariffs at a level representing that for which an efficient service provider would also earn a fair return. The regulator's view on the firm's cost of capital thus allows setting tariffs while taking into account the need to invest in the asset and the service required of the company – for instance, the treatment level of wastewater discharge, but also the level of leakage in the water network, or its expansion.

Of course, the cost of capital is also a key data point for an investor in a private company or project: if the expected return from the investment does not at least equate the cost of capital, then the investor should walk away from the project – or find a way to increase returns.

We argue that the regulator of Thames Water has been setting the WACC inadequately, using a long invalidated asset pricing model as well as the wrong data.

As a result of setting the WACC at a very low level, Ofwat was better able to meet its social mandate objectives: to keep water tariffs lower than they otherwise would be if the firms had their way.

However, it also increasingly created toxic incentives for the firm and its investors, who were faced with a higher market cost of capital and therefore had to engage in adaptive tactics to meet their own return targets in a context where the regulator would not recognise the level of return required by the market to invest in a utility company regulated by Ofwat.

This process and the level of the WACC imposed by the regulator are public knowledge and of course known to investors. The implications for the firm's behaviour become a matter of simple economic reasoning: faced with a higher cost of capital than the one it is allowed to recoup by the regulator, a firm can make the choice to walk away from the investment (at a very large cost) or to increase the risk profile of the investment to extract a higher return, more aligned with its own cost of capital, but at the expense of bringing the firm to the brink of insolvency.

The inability of the regulator to take the market price of risk into account when estimating the fair return of the private sector thus played a role in pushing the water utility to adopt a reckless behaviour to reach the level of return required by the market.

Crucially, this behaviour should have been clear to any new investor acquiring shares in the holding company as historic investors chose to exit the investment. In other words, a comparative analysis of the market costs of capital of Thames Water with its regulated cost of capital left little ambiguity as to where the firm stood in terms of incentives.

Reg flag 2: capital structure and dividend payouts

Payments to shareholders exhausted the balance sheet and created a mountain of debt

As a response, investors in Thames Water created a structure to extract the maximum amount of cash as fast as possible, which also created a huge debt pile, leading to a necessity to conserve capital. It should have been clear from 2016 onwards that there would be no potential for further payouts for many years.

2. Dividends and shareholder loan repayments to the shareholders of Kemble Water Holdings, 2007-22 (£m)

Year	Dividends	Shareholder loans	Total payouts
2007	0	0	0
2008	72.6	29.4	102.0
2009	187.2	34.7	221.9
2010	156.4	34.6	191.0
2011	115.1	34.9	150.0
2012	165.1	34.9	200.0
2013	74.5	17.5	92.0
2014	43.6	54.9	98.5
2015	61.6	36.9	98.5
2016	1.5	0.0	1.5
2017	22.8	77.3	100.1
2018	0	0.0	0.0
2019	0	0.0	0.0
2020	0	0.0	0.0
2021	0	0.0	0.0
2022	0	0.0	0.0

Note: Kemble Water Holding is the holding company of Thames Water

Following the passage of the Water Act 1989, Thames Water was privatised and listed on the London Stock Exchange in 1989. From 1989 to 2000, Thames Water was an independent company, during which period it pursued a growth strategy by buying or setting up businesses around the world. By 2000, Thames Water had companies with operations in Malaysia, Thailand, Singapore, Australia, Chile and Turkey. Although most of these companies were related to the provision of water and waste water, Thames Water also entered property development as well as consulting businesses. Leverage (debt to total assets) also increased during this time. From 6.45% in 1991, it had risen to 33.9% by 2000.

In 2000, RWE Group, a large German utility, took over Thames Water and continued with the practice of expanding the group into areas unrelated to its roots of providing water and sewage services to London. By December 2001, the revenue from the regulated utility accounted for 63% of Thames Water's total revenues. The number of countries where Thames Water was operating steadily increased, as it added businesses in Chile and further projects in Turkey and the US. During this period of RWE ownership, the business even invested in the London Underground public-private partnerships, buying 20% of the ill-fated Metronet Rail SSL and Metronet BCV SPVs.

In 2004, Thames Water group conducted a strategic review and came to the view that it should focus on the UK and Europe. As a result, large sections of the international business were sold. Of total group revenues in 2004 of £1,945.7m, the businesses from the Asia Pacific and Americas contributed only £89.3m and £75.8m, respectively. It could be concluded that these businesses were more of a distraction than contributing significant value. In 2005 RWE conducted its own strategic review, concluding that the group was to focus on electricity and gas supply rather than continue holding on to regulated water assets. The group announced that Thames Water would be sold by 2007 and any proceeds would be returned to shareholders by way of special dividends. Although initial estimates for proceeds from the sale were £7bn to £12bn, Thames Water was eventually sold to a Macquarie Bank company, Kemble Water Holdings, for £8bn (an equity value of £4.3bn and the assumption of £3.2bn of debt.)

It is during the subsequent years, from 2007 to 2017, that we can observe a real change in the way Thames Water was managed. Gone were the attempts to expand into other industries and countries; from 2007 there was a focus on the utility, accompanied by significantly increased leverage and distributions to shareholders (figure 2). In the early years of the Macquarie consortia controlling Thames Water, large dividends and interest on shareholder loans were paid. However, from 2015 the balance sheet capacity for Thames to support such distributions appears to have been exhausted. Although there were still dividends and interest on shareholder loans paid in 2016 and 2017, since then very little cash has been distributed to shareholders. In 2017 Macquarie ended its association with Thames Water, selling its final stake to Omers and Wren House, with other investors also selling out to the current shareholders.

Red flag 3: risk factor exposures

How risky can a utility really be?
Thames Water's exposure to key risk factors that have been shown to drive market prices has been high, and rising, for a significant period of time: this leads to an increasingly higher market risk premium and therefore discount rate and a likely loss in value that was not recognised for years.

There are strong public policy considerations for ensuring that a utility remains functioning and providing a service. As a result, because they provide the necessities of life and despite being complex businesses to operate, utilities should, in theory, be relatively low risk for investors. They are sometimes described as 'boring' because they are stable and predictable.

There are four main risk factors found to explain the returns of infrastructure assets: leverage, profitability, size and investment.

Leverage
Leverage is a key risk factor in examining the returns of infrastructure assets. As shown in Blanc-Brude and Gupta (2021), leverage is positively linked to the risk premium of an asset; the more leverage, the higher the risk of future dividends ceteris paribus. In the case of Kemble Water, the asset is significantly more leveraged than other similar water assets and compared to infrastructure as a whole (figure 3).

Profitability
The second factor that helps explain the risk premium for infrastructure is profitability (net profit after tax/total assets). This factor exhibits a negative relationship with the risk premium of infrastructure assets, ie, higher profits indicate more likely future dividend payouts and a lower discount rate. For regulated water utilities we would not expect high profits. The UK utilities sector has seen its profitability drop by almost 30% since 2015. Crucially, Kemble Water's profitability is significantly lower than that of its peers. This would have a negative impact on the risk premium for Kemble, compared with other utility assets, resulting in a higher discount rate. With the trend for profitability negative, we would also witness an ever-increasing risk premium over time.

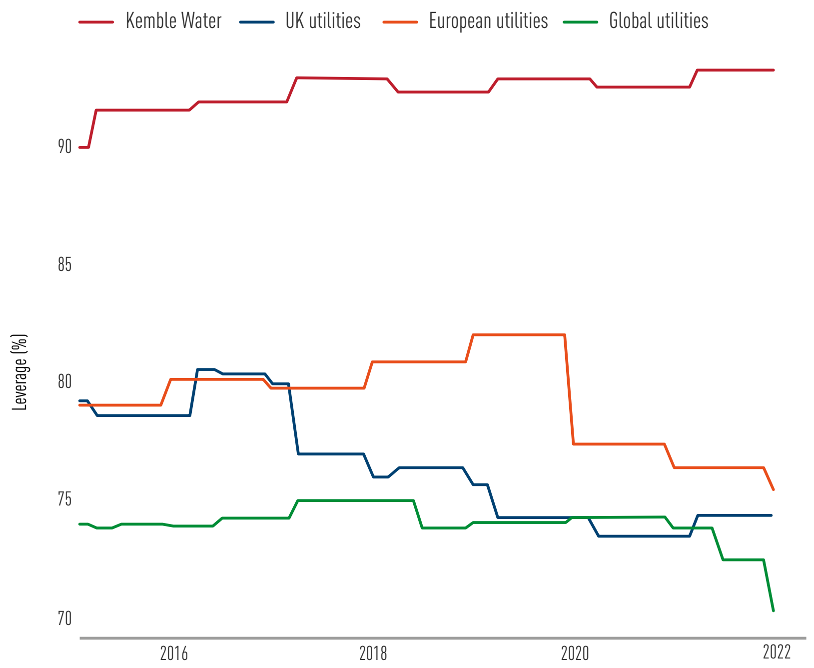
Size
The third factor presented here is size, or the total assets of a firm. Size was found to have a positive relationship with the risk premium for infrastructure assets (see Blanc-Brude and Gupta [2021]). The larger the asset, the greater the return because the asset is more illiquid and more complex. Kemble Water is significantly larger than its peers in the UK water sector as well European and global utilities. As a result, investors would again expect a higher risk premium for Kemble Water than other infrastructure assets. However, the general trend of growth in the size of the asset stopped in 2020.

Investment
Finally, we consider the investment factor (capital investment/total assets). Blanc-Brude and Gupta (2021) found that a higher investment factor results in a higher risk premium for assets. Indeed, during periods of higher investment, infrastructure companies face higher risks of delays and cost overruns, which are well-known problems in large capital projects. All these effects make future cash flows more uncertain and increase the risk premium.

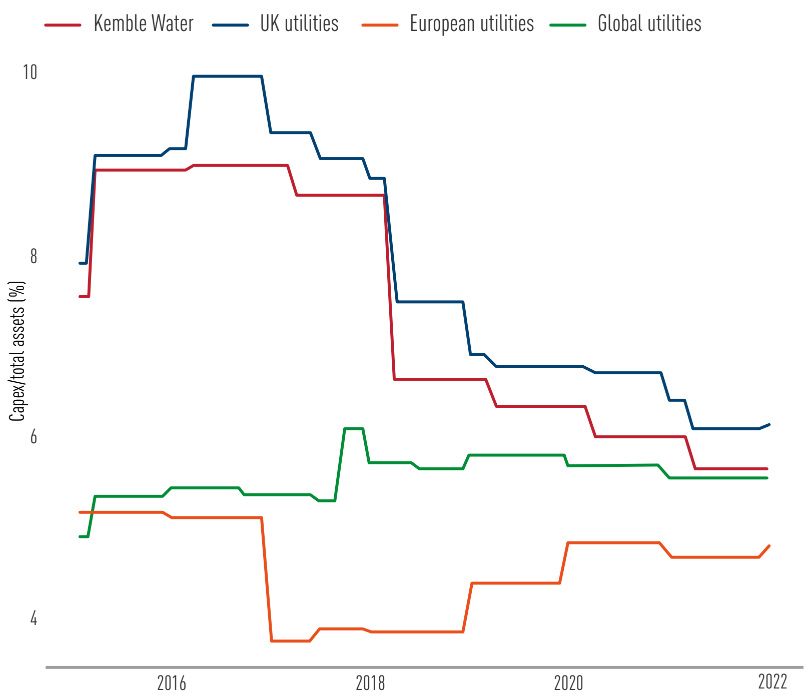
Kemble Water and UK utilities have comparable investment factor exposures. This is understandable as they are governed by the same investment/regulatory cycle. However, there have also been changing investment cycles that have resulted in changing risk premiums. Specifically, an increase in the factor exposure around 2015 and 2016 for UK water utilities and Kemble Water respectively increased expected returns, with a subsequent decrease from 2018. This change in the factor, first up then down, would have led to similar movements in the risk premium for Kemble Water and, consequently, the discount rate and valuation. Still, throughout the period, we also see that Kemble is increasingly investing less, as a function of its size, than its peers in the UK.

We can also observe that, for both Kemble and UK utilities, the investment factor is higher than for European or global utilities. This would indicate that the risk premium should be higher, hence a higher expected return.

3. Leverage of Kemble Water Holdings compared to the median leverage for UK water holdings and global infrastructure



4. The investment factor of Kemble Water versus its peers



A high risk profile
From this comparative analysis of the key systematic risk factors to which Kemble Water is exposed, investors should have been able to conclude that the investment:

- was highly levered;
- produced low profits compared to its peers;
- was very large;
- had low capex compared to other utilities; and
- was much more volatile than its peers.

These had obvious consequences for the valuation of the asset.

Conclusion
These findings should have at the least led the latest investors to question the reported value of the company – not to mention the fact that the reported

valuation had in fact increased over time - because they all signal that Thames Water should have instead been losing value for many years. Using our own benchmarks to generate a comparable set of data points for a typical company with the same characteristics as Kemble Water, our measures of risk factor exposure, duration (exposure to interest rate risk) and likelihood of dividend payouts signal that the firm is likely to have lost between 30% and 50% of its value over the past decade, in large part due to the evolution of its risk profile and the market price of risk.

While this does not constitute a formal assessment of the fair value of Thames Water and its holding company, it is a robust point of reference from which investors should have questioned what they knew and the valuation of the asset.

Reference

Blanc-Brude, F., and A. Gupta (2021). The volatility of unlisted infrastructure investments. EDHEC Business School.

Achieving diversification in unlisted infrastructure investment

A Smart Infra portfolio construction

Frédéric Blanc-Brude, Founding Director, EDHEC*Infra* & Private Assets Research Institute; **Abhishek Gupta**, Associate Director, EDHEC*Infra* & Private Assets Research Institute; **Moataz Farid**, Quantitative Analyst, EDHEC*Infra* & Private Assets Research Institute

Unlisted infrastructure investments are notably illiquid due to their substantial size and their few secondary market transactions, creating challenges for portfolio construction.

Despite these limitations, large institutional investors pursue infrastructure investments for diversification purposes.

Achieving broad diversification in this asset class is difficult because the lack of liquidity restricts entry and exit points, complicating portfolio rebalancing.

Additionally, the inability to short sell in private markets also limits the scope of infrastructure investing to a long-only strategy.

Introduction

Previous research has suggested that unlisted infrastructure equity offers a significant potential to improve total portfolio diversification; however, this is on the assumption that the asset class is accessed on a well-diversified basis (Amenc et al [2022]). But what does this mean for an investor in infrastructure in practice? Is there a minimum number of assets or sectors that justifies using the phrase 'well-diversified' in the annual report? Is a portfolio of just 10 infrastructure assets necessarily under-diversified? We show that answering these questions is not as simple as totting up the assets, sectors or countries in which individual investments have been made.[1]

In this paper, we aim to answer two questions:

Is it feasible to build a diversified infrastructure portfolio? We construct several portfolios using a 'brute force' approach. These are 100 equally weighted random portfolios for each target number of constituents, from five to 100, irrespective of any other sector or geography criteria. These brute force strategies show that on average portfolio diversification can be achieved by increasing the number of assets in the portfolio. However, holding a large number of assets in an infrastructure portfolio is not feasible (Amenc et al [2023]). While infrastructure investments are very heterogeneous and different from one another, it is important to recognise the existence of common risk factors in a portfolio of such investments. We show that achieving a well-diversified portfolio of infrastructure investments is nonetheless possible with a limited number of investments – as long as the key risk factors found in these investments are used to build the portfolio accordingly.

What role do infrastructure investments have in a multi-asset class portfolio? We construct a portfolio that includes nine asset classes. We then add infrastructure to the portfolio and examine the implications using different optimisation techniques such as return targeting, risk targeting and equal risk contribution. We show that infrastructure investments can have a weight ranging from 4.4-13.1% depending on investors' risk profiles.

1 A longer version of this paper is available here: https://publishing.edhecinfra.com/papers/2024_smart_infra.pdf.

Portfolio construction: building a well-diversified infrastructure equity portfolio

Building infrastructure portfolios using brute force diversification strategies
In this section we consider different strategies to diversify a portfolio invested solely in unlisted infrastructure asset class. We first consider allocating capital across a range of assets, sectors or geographies. These approaches reflect the way diversification is often presented by fund managers. We label them 'brute force' diversification strategies because they rest on the simple assumption that 'more is less' – ie, more assets, sectors, countries result in less risk.

To build the infrastructure portfolio, we sample randomly from the 600-plus assets in the infraMetrics database and produce 100 portfolios of five assets, 10 assets, 15 assets, etc.[2] For each group by number of assets, we compute the average return, risk and Sharpe ratio for the 100 portfolios. We show in panel A of figure 1 that, to achieve diversification, fund managers must hold a large number of assets; it takes at least 100 assets to substantially reduce portfolio volatility and achieve an average volatility of 0.13. As the number of assets increases, the 95% confidence interval (illustrated by the grey vertical lines) narrows, indicating that the dispersion of the volatility and Sharpe ratio is decreasing. This suggests that the predictability of the portfolio's performance improves with more assets, as idiosyncratic risks are diversified away. However, the marginal benefit of adding more assets diminishes with each additional asset added. Reduction in volatility is very minimal beyond 25 assets.

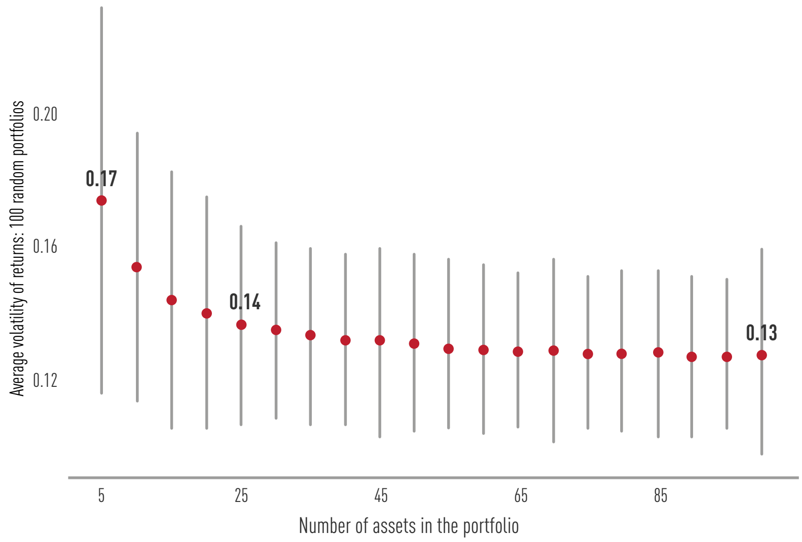
We then investigate the risk-adjusted returns across different strategies, such as adding more TICCS industrial sectors and geographies into the portfolio. Figure 2 shows an illustration of building an infrastructure portfolio across 12 sectors and 12 regions. Although on average the Sharpe ratio is 0.15, the upper and lower bounds of the confidence interval suggest that this might vary significantly within each strategy and there is no guarantee that all the portfolios (including those with 12 sectors or 12 countries) achieve higher diversification benefits. This is because many of the common factors that explain returns are not sector specific but instead arch back to the fundamentals of private companies: profits, size, leverage, etc.

Private infrastructure assets represent

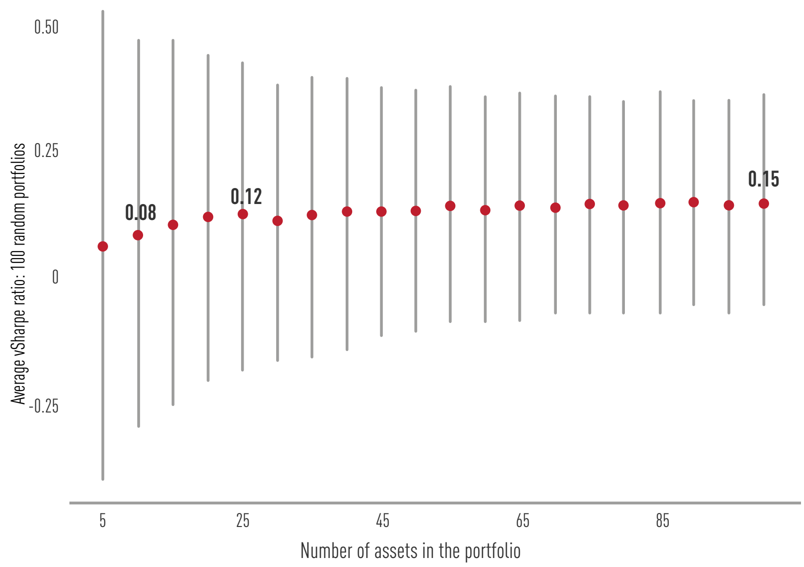
2 https://indices.edhecinfra.com/launcher

1. Brute force diversification approach

A. Mean portfolio volatility and number of infrastructure assets



B. Mean portfolio risk-adjusted returns and number of infrastructure assets



Notes: the dotted points are the average of 100 randomly chosen portfolios for each number of assets. The grey bars are the 95% confidence intervals. Panel A demonstrates the average volatility of 100 random portfolios for the brute force diversification by number of assets. Panel B demonstrates the average Sharpe ratio of 100 random portfolios for the brute force diversification by number of assets.

2. Comparison of the three brute force diversification strategies

	100 assets – brute force strategy	100 assets and 12 sectors	100 assets and 12 countries
Annualised return	2.9%	2.8%	2.9%
Annualised risk	12.6%	12.6%	13.0%
Sharpe ratio	0.15	0.14	0.15
[Upper, lower bound]	[-0.03, 0.32]	[-0.001, 0.29]	[-0.09, 0.39]

Notes: Comparison used 100 assets from 100 simulated portfolios and risk factors diversification based on 100 simulated portfolios of 25 assets. Results are in US dollars.

an indivisible investment, making constructing a portfolio with a large number of assets can be not only impractical but also financially unfeasible. Consequently, private infrastructure investors are typically restricted to holding a small number of assets. Blanc-Brude et al (2022) show that fund managers hold on average no more than 25 infrastructure assets in their portfolio at any one time, making the brute force diversification strategies unachievable.

Building infrastructure portfolios using the Smart Infra approach

To reduce idiosyncratic risk within the portfolios, we use the logic of factor investing in the context of unlisted infrastructure investments. This strategy involves assessing individual infrastructure investments for their exposure to key systematic risk factors and tilting our portfolios towards assets that have high exposure to these systematic risk factors. These five key risk factors are proxied by firm-level financials and a country risk factor and are then used in the infraMetrics model as illustrated in figure 3. We refer to this approach as ‘Smart Infra’, as it follows a multi-step approach that not only tilts towards a given factor or group of factors, but also achieves diversification within the factors tilt through the combination of alternative weighting schemes. This is a multi-step approach as illustrated in figure 4.

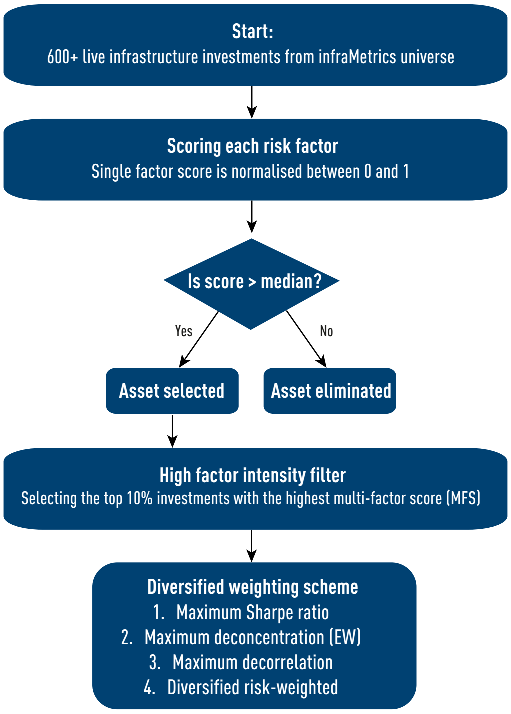
Our approach filters the number of assets in the infraMetrics universe to the assets that have a strong exposure to individual risk factors and a strong multi-factor intensity overall. This makes the portfolios less sensitive to the underperformance of one specific factor and enables them to benefit from a higher potential for outperformance over the long run. We apply a diversified weighting scheme to diversify idiosyncratic risks and achieve the highest possible risk-adjusted return. The outcome of this approach is a ‘high factor intensity’ (HFI) portfolio that achieves high risk-adjusted returns with small number of assets. Figure 5 shows that a 25-asset HFI portfolio achieves higher risk-adjusted returns, measured by Sharpe ratio, than both brute force portfolios built with 100 randomly chosen assets across 12 different sectors and 100 randomly chosen assets across 12 different geographies. This confirms that, by applying our Smart Infra approach, fund managers can achieve diversification through concentration. Using our Smart Infra approach, investors can construct portfolios that are not only theoretically viable but also practically achievable, leveraging the systematic risk factors exposure for each individual asset.

As an illustration of our Smart Infra approach, we constructed a ‘high risk factors’ index, including 35 assets, that is highly diversified. Panel A of Figure 6 shows the cumulative returns time series of the HFI portfolio over the period 2009-23 along with the broad market infra300 capital weighted index (weights capped at 5%), which tracks 300 assets in 15 sectors and 20 countries. In terms of riskiness, we observe the maximum drawdown for both indices in panel B of figure 6, as displayed, the HFI index exhibits less drawdowns than the infra300 index. This proves that the risk factor diversification, along with the weighting scheme, used to construct the HFI index

3. infraMetrics key systematic risk factors

Factor	Definition (proxy)	Effect on price	Economic rationale	References
Size	Total assets	Negative	Larger assets are more illiquid and complex transactions	Fama & French (1993)
Leverage	Total debt/Total assets	Positive	Higher leverage increases the risk of future cash flows to shareholders	Blanc-Brude & Tan (2019)
Profits	Return on assets before tax	Positive	Higher profits make future dividend payouts less uncertain.	Blanc-Brude & Tan (2019)
Capex	Capex/Total assets	Negative	Higher capex increases the risk of construction cost overruns and delays, making future dividends more uncertain.	Blanc-Brude & Tan (2019)
Country risk	Term spread	Positive	More uncertain long-term macro prospects (yield curve slope) correlate with greater risks for investors in infrastructure.	Chen & Tsang (2013)

4. Smart Infra multi-step approach

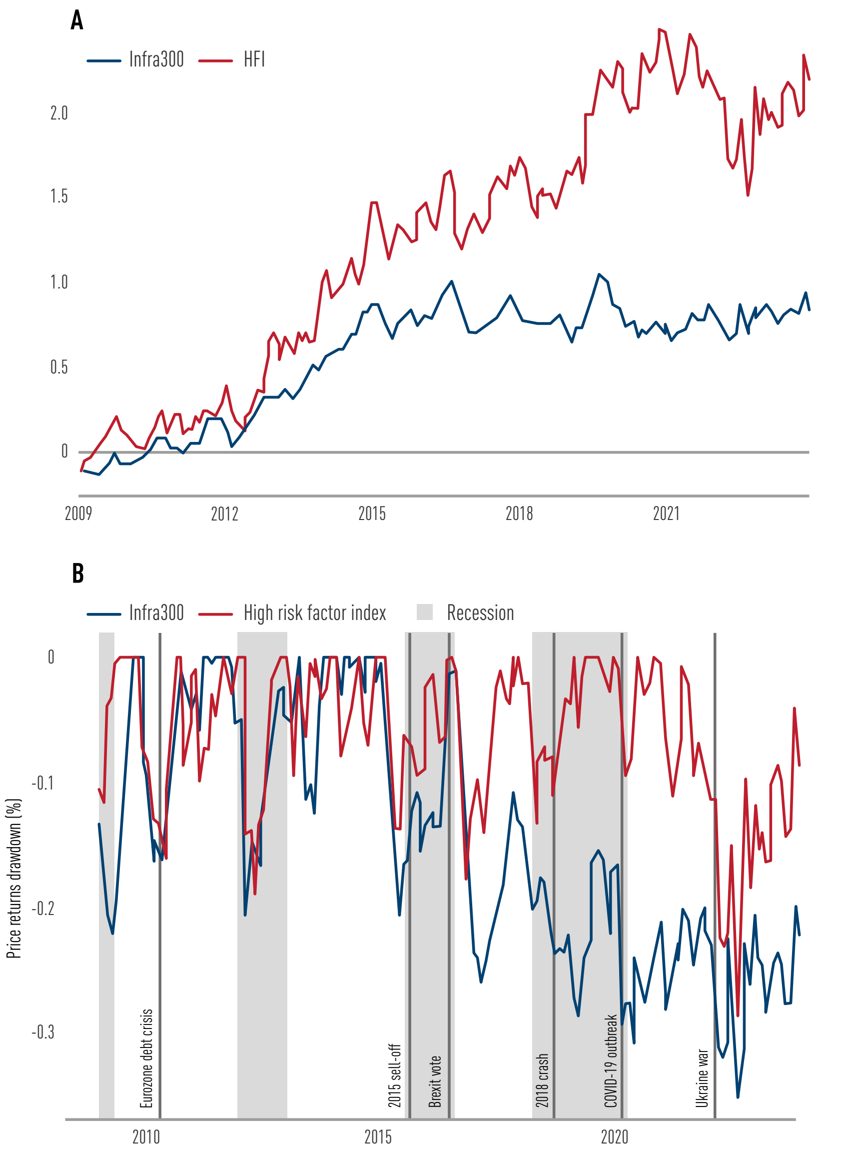


5. Comparison between the brute force and risk factor diversification strategies

	100 assets – brute force strategy	100 assets and 12 sectors	100 assets and 12 countries	High risk factors portfolio with 25 assets
Annualised return	2.91%	2.78%	2.90%	7.60%
Annualised risk	12.7%	12.5%	12.8%	18.5%
Sharpe ratio	0.151	0.143	0.149	0.357
[Upper, lower bound]	[-0.023, 0.325]	[-0.01, 0.296]	[-0.07, 0.368]	[0.173, 0.540]

Notes: This shows a comparison between the three brute force diversification strategies with 100 assets from 100 simulated portfolios and risk factor diversification based on 100 simulated portfolios of 25 assets. Results are in US dollars.

6. Infra300 vs HFI portfolio with 35 assets cumulative returns



8. Average industry expectations of risk and return across different asset classes

Asset class	Return	Risk	Sharpe ratio
High risk factors index	10.03%	19.19%	0.588
US equity	6.57%	16.12%	0.408
Emerging equity	8.35%	20.21%	0.413
Corporate bonds	4.58%	5.16%	0.888
Government bonds	4.03%	4.63%	0.871
Real estate	6.54%	12.20%	0.536
Private equity	8.92%	20.83%	0.428
Hedge funds	5.37%	7.04%	0.762
Commodities	4.06%	17.32%	0.235

Notes: The forward-looking data for asset classes with exception to the high risk factors are the average of the forward-looking data provided by Blackrock, JP Morgan, Morgan Stanley, BNY Mellon, Invesco, Schroders, Northern Trust, State Street, Callan and Envestnet. For the high risk factors index, we use the weighted average expected returns estimated by EIPA and the historical volatility based on the Smart Infra diversified weights.

9. Correlation coefficients of the high risk factors index with other asset classes

Asset class	High risk factors
Equity	-0.05
Emerging equity	-0.08
Corporate bonds	0.07
Government bonds	0.22
Real estate	0.15
Private equity	-0.05
Hedge funds	-0.08
Commodities	-0.21

7. Risk profile comparison between the infra300 index and the high risk factors index created through the Smart Infra approach

	Infra300	High risk factors index
Annualised return	4.1%	8.0%
Annualised risk	10.4%	17.6%
Sharpe ratio (rf = 1%)	0.297	0.395

make it more resilient to drawdowns than the infra300 index. Similarly, figure 7 shows that the HFI portfolio outperforms the market and achieves a better risk-adjusted return with 35 assets than the infra300 that has 300 assets.

Strategic asset allocation: infrastructure in the total portfolio

Next, we look at what role infrastructure investments play in a multi-asset class portfolio. We construct a portfolio that includes nine asset classes, including traditional asset classes such as US equity, emerging equity, corporate bonds, government bonds, commodities and alternative investments such as private equity, real estate, hedge funds, commodities and unlisted infrastructure high-risk factors index. Using the infraMetrics universe of unlisted infrastructure investments, we then create capital market assumptions (CMAs) for the high risk factors index and measure its correlation with other asset classes. Figure 8 shows that the high risk factors index has the highest returns and the fourth highest risk-adjusted returns (Sharpe ratio). Figure 9 shows the correlation between the high risk factors index and other asset classes, as illustrated, has the lowest correlation with other asset classes. This demonstrates the diversification benefits the high risk factors index brings to a multi-asset class portfolio.

Building multi-asset class portfolios

We compute optimal portfolio weights for a range of risk, return and diversification targets for two profiles of investors – 'conservative' and 'aggressive'.

Conservative investors follow a 20:80 strategy and allocate 20% to US equities and 80% of their portfolios to corporate bonds. This is an example of a well-funded pension plan with a focus of liability-driven investment to protect the existing fund contribution and hedge their liabilities.

Aggressive investors follow a 60:40

strategy and allocate 60% of their portfolio to US equity and 40% to corporate bonds. Such an investor would have a higher risk tolerance and want to achieve higher returns.

For each, we compute two types of mean-variance optimisations, a return-targeting and a risk-targeting optimisation, as well as a risk-only optimisation technique.

Return targeting: This strategy is based on finding an allocation that achieves a portfolio return greater than or equal to the 60:40 and 20:80 portfolios, while minimising the portfolio risk. The portfolio is fully invested, and short selling is not allowed.

Risk targeting: This strategy is based on finding the optimal portfolio weights that keep the portfolio risk below the target of the 60:40 and 20:80 portfolios while maximising returns.

Equal risk contribution (ERC): This strategy is based on finding the optimal portfolio weights to minimise the risk contribution from all asset classes, while minimising the effective number of constituents (ENC).

For the first two strategies, we also apply the following two constraints:

ENC is at least six.

The allocation to all illiquid assets (real estate, private equity, hedge funds, commodities, risk factors indices) does not exceed 20% of the portfolio, leaving at least 80% invested in liquid assets.[3]

Results

The outcome of the different optimisation techniques is shown in figures 10 and 11, demonstrating that, across three different portfolio optimisation techniques, private infrastructure can indeed play an important role in a multi-asset portfolio as a strategic asset class that complements other allocation classes.

Figure 12 presents a comparison of Sharpe ratios across different portfolio strategies with and without infrastructure. The portfolios that incorporate infrastructure assets consistently achieve higher Sharpe ratios. This confirms the positive role that infrastructure can play in the portfolio.

10. Return and risk targeting portfolio optimisation techniques to build multi-asset class portfolios for conservative and aggressive investors

		Return target		Volatility target	
Target		4.98%	5.80%	7.40%	11.80%
	Asset class	**Conservative**	**Aggressive**	**Conservative**	**Aggressive**
Weights	US equity	11.40%	11.80%	12.90%	19.70%
	Emerging equity	7.17%	11.29%	14.40%	26.00%
	Corporate bonds	22.69%	22.90%	21.90%	12.70%
	Government bonds	25.62%	25.50%	23.70%	10.70%
	Real estate	7.61%	6.44%	5.10%	0.0%
	Private equity	0.0%	0.95%	1.80%	8.0%
	Hedge funds	8.10%	2.43%	0.0%	0.0%
	Commodities	13.10%	8.40%	7.10%	10.90%
	Smart Infra	***4.40%***	***9.20%***	***13.10%***	***12.0%***
Return		5.31%	5.80%	6.10%	6.80%
Risk		6.11%	5.90%	7.40%	10.90%
Sharpe ratio		0.706	0.717	0.69	0.537

11. ENC target portfolio optimisation techniques to build multi-asset class portfolios for conservative and aggressive investors.

	Asset class	**High**	**Mid**	**Low**
ENC target		7	6	5
Weights	US equity	14.1%	10.4%	7.4%
	Emerging equity	11.8%	7.7%	5.4%
	Corporate bonds	19.3%	24.0%	24.1%
	Government bonds	19.6%	26.0%	33.8%
	Real estate	5.2%	5.5%	6.3%
	Private equity	3.7%	3.1%	3.5%
	Hedge funds	5.1%	5.3%	5.3%
	Commodities	15.2%	15.2%	10.5%
	Smart Infra	***5.9%***	***6.2%***	***4.9%***
Return		5.7%	5.5%	5.3%
Risk		7.6%	6.3%	5.4%
Sharpe ratio		0.621	0.714	0.793

12. Sharpe ratio comparison across portfolios with high risk factors index and without infrastructure assets

	Return targeting		Risk targeting	
Allocation	20/80	60/40	20/80	60/40
Portfolio with high risk factors	0.706	0.717	0.690	0.537
Portfolio without infrastructure	0.668	0.631	0.640	0.483

Notes: Sharpe ratio is calculated based on 1% risk free rate. All calculations are in US dollars.

Conclusion

To conclude, the Smart Infra approach described in this paper makes diversification of unlisted infrastructure investments feasible within portfolios. Hundreds of bets can be necessary to build a portfolio with fully diversified idiosyncratic risks unless these assets are selected based on their risk-factor exposures. Trying to add decorrelation to the portfolio by adding more assets in different sectors and countries ignores the fact that investments are not only linked by sectors and countries but also by their risk profile as a business – ie, the risk factors described in this paper. These risk factors are universally available in all assets because they represent the systematic risk that the market prices in these assets. This universal availability enables investors to access exposure to these factors much more easily than sector and country bets.

Defining a diversification strategy as: "We need to add 20 new transport investments in 10 different countries to the portfolio" is a non-starter for any deal team. Instead, "We need to add 10% of exposure to the size factor to the portfolio" is relatively easily implemented.

The principles of risk factor diversification illustrated here demonstrate that in private markets, where investors are restricted to holding a limited number of assets, they can still achieve diversification through concentration. Our approach

3 The choice of 20% is ad hoc but consistent with average allocations for some large institutional investors such as US public pension funds.

is not limited to unlisted infrastructure equity alone but can be extended to other illiquid asset classes such as infrastructure debt, real estate, and private equity. By applying similar strategies, investors can leverage the benefits of systematic risk factor exposure to achieve more efficient diversification, thereby enhancing portfolio performance and mitigating idiosyncratic risks across a broader range of investments.

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