Infrastructure investment - an introductory guide

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September 2022

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Abstract

This is an introductory guide to infrastructure investment for financial institutions such as insurance companies and pension funds, which has been prepared by the Infrastructure Working Party of the Institute and Faculty of Actuaries. It describes some of the risks of such investments and gives a broad indication of the returns which such investors may have made on their investments in the past.

Those readers whose institutions have already taken the plunge into infrastructure will know that it is a highly complex and diverse field of activity. This guide does not explore all the matters which investors take into account, but it does attempt to give an indication of many of the more important points.

One of the questions we have thought about is, what is infrastructure? Physically it has some similarities with commercial properties such as shops, offices, and warehouses, as well as with residential housing. However, this report confines itself to facilities which serve a whole community, not just a particular family or business, or a limited group of families or businesses. Thus, we have taken infrastructure to cover facilities such as renewable energy generators, transport and water installations, schools, hospitals, flood defences, communications, etc., but we have excluded consideration of military structures. We are very conscious of the fact that an investor may own or participate in the ownership of a particular infrastructure asset, but the reality when considering risks is that the asset may form part of a more widely connected system providing a comprehensive service to many people. There is also the important consideration that the risks and returns depend not only on the physical assets but also on the uses which people make of them to provide community services, and how adaptable these assets may be to meet changing circumstances like climate change and the advances of technology.

The key reason for institutions to consider infrastructure ownership is because it can offer long-term and relatively stable income streams, which sometimes (at least to some extent) keep pace with inflation. Another reason for institutions to invest in some kinds of infrastructure is because they believe that this can be demonstrated to be socially desirable and hence may tend to enhance their reputation with their own stakeholders such as policyholders and pension fund members.

Infrastructure will normally form a comparatively small proportion of an institution's investment portfolio, perhaps between 5% and 15% in many cases. The risks described here will to some extent overlap with risks in the remainder of the portfolio but when the general investment outlook changes, the reported values of the infrastructure investments may not change as rapidly as the values of stock exchange investments. An institution will naturally be concerned with the overall performance impacts of including infrastructure in its portfolio, and we will describe some tentative exploratory steps we have taken to examine this issue.

In section 1 we summarise the long history and evolution of the infrastructure market. Among other things we demonstrate the variety of financing methods which have been adopted at different times, including partnerships between the public and private sectors. Such partnerships may continue to play a part in future, where investors are willing to meet conditions laid down by public bodies.

Section 2 discusses in greater depth the reasons why investors are interested in infrastructure and shows the very large sums which have been invested by the top 20 institutions in this field. Three quarters of the sums invested since 1994 by these "top 20" came from pension funds and insurance companies. There are regulatory considerations which institutions need to take into account before investing in this field, including the necessity to carry out proper risk analyses and risk capital calculations. One factor which may cause some institutions to hesitate before committing large sums to infrastructure is that it will often be difficult to sell the investments at short notice, particularly in adverse market conditions.

In Section 3 we consider various types of infrastructure, including the difference between the risks and returns of "greenfield" and "brownfield" sites when new facilities are being constructed. We also discuss the differences between "demand" assets which can generate revenue streams for investors from the users of the facilities, and "social" assets which do not normally generate revenue streams from users but may produce revenue streams from public bodies. Finally, we look at the "shape" of the cash-flow profile over the expected lifetime of an asset.

Section 4 describes the very different ways in which investors can get exposure to infrastructure, i.e. direct ownership or direct investment in projects, buying the shares of listed infrastructure companies, or investing in an unlisted infrastructure fund of a "private equity" nature. There are also infrastructure "platforms" which enable investors to share in the direct ownership of assets, thus increasing the spread of risk and sharing between them the relatively high costs of due diligence. We have not considered infrastructure bonds, because of the similarities with bonds in general, although it should be noted that the longer term risks of default may not always be fully reflected in the credit ratings of listed infrastructure bonds.

Section 5 reports on the steps which investors can take to benchmark the performance of their infrastructure investments. Some of these steps will be to find out how well the investments are performing financially, but investors are also starting to want to know the extent to which they are meeting social and environmental targets in comparison with others. There are no simple answers to finding good benchmarks, and considerable thought will be needed on which of the alternatives discussed here (or others) will most suit the needs of the investor concerned.

In Section 6 we present an extended description of the risks which may be present in infrastructure investment. It is the existence of so many risks which is the reason why it may be advisable not to devote too high a proportion of the institution's overall investment portfolio to any one infrastructure asset: having a good spread of risk among a large number of assets may often be seen as essential. We have grouped the risks under these headings: political, regulatory capital, social, technological, climate change, economic/financial and governance risks. One of the reasons why infrastructure funds are popular is that they each provide a spread of risk because they own a number of different underlying investments, which also differ in terms to maturity. On the other hand, most of these infrastructure funds will have risks associated with their own gearing (for example the need to pay higher interest rates after refunding loans) which could impact on them all at much the same time.

Section 7 discusses Environmental, Social and Governance (ESG) risks and Sustainable Development Goals (SDGs) in relation to infrastructure. We believe that these aspects will become increasingly important for infrastructure investors in the future, as there develops a wider recognition of the need for infrastructure to be sustainable and meet objectives which are seen as socially and environmentally responsible. We reference many of the guides issued by other organisations which investors may wish to take into account in determining their own policies. In particular it may be possible for investors to start to influence their infrastructure asset managers in the ways they manage the assets, both socially and environmentally.

Finally, section 8 summarises what we have found out about the past performance of infrastructure investments, though we have been hampered by a lack of data in a suitable form. Broadly speaking the long-term listed infrastructure performance reported by some of the largest investors does not appear to be driven by factors markedly different from those driving the performance of global listed equity markets. There are suggestions, though, that the reported performance from quarter to quarter may be somewhat less volatile than the other classes, which may be because the valuations are subject to time delays when circumstances change in a major way, unlike stock exchange valuations where the effect on markets may be immediate. We also delve into more detailed aspects of past performance and how adding infrastructure to a wider portfolio might affect reported performance and portfolio volatility.

In conclusion we believe that investors will continue to be attracted to infrastructure, provided they consider that the prospective returns will be sufficient to counterbalance the undoubted risks, because of a desire to diversify their overall portfolios and to strengthen their reputation through good management of the social impacts.

Keywords

Infrastructure investment; risks; Investment performance; ESG; SDG; public-private partnerships.

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Research methodology

We have drawn on the varied experiences of Working Party Members, both in the UK and overseas, and have also carried out literature searches. In addition, we were given access to some of the infrastructure performance data prepared by the EDHEC Business School and have drawn our own conclusions from it.

Although there is a very large literature on infrastructure, which we have researched on a sample basis, we did not find much that has been published about infrastructure as an investment for financial institutions. To a considerable extent, therefore, this paper is based on our own experiences and investigations, supplemented by:

- reports made to their stakeholders by some of the principal investors,
- a meeting with EDHEC and research papers published by them,
- various published performance indices,
- published papers by the Principles for Responsible Investment (PRI) Corporation.

Section 1 - History and evolution of the infrastructure market

The first steps

1.1 According to Merriam Webster, the word *infra* means “below”, which can be taken to imply that infrastructure is the “underlying structure “of the economy of the country, through fixed installations such as roads, bridges, dams, the water and sewer system, canals, railways and subways, harbours and airports. The oldest known canal was built in 4000 BC in Mesopotamia, now known as Iraq and Syria, and in 3300 BC, the Indus valley civilization in India and Pakistan had a sophisticated canal irrigation system. Table 1 shows a list of some infrastructure from the past, built using various resources.

Table 1: Methods of financing infrastructure down the ages (Source: European Infrastructure Bank)

Infrastructure	**Finance/Resources**
Temples	Slave labour, user fees
Canals	Military or paid labour, tolls
Cities	Paid labour, property purchases
Theatres/Stadia	Gifts and user fees
Water supply	User fees to water companies
Sanitation/Public baths	Local authorities and user fees
Roads	Taxes, tolls
Ports	Local companies/user charges

Infrastructure development in Britain

1.2 Before 1750 infrastructure in Britain consisted mostly of churches, inns, roads, bridges, harbours and coal mines. The Romans had built main roads using deep roadbeds of crushed stone as an underlying layer to keep them dry, but later roads were much less well constructed and often impassable in bad weather.

1.3 Canals were built in the late 18th century for transportation of raw materials and finished goods as factories developed in the Industrial Revolution. Sea navigation was supported by ports and

lighthouses, and new ports were being developed by local manufacturers to export their products. By 1800 many towns and cities had piped water supplied by companies that charged users, but sanitation was generally still primitive, with waste emptying into cellars, pits or streams.

1.4 The UK saw very significant industrialisation and urbanisation during the 19th century. As the economy grew, there was massive infrastructure construction, accompanied by technological innovations, and roads were considerably improved. Railways, sewers and electric grids are some of the innovative & long-lasting examples. Many of the new facilities, for example railway lines, were at first financed privately through joint stock companies in a search for profit. There was no Government participation and the companies had to bear the risks as well as reaping the returns. The first major railway line was built from Manchester to Liverpool in the 1830s and many others followed throughout Britain.

1.5 However, as time went on the railway companies became less prosperous, and by about 1900 they were starting to suffer from competition by newly invented motor vehicles. After the Second World War the railway industry was nationalised, and the same happened with other industries reliant on infrastructure, such as coal, iron and steel, telecommunications, aviation, electricity and gas. This meant that the Government was now directly responsible for running much of Britain's infrastructure and for new investment in it when necessary.

1.6 This new system proved to be unsustainable. Electricity, telecommunications, water, gas, airports and railways were privatised in the 1980s, which led to the state-owned enterprise share of GDP falling from 11 % to 2 % in the years 1979-1997 (European Commission, 2016, p.95). Therefore, the development and operation of economic infrastructure took the centre stage and became the responsibility of private sector companies which were regulated by regulators appointed by the Government. Nevertheless, some infrastructure sectors remained controlled by the public sector, such as roads, London's transport network, and the nation's flood defences. In 2002, there was one instance of policy reversal when the Government again took control of the railway network, though enabling private companies to provide customer services through a franchise system.

1.7 In March 2021, the UK government announced a new National Infrastructure Bank which will provide debt and equity capital, state guarantees and advisory services to infrastructure projects around the country. The aim is to support struggling projects to acquire finance by assuming some of the revenue risk and attracting in other investors. It should be noted that the investor interest in the UK is very high but there have not been enough opportunities. Institutional investors such as pension funds and insurance companies are keen to invest in the long-term credit profile of infrastructure assets. For example, Aviva Investors, a part of Aviva Insurance, announced in October 2020 that it wants to invest £10bn in UK infrastructure as a response to government plans.

Public-Private Partnerships

1.8 After World War II the major focus of infrastructure development was carried on in many countries by the public sector because of ownership, financing and delivery of infrastructure projects. As a result of privatisation, a major shift happened in several countries from the 1980s to the 1990s alongside the introduction of Public-Private Partnership (PPP) schemes, which enabled public sector bodies and private companies to set up contractual arrangements to share costs, revenues and responsibilities between them for new projects.

1.9 Over the course of time PPP schemes grew and became increasingly popular. In terms of the largest share of PPP projects, Europe ranks first (about one-third) then followed by North America, Asia and Latin America. In-between "pure" public and private provision of services, rather different "PPP or concession models" of mixing public and private responsibilities are at work in different sectors and countries, and at different levels of government.

1.10 In Britain a form of PPP known as the Private Finance Initiative (PFI) emerged to build social infrastructure such as hospitals and schools in the 1990s. Under the PFI the private sector financed,

developed and operated the buildings, for use by the public sector in return for a rental for the next 30 years. It should be noted that the private sector often took the whole of the financing, construction and maintenance risks. However, the PFI has been abandoned for new projects because public bodies were finding that the rents they had to pay (which were often inflation-linked) were financially insupportable. Some people claimed that it would have been cheaper for the public body to have constructed and run the building itself, though their calculations did not appear to take account of the costs of risk and finance.

1.11 We believe that new forms of PPP will continue to emerge and that there will always be a significant place for private investors, including insurance companies and pension funds, to play a major role in the financing and management of infrastructure schemes around the world.

Section 2 - Why institutional investors consider infrastructure

2.1 Infrastructure is a multi-faceted asset class which can exhibit both equity and bond-like asset characteristics. At the heart of the proposition for infrastructure investment is a fundamental imbalance in demand and supply across many countries. User demand for infrastructure services is typically strong, even in times of poor economic growth. On the other hand, traditional public sector supply of infrastructure services is constrained by a combination of limited fiscal resources and the costs of replacing ageing assets. Beyond these economic fundamentals, infrastructure as an asset class has some investment characteristics that have distinctive risk/return profiles that are attractive to long-term, institutional investors, including:

- **Long life asset** - the lifespan of the underlying asset typically has a long duration and it may operate or provide infrastructure services to last more than 30 years.
- **Lower volatility than broader equity markets** - historically, infrastructure returns have proven to be less volatile than many other traditional asset classes in terms of reported returns, thereby offering the potential to deliver diversification benefits at the portfolio level.
- **Monopolistic assets** - many infrastructure assets have high barriers to entry as the large capital requirements, illiquidity and strict regulations make it difficult for competitors to enter the market.
- **Asset/liability duration-matching** - the long-term nature of infrastructure investments can prove to be a good match for investors who have long-term liabilities, thereby reducing reinvestment risk.
- **Current income** - infrastructure assets, specifically operational assets can generate relatively attractive levels of current income compared to other asset classes.
- **In-elastic demand** - many infrastructure assets provide essential services that tend to be resistant to economic downturns due to in-elastic user demand.
- **Predictable revenue and inflation protection** - the contractual nature of the revenues of many infrastructure assets is attractive, especially when combined with the ability to pass on higher costs, due to inflation adjustment clauses in the pricing mechanism of many infrastructure projects, thereby providing a return that grows in line with inflation. This is an attractive feature for institutions that require real returns.
- **Historically low default rates** - the cumulative default rates on infrastructure investments tend to flatten out over the first ten years of a project, and are consistent with investment grade corporate bonds.
- **Socially responsible investments** - these may provide opportunities to enhance the investor's reputation in responsible investing.

However, not all these features will necessarily be present in every case and investors will in any event need to balance them against the risks which are described in later sections of this paper.

Allocations by global institutions

2.2 The infrastructure asset class got its start for investing institutions in the mid 1990s when the Australian government mandated the country's pension funds (known as Superannuation Funds) to invest in certain Australian infrastructure assets. Similarly, many of the large Canadian pension funds pioneered investment in the infrastructure sector and institutional investors' interest has been growing since the early 2000s in Europe, Asia and the US.

2.3 A key driver in this process is a renewed approach to asset allocation after the financial crisis of the early 2000s, following the bursting of the "tech bubble". The investment industry presented infrastructure as one of the new "alternative" asset classes (alternative to mainstream listed equities and bonds), which was expected to provide new sources of return and better diversification of risk. In addition, infrastructure investing struck a chord with many investors who expressed interest in long-term "real assets" that appear to be more solid than many other more complicated products.
Infrastructure remains one of the fastest growing asset classes, given the significant demand from institutional investors. According to Prequin, annual investment in unlisted infrastructure was circa $1bn in 2000 and now stands at over $100bn per annum.

Strategic investors in infrastructure

2.4 Strategic investors in infrastructure include construction companies and operating companies (example names are in Table 2). These companies target large projects and may specialize in subsectors such as water, power or transportation. To create greater alignment between the infrastructure asset sponsor (for example, the government or local authority) and the construction company which is awarded the construction contract, the construction company will typically be required to have "skin in the game" - that is itself to make an investment in the infrastructure asset. As discussed later in the following sections, these infrastructure assets will often be structured through an arrangement that includes a concession to build and/or manage the new infrastructure asset for a pre-defined period of time. See also the section on Public-Private Partnerships (PPPs) in paragraphs 1.8 to 1.11.

Table 2: Examples of strategic investors in infrastructure

- Abertis
- Acciona
- Aecom
- Alstom
- Atkins
- Balfour Beatty
- Bechtel
- Bilfinger Berger
- Bombardier
- Carillion
- Cintra
- Clark Construction
- Colas Group
- Edf
- Egis
- Eiffage
- Ferrovial
- Fluor
- General Electric
- GDF Suez
- Hochtief
- Honeywell
- Icade
- Impregilo
- John Laing
- Johnson Controls
- Keolis
- Kiewit
- Koch
- Parsons
- Pomerleau
- Sacyr
- Siemans
- Sinohydro
- Skanska
- SNC Lavalin
- Strabag
- Veolia
- Vinci Construction
- Walbridge

Ideally, institutional investors would benefit by building relationships with the above-mentioned companies that operate on a global basis to provide technical consulting, engineering, finance and project management of infrastructure assets. However, institutional investors will still require specialist governance structures and skills to originate, evaluate, monitor and realise infrastructure investments.

Investments by institutional investors

2.5 Table 3 shows the top 20 institutional investors globally in infrastructure investments.

Table 3: Top 20 institutional investors globally by amounts invested

Institution	Investor type	Country	Allocation to infrastructure (%)	Amount invested in infrastructure ($ billions)
CPP Investments	Public Pension Fund	Canada	9.8%	$36.6
Abu Dhabi Investment Authority	Sovereign Wealth Fund	United Arab Emirates	5.0%	$29.0
Caisse de depot et placement du Quebec	Public Pension Fund	Canada	8.8%	$25.2
Allianz Global Investors	Insurance Company	Germany	3.4%	$24.2
National Pension Service of Korea	Public Pension Fund	Korea	3.1%	$23.9
APG	Public Pension Fund	Netherlands	2.9%	$19.9
Ontario Municipal Employees Retirement System	Public Pension Fund	Canada	20.0%	$16.5

AustralianSuper	Public Pension Fund	Australia	10.5%	$16.4
BCI	Public Pension Fund	Australia	10.1%	$15.9
China Investment Corporation	Sovereign Wealth Fund	China	1.4%	$15.0
PSP Investments	Public Pension Fund	Canada	10.8%	$14.3
Ontario Teachers' Pension Plan	Public Pension Fund	Canada	8.2%	$14.0
Legal and General	Insurance Company	United Kingdom	0.7%	$13.0
Pensioenfonds Zorg en Welzijn	Public Pension Fund	Netherlands	3.9%	$12.0
Unisuper	Public pension Fund	Australia	14.2	$10.1
Universities Superannuation Scheme	Private Pension Fund	United Kingdom	7.7%	$8.4
Australia Future Fund	Sovereign Wealth Fund	Australia	6.4%	$8.4
Manulife Investment Management	Insurance Company	Canada	2.2%	$7.9
Alberta Investment Management	Public Pension Fund	Canada	8.1%	$7.6
Qsuper	Public Pension Fund	Australia	7.8%	$7.3

Source: Infrastructure Investor, Global Investor 50, 2 June 2021

Infrastructure in a portfolio context

2.6 The stable, often inflation-linked, cash flows produced by infrastructure assets coupled with their long-term return profile explains why infrastructure is likely to appeal to institutional investors. The challenge for most institutions remains how the investment profile of infrastructure fits with other asset classes in their portfolios.

2.7 While infrastructure as an asset class is often compared with private equity and real estate, it has distinct characteristics such as substantially longer duration, historically lower volatility and less sensitivity to the business cycle and less liquidity. Depending on the type of infrastructure asset and the associated risk profile, projected annual returns have ranged from about 8% to over 25% (in US dollar terms). These returns are also dependent on the specific characteristics of the asset, including its stage of development, whether it is “Greenfield” (i.e. a project that needs to be constructed on undeveloped land) or “Brownfield” (i.e. an existing asset or formerly used site that needs to be managed and/or can be improved).

In addition, other factors could also impact returns. For example:

- Jurisdiction of investment - investments in developing markets generally command a premium to investments in developed economies.
- Sector - some sectors may be more competitive or less monopolistic (e.g. telecommunications) or subject to patronage risk (e.g. ferry companies).
- Risks - especially investors’ perceptions of political risks.

Figure 1 illustrates the expected risk-return profile of brownfield and greenfield infrastructure investments compared to listed equities and bonds.

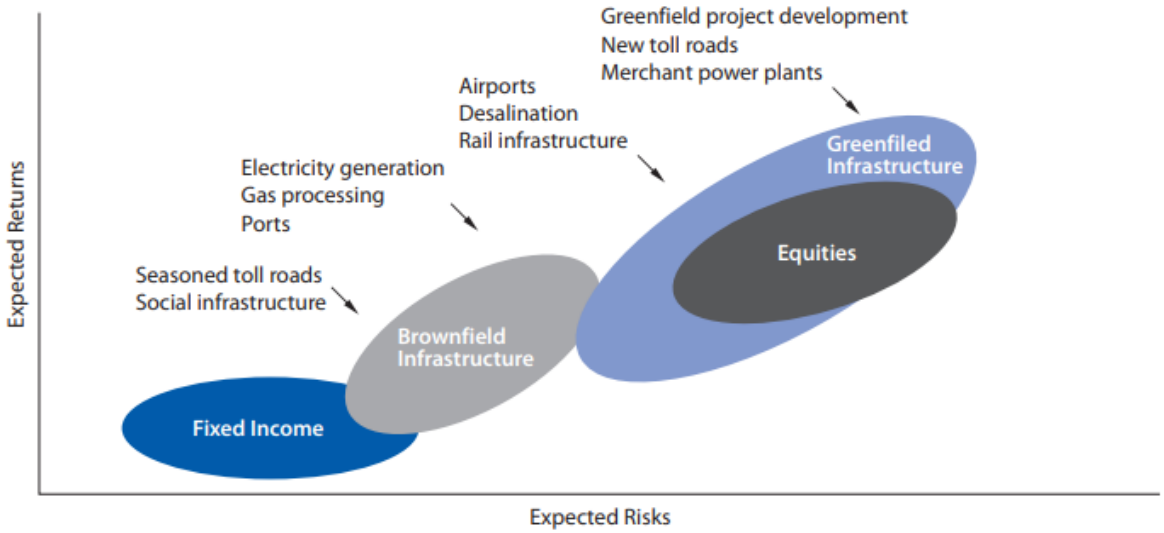

Figure 1: Expected risk-return profiles (European Investment Bank (EIB) Papers, Volume 15, 2010)

Optimal allocation to infrastructure

2.8 Determining overall asset allocation is one of the first and major challenges an institutional investor faces long before actual investment decisions are made. Looking at the target allocation to infrastructure investments in the portfolios of institutional investors, one observes a significant variation between European pensions funds, with no or low single-digit allocations to over 20% for Canadian pension funds (for example, Ontario Municipal Employees' Retirement Systems (OMERS)).

2.9 There is no consensus regarding the optimal allocation to infrastructure investments. While modern portfolio theory (mean-variance optimisation) or asset liability modelling is well established in the context of public market investments such as listed equities and fixed income, a challenge for infrastructure investments is the access to and the appropriate use of historical performance and risk data. Such studies assume that the optimal portfolio allocation is a function of the probability distribution of returns, the asset's risk/return relationship, and the interaction of different assets as measured by the correlation of returns.

2.10 Data providers such as Prequin and Cambridge Associates collect and provide long term cash flow and return data for infrastructure investments, which may be used for the above-mentioned quantitative studies in order to determine the optimal allocation to infrastructure investments. However, such data typically exhibits auto-correlation, which smooths out or reduces risk, as measured by volatility and correlation. If not corrected for, this auto-correlation would increase the optimal allocation to infrastructure investments. Therefore, one may have to utilise certain "un-smoothing" techniques to compensate for the biases mentioned above. Moreover, performance data may include not only an infrastructure component but also a financing component that may not be replicated in future.

2.11 Even after a target allocation to infrastructure investments is determined, thereafter a commitment strategy has to be implemented. This is because unlike traditional asset classes, where capital is put to work immediately, infrastructure investments are typically made through a series of capital calls over a number of months or even years once an infrastructure asset or fund is identified. This stage will also require the institutional investors to consider other aspects such as distribution or realisations, including the maturity of their portfolio relative to its overall lifecycle, in order to maintain the target allocation to infrastructure investments.

2.12 Overall, it is clear that considering a commitment strategy to achieve and maintain allocation targets is as important to institutional investors as setting the targets.

Section 3 - Types of Infrastructure

3.1 While the infrastructure sector covers a wide range of asset types, they all display some common characteristics described in Section 4 of this paper. The return and risk profile of infrastructure assets varies depending on the maturity (i.e. greenfield or brownfield) and revenue characteristics (i.e. demand or availability) of each asset.

Greenfield versus Brownfield

3.2 Early stage or greenfield assets provide capital growth followed by long-term income flows, whereas operational or brownfield assets typically provide access to long-term contracted cash flows.

> **Greenfield:** These are often termed as development/early-stage projects or entirely new projects and require a construction phase prior to operation and before delivering a revenue stream. These assets therefore involve an added element of risk to the investor compared to a mature asset and this will be reflected in a higher projected level of return, often double digits. This higher risk partly reflects the uncertainties involved with construction such as time lags, cost over-runs, contractor insolvency and patronage risk reflecting the unproven level of final demand for the service to be provided.
>
> **Brownfield:** These are often termed as mature stage projects and see the investor acquire an up and running asset or at least the site on which a previous asset stood. Here the principal activity consists of operating, maintaining and managing long term revenue flows and life cycle costs. Typically, these are mature projects with predictable revenue streams where running yield dominates the investment return. The risks involved in brownfield projects are clearly lower than those of a greenfield project as at least a portion of the overall investment will be income producing from the start. However, it should be noted that some brownfield projects may involve a second construction phase to an existing asset such as demolition, de-pollution, extension, rebuilding, refurbishment, or upgrade, in which case they have some similarities with greenfield projects. Brownfield assets will incorporate varying degrees of risk depending on how well established the operation is and, if demand risk is involved, how stable demand is for the service provided.

An example is the expansion of 40 miles of the boundaries of London along the river Thames into Kent and Essex. The local government made the case for 200,000 new homes and creation of 300,000 new jobs in 2003. This was to be done with the combination of both greenfield and brownfield sites. Another example is the construction of the new HS2 railway line from London to Birmingham, passing through brownfield sites in towns and greenfield sites in the countryside. A recent annual report by The Countryside Charity (November 2021), estimates that brownfield land - land that has previously been built on - has the capacity to build 1.16 million new homes.

Construction faults

3.3 For both greenfield and brownfield developments, any latent construction faults may need to be remedied at the investor's expense once any contractor's warranty period has expired.

TICCS (The Infrastructure Company Classification Standard)

3.4 An alternative classification standard for types of infrastructure assets commonly used in industry was created by EDHECInfra - TICCS (The Infrastructure Company Classification Standard). This standard is highly detailed and can be useful for portfolio analysis. It is summarised in the Appendix.

Demand assets versus availability assets

3.5 Another key distinction between infrastructure assets is whether they are demand assets or availability assets. These two categories are also often referred to as “Economic” (demand) or “Social” (availability) infrastructure assets.

> **Demand assets:** This describes assets where the revenue received by the operator is related to the actual use of the infrastructure service. This means that a degree of demand risk or patronage risk is borne by the investor in that a fall in use will affect revenues and return levels. Transport, communications, and utilities infrastructure are examples of demand assets. Often the charge for the service is directly borne by the consumer with the private operator of the asset levying the charge. Given the monopolistic characteristics of infrastructure, the private operator is often subject to some degree of regulation or Government control in determining what fees can be charged and on the standard of the service to be provided.
>
> **Availability assets:** This covers assets where the private sector is rewarded for making available the required infrastructure while a public body will continue to provide the underlying service. The private sector’s (or investor's) responsibility will be the initial design and construction, and the operation and maintenance of the asset to a required standard. The private operator’s fee will be provided directly from the public authority. Hospitals, schools, affordable housing and even prisons are examples of this. The degree of regulation of the private operator may be no higher than in some demand projects but this government involvement is likely to be formalised through a highly structured and detailed concession agreement.

Infrastructure sectors

3.6 The table below shows the different main infrastructure subsectors by demand assets and availability assets.

Table 4 - Examples of Demand and Availability Assets

Demand Assets *(Economic infrastructure)*	• Transport: Bridges, roads and tunnels with toll charges, airports, seaports • Energy & Utilities: Oil and gas processing, transportation and storage, Electricity distribution network • Fresh water systems • Waste water systems • Communications: fixed line networks, mobile masts, satellites, broadcast and transmission facilities
Availability Assets *(Social Infrastructure)*	• Education facilities • Healthcare facilities • Prisons • Affordable housing • Flood protection

Expected performance of infrastructure assets over a lifecycle

3.7 One way to examine the return drivers of infrastructure assets is to separate a theoretical project into four phases (as specified in sections 3.10-3.13). The duration and importance of each phase will differ from asset to asset and not all assets will experience the final phase. However, it is useful in envisaging how the returns from infrastructure assets are affected by different factors at different points in time. It is most applicable to demand or economic assets but can also be applied to availability or social assets depending upon how payments have been structured at conception.

3.8 By acquiring or selling investments at different times an investor can limit his exposure to certain phases depending on his preference. For example, an investor may focus on brownfield or mature assets by acquiring assets in their operating phase and so avoid risks associated with construction.

3.9 Figure 2 shows the typical value and cashflows of an infrastructure asset as it matures from early stage/greenfield to brownfield/mature asset (i.e. covering the construction phase, early operating phase and the maturing phase).

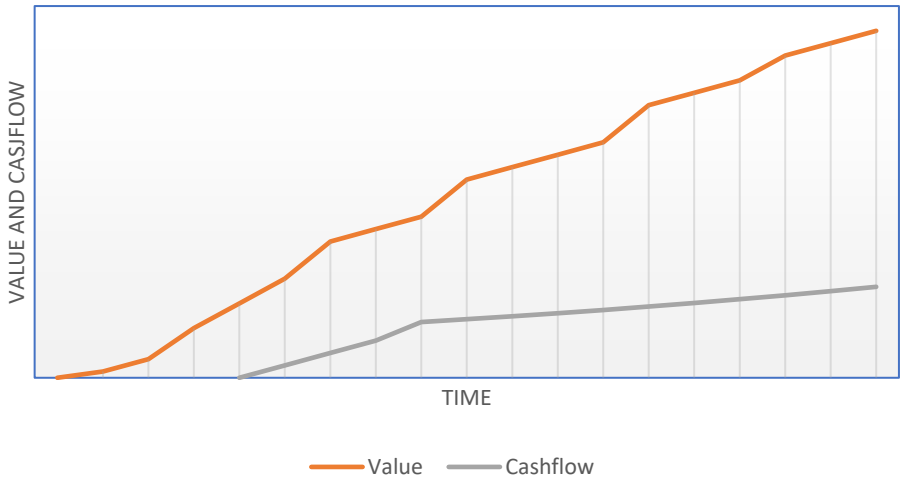

Figure 2: Infrastructure performance lifecycle

Stage 1: Construction phase

3.10 Generally, to bid for an infrastructure concession, the bidding consortium assembles a Special Purpose Vehicle (SPV). The SPV will incorporate equity investors and subcontractors (who will manage the construction and operating risks) as well as contractual agreements with lenders (who provide the bulk of the required funding). A detailed financial structure will also be put in place at this point to ensure project risks are identified, distributed, and rewarded appropriately. At the point of becoming preferred bidder the SPV will have a value (over and above any par investment value) even though the asset is still to be built and no revenue is forthcoming. The formation of the SPV enables the equity investor to allocate the construction risks to the subcontractors who are best able to manage those risks, often on fixed-price contracts. However, the construction phase still represents some significant risks to the investor should the sub-contractors fail to perform or go out of business, leaving the asset in a partially completed state. The value of the infrastructure asset will also grow as the construction work progresses, as the commissioning date nears and as risks are reduced. Consequently, there is likely to be a significant step-up in value once the asset is commissioned. In summary, infrastructure assets are likely to show a strong appreciation in value during the construction phase. If there is likely to be a long period after construction during which the asset is being commissioned and technical loose ends are being tidied up, this may present its own risks for the investor if commissioning takes longer than expected.

Stage 2: Early operating phase

3.11 Once construction and commissioning are completed and the asset starts to be used, revenue starts to flow to the operator and the asset values rise. Initially there is a jump in revenue and asset value. Once the sustainable level of demand for the asset is determined, a lower discount rate can be used in valuing the asset. This reduction in uncertainty, regarding the end of construction and the level of sustainable revenues, provides the investor with the opportunity to achieve an increase in capital value through refinancing. This refinancing may be the swapping of initial expensive debt for cheaper debt. Alternatively, investors may even increase the gearing if the lender relaxes restrictions on the permitted loan to asset ratio. Similarly, a relaxation by the lender of any minimum debt coverage ratios can also result in capital value uplifts because the risk is lower as the asset (project) is up and running and generating revenue.

Stage 3: Maturing phase

3.12 After an asset has been up and running for some time, revenues will stabilise (flatten) and the value of the asset will stabilise. Thereafter, revenues may continue to grow more gradually, reflecting organic growth in demand, and there may be further opportunities for refinancing as this occurs. However, with some types of assets there may also be opportunities to improve cash flows through active management. This may be achieved through making improvements in operating efficiency or through economies of scale if the operator owns other similar assets. For example, in the case of airports, there will often be opportunities to increase revenues other than through increasing passenger numbers, for example by providing retail facilities, car parks or hotel accommodation. All these opportunities are likely to be explored in the maturity phase to boost income and values at a time when core cash flows are likely to be stable. Unfortunately, this phase may also see the need for further expenditure by the investor to refurbish or upgrade the asset, to replace worn-out parts or to meet new regulatory requirements, without a corresponding improvement in revenue.

Stage 4: Hand back phase

3.13 For assets with no fixed life (common with ports, airports and utilities) and which do not revert to the Government, there is no hand back phase and the asset will continue through the maturing phase. However, for assets with set concession terms (common for roads, bridges and tunnels as well as most social infrastructure assets), the capital value of the asset will start to fall as the end of the concession is approaching. This will eventually result in a capital value of zero at the time the asset reverts to the Government (although there may sometimes be a residual value). There may also be a requirement for some capital expenditure towards the end of an asset's life as it is invariably a condition of concessions that the asset be handed back in a satisfactory condition.

3.14 Throughout the investor's ownership of the project there will be a requirement from time to time for capital expenditure to fund major refurbishments or upgrades although these may have been dealt with in advance through a sinking fund provision. If there is no hand back after a fixed term, the investor will remain responsible for the cost of eventual removal of the asset and reinstatement of the site, and a sinking fund provision may be needed so that the community can be satisfied that the necessary resources will be made available.

3.15 To summarise, the exact performance profile of an infrastructure asset is determined by a large number of factors. These include whether the asset is greenfield or brownfield, a demand or availability asset, and the type of infrastructure sector. In addition, the extent and duration of any construction phase, the time taken before an asset reaches maturity, the long-term potential for growth in demand for the service, the potential for active management, and whether the concession has an indefinite or fixed life also play an important role in determining the risk/return profile of infrastructure investments. Consideration must also be given to the possibility of having to undertake further expenditure in later years and the possibility of premature obsolescence. The extent to which costs and revenues will be affected by inflation also needs to be taken into account.

Section 4 - How to invest in infrastructure

4.1 The combination of strong investor demand for infrastructure investments and an increase in the deal flow of infrastructure assets has led to a rapid expansion of interest in the sector. It has also led to the maturing of the infrastructure sector to the degree that it can now be referred to as a standalone asset class. One product of this has been the establishment of a number of specialist infrastructure funds.

4.2 There are three primary ways for investors to gain exposure to infrastructure investments:

1. Direct investment in infrastructure projects

This is achieved through direct investment in infrastructure projects by securing a concession or the ownership of the asset. Although direct investments provide more control to the investor over the underlying assets, this method of investment typically requires large capital outlays that could limit diversification opportunities for most investors. It also requires specialist due diligence, management skills and governance structures that may not be readily available within the investor's organisation.

2. Investing in listed infrastructure funds or companies

Listed infrastructure funds or companies provide an excellent access point for small or new investors to gain an exposure to some of the unique characteristics of infrastructure projects. However, the limited choice of pure infrastructure companies and the higher volatility of returns that result from their stock market listings also present investors with problems and may detract from the fundamental stability of the underlying assets.

3. Investing in unlisted infrastructure funds

Gaining exposure to infrastructure businesses through an unlisted fund offers the possibility to share the cost of entry with other investors and leave the due diligence process and active management to a qualified investment team, who are probably better placed to make quick decisions and deal day-to-day with the investments. Unlisted funds also contain sufficient numbers of assets to diversify away specific project risk, thereby providing investors with a portfolio of infrastructure investments that achieves a level of diversification. Unlisted funds will usually show less reported volatility than listed shares as the value of the fund will be priced in relation to the Net Asset Value (NAV) of the fund (typically determined by independent valuations) rather than by the open market. The downside of unlisted funds is predominantly one of liquidity with holdings in these funds not being as easily redeemable as shares in a listed company. However, a key motivation for infrastructure investment is the access to long term returns and so this should not present a problem for most institutional investors. The performance of an unlisted fund which has borrowings (as is often the case) will be influenced not only by the performance of the infrastructure it holds but also by the positive or negative performance contributed by those borrowings, for example if they need to be refinanced at different interest rates.

To date, unlisted infrastructure funds have historically been the vehicle for infrastructure investment which has been preferred by most investors.

4.3 Table 5 compares the types of infrastructure investments:

Table 5: Features of the three main types of infrastructure investment

	Direct infrastructure investment	Unlisted infrastructure funds	Listed infrastructure funds or companies
Investment manager	Self	Third party	Self or third party
Access to investments	Opportunistic	Opportunistic	Universe of listed infrastructure companies
Typical investment amount	Large	Moderate to large	Small
Ability to diversify	Number of investments limited by size of capital required for each investment	Diversification possible due to pooled arrangement	High due to small amount of capital required to gain exposure to individual securities
Liquidity	Very Low	Low, typically 10 years or more lock-up period	High, typically daily
Reported Volatility	Moderate at early stage, low at maturity	Moderate at early stage, low at maturity	High as underlying securities are exchange listed. Volatility may be correlated with that of listed equities, so that diversification benefits from infrastructure are reduced.
Opportunity to actively manage the infrastructure	High but requires in-house expertise	High (done by the manager with no involvement by the investor)	High (done by the managing company with no involvement by the investor)
Expenses	High, may include a performance fee element	High, likely includes a management fee plus a performance fee	Low to medium
Access	Very low	Low - funds typically open only to qualified or institutional investors	High - underlying securities can be bought on the open market
Investment time horizon	Long term	Typically 3 to 7 years	Short term

4.4 In the last 10 to 15 years, many institutional investors have revisited their allocation to infrastructure as an asset class for some of the following reasons:

1. Private equity structures

Many early investors in infrastructure, particularly through private equity fund structures, felt that their infrastructure investments did not provide stable, inflation-protected, long-term cash flows as outlined in their base case for infrastructure investments. Instead, many institutional investors were holding highly leveraged, high-risk investments which performed poorly against expected returns and other comparable asset classes.

2. Duration matching

Many institutional investors did not achieve their liability-matching objective as there was a mismatch between the term life of the underlying investment vehicle (typically ten years) and their long-term liabilities. This resulted in significant re-investment risk due to the early realisation of investments, mainly due to the fund structure which held the underlying infrastructure investments. More recently,

many institutional investors and infrastructure fund managers have developed funds with longer terms and more flexible exit strategies.

3. Fees

Many institutional investors realised that private equity fund fees were very high relative to the (expected) performance of the asset class. A major concern was also the fees levied by parties to an infrastructure transaction, such as those relating to acquisition, advisory, finance arrangement, project development, and so on. More recently, reasonable fee levels and appropriate incentive structures, and transparency of investments, have been at the forefront of institutional investors' needs.

4. Asset allocation

There has been a lot of new thinking around asset allocation and where/how an asset class fits into the broader portfolio. Historically, most asset classes were conventionally defined as a group of assets that have similar risk-return characteristics. Following the 2008 global financial crisis, when asset class diversification mostly failed, many institutional investors have been attracted by a strategy of diversification across underlying economic drivers and market risk factors. In the case of infrastructure investments, this includes counterparty risk, event risk, asset/project specific risk, legal risk, political risk, inflation risk and re-investment risk, amongst other risk factors.

4.5 More recently, a number of larger and more sophisticated institutional investors, with large in-house teams, have started to invest directly in infrastructure investments, often by pooling assets with like-minded institutions. This approach has the advantage of greater control over investments, in a more bespoke and lower cost arrangement that better meets their investment objectives, and enables an institution to get more diversification than it could on its own. Some examples include Industry Funds Management (Australia), Global Strategic Investment Alliance (OMERS led) and Africa 50 Infrastructure Fund (supported by the African Development Bank), as well as the Pensions Infrastructure Platform (PIP) and the Local Authority pooling arrangements in the UK.

4.6 Investors in infrastructure will of course need to have regard to any rules laid down by their regulators. These rules may include requirements for risk analyses and liquidity and may affect the amount of free capital the investor is required to hold against its investment risks. See section 6.5.

Section 5 - How to benchmark infrastructure investments

5.1 Another practical question for institutional investors is how they should benchmark the performance of their infrastructure investments. Like all new and alternative asset classes, this is notoriously challenging. While this section aims to provide some general principles, each institution may have a different approach in benchmarking their infrastructure investment performance, specific to their own circumstances and the goals of their infrastructure investment programme. The key to finding suitable benchmarks is to consider the purpose of the benchmarking exercise, for example either to report performance to stakeholders or to identify actions which need to be taken.

Financial benchmarking

5.2 One of the biggest challenges associated with creating benchmarks for infrastructure investments is that there is no perfect solution or single benchmark that meets every investor's needs. Some of these complications include:

- Lack of a readily available universe of transactions and assets makes it challenging to construct a replicable index. As such, there is no recognised index that captures the entire opportunity set available to infrastructure investors.
- The long infrastructure investment horizon whereby success is achieved over a number of years conflicts with the short time frame typically used for measuring investment performance.
- The timing of cash flows is unpredictable (especially during the greenfield phase).
- The "j-curve" effect occurs, where management fees and set-up costs at the start of an infrastructure investment typically result in significant negative net performance early in the life of a typical infrastructure investment.

5.3 In practice, there are a number of possibilities for benchmarking infrastructure investments, including:

1. Listed equity indices

Infrastructure investments, at some institutions, are benchmarked against listed equity indices (typically with an out-performance target) as this is the asset class from which funds are diverted into making infrastructure investments. However, listed equity indices possess the following challenges:

- The factors driving listed equity performance are different to those driving infrastructure returns.
- Listed equity indices are more volatile over the short-term than infrastructure investments.
- Listed equity returns are typically time-weighted returns, while infrastructure returns use money-weighted returns.

Examples of listed equity indices include the FTSE All Share Index or the MSCI Global Equity Index.

2. Listed infrastructure indices

Another option would be to benchmark the performance of infrastructure investments against the performance of listed infrastructure indices. While there is a wide definition of infrastructure among index providers, at least there is a greater level of commonality between the listed infrastructure constituents and potential infrastructure investments that institutions may consider.

Examples of listed infrastructure indices include the S&P Global Infrastructure Index or the Dow Jones Brookfield Global Infrastructure Index. Other examples are described in the Appendix.

For institutional investors, it is important to realise that no listed infrastructure index is a perfect representation of the infrastructure market, and the type of infrastructure exposure they are exposed to or desire. However, a close study of certain listed infrastructure indices illustrates the type of returns

that are achievable from infrastructure investments as well as the defensive nature or low volatility of certain infrastructure sectors.

Finally, an investor in private infrastructure investments could create a private benchmark by adding an illiquidity and other premiums, relating to differences in geography, leverage or sector exposure, to a listed infrastructure index.

3. Peer group of unlisted infrastructure funds

Another method of benchmarking is to compare infrastructure investment performance against general industry performance using a peer group of unlisted infrastructure funds to analyse performance. However, peer group analyses possess the following challenges:

- Peer group returns are not necessarily investable, as investors will not have access to all of the investment managers that constitute the peer group.
- The average or median performer is not known in advance.
- Peer groups include a number of biases, including self-reporting, selective reporting, back-filling and survivorship bias.

In practice, it may take an institutional investor a number of years to fully understand the infrastructure investment market and to construct a meaningful peer group for benchmarking analysis.

On the other hand, peer group analysis is measurable and reasonably represents the performance of the universe of available infrastructure investment managers that could be selected. In addition, peer groups can be used to conduct studies across different factors such as infrastructure investment strategy, fund size and geography, which can assist institutional investors in measuring the success (or failure) of infrastructure investment managers.

Examples of peer groups of unlisted infrastructure funds are provided by Preqin or EDHEC, financial data providers for alternative investments. However, it is important to remember that their performance includes the impact of financial gearing as well as infrastructure returns, and that their short-term volatility may be reduced by reporting delays in the underlying funds.

4. Absolute rate of return

Absolute returns benchmarks, although less common, tend to focus on a reasonable long-term return expectation from infrastructure investments. Absolute return benchmarks may provide a long-term proxy of returns expected from infrastructure as an asset class, either as a cost of capital (i.e. risk free rate plus expected inflation plus risk premia) or as a discount rate against actuarial liabilities.

5. Commercial property

Because of the similarities between infrastructure investments and commercial property such as shops, offices and factories, it makes a lot of sense to adopt commercial property as a benchmark for some purposes. This might either be the investor's own commercial property holdings or else the performance of commercial property in the economy as a whole.

6. The whole portfolio other than infrastructure

Another possibility is to benchmark the performance of the infrastructure portfolio against the performance of the investor's whole portfolio other than infrastructure. This has the great advantage of simplicity and gives an indication of whether the infrastructure has been a worthwhile investment.

5.4 From the above, it can be seen that it is difficult to find a single metric that satisfies all the requirements of a benchmark to measure infrastructure investment performance. Therefore, the selection of a suitable benchmark should be determined by institutional investors once they have finalised an infrastructure investment strategy and the mode of investment into the asset class.

Non-financial benchmarking

5.5 Investors will also increasingly want to benchmark their infrastructure holdings against social and environmental targets, for example in terms of carbon usage, resilience to climate change, or progress towards meeting the United Nations' Social Development Goals. This is not easy to do but some of the possibilities are:

1. Comparisons with peer groups

2. Comparisons with non-infrastructure investments held in the investor's own portfolio

3. Measurements of gradual improvements over time in each one of the investor's own infrastructure investments (one way of doing this might be through regular user surveys).

5.6 Where the infrastructure is held in the form of unlisted funds, the investor could engage with the managers of those funds and request them to report on their own social and environmental outcome targets and the progress they are making towards these.

Section 6 - Risk Factors

6.1 This section looks at the risks for investors in infrastructure projects or assets which could impact the valuation and assessment of any particular infrastructure investment.

6.2 The risks generally vary by the nature of the underlying assets (e.g. transport versus utilities), the way the project is financed (e.g. capital structure, risks borne by public and private sectors), funded and managed, and the environment in which the assets operate or are built. They also vary across the life cycle of an asset which is made up of three phases: project development, construction and operation. Many investors perceive higher risks in the development and construction phases and thus it is important to manage the allocation between the different phases within a portfolio.

6.3 The main risks can be grouped as follows (in no particular order of importance):

1. Political

This may be at national and/or geopolitical level with significant impact on the infrastructure sector. Governments may change their policies such as by re-nationalising core infrastructure, imposing controls on the prices which can be charged to users, introducing more stringent safety rules, or simply not renewing concessions. Where the asset is located outside the investor's home country, these dangers may be more acute.

2. Regulatory Capital

There are various forms of regulation including ones which create barriers to entry, promote competition and control pricing. For example, against the political pressure to demonstrate adequate protection for consumers, many economic regulators in Europe have been tightening the controls around the allowed rates of return and have imposed significant improvements in efficiency and performance targets. Whilst this would limit the financial flexibility of the businesses as well as their ability to outperform, it pushes businesses to adapt and embrace rapid technological progress (Linklaters, 2019).

One of the primary considerations by insurance companies when deciding upon an allocation to infrastructure is the regulatory capital charge associated with such an allocation. Practitioners in the UK currently refer to the Solvency II Directive - the prudential regulatory regime for EU insurers. Solvency II is designed to be a risk-based framework, in which insurers' capital requirements reflect the type and extent of the risks to which these are exposed (e.g., liquidity risk, market risk, currency risk, default risk, spread risk).

The riskier the asset allocation is perceived to be, the higher the solvency capital requirement (SCR) associated with the investment, so as to limit the insurer's chance of financial ruin over the next 12 months to a 1-in-200 year event. There are ways to mitigate some of these risks, and the Solvency II guidelines recognise these (e.g., hedging of foreign currency exposure). The economic capital charge can also be moderated by the diversification factor associated with the company's existing on-balance sheet asset mix (this factor allows for the inter-correlation between certain asset classes). The guidelines further allow for strategic holdings in unlisted long-term equity, which are more favourably treated from a risk capital perspective (e.g. the symmetric adjustment or dampener, which depends on prevailing listed equity market movements, does not apply to long term equity positions).

We note that the proposed Solvency II reforms applicable to the UK are underway at the time of writing this paper. The proposed changes are significant and include a material reduction in the risk margin, a change to the spread used for the matching adjustment, an allowance for alternative assets to more easily be included in matching adjustment portfolios, and changes to existing reporting obligations (Her Majesty's (HM) Treasury, 2022).

Of relevance to infrastructure projects, is the effect of Basel III on banks' appetites for financing these. Basel III is an international regulatory framework for banks, developed by the Basel Committee on Banking Supervision (BCBS). Since Basel III was introduced, banks have not been as eager as they once were to finance infrastructure projects. Basel III requires banks to hold higher levels of capital

against long dated and less liquid project finance loans (BearingPoint Institute, 2013, p.5), hence increasing the banks' marginal cost of funding.

The decline in uptake of infrastructure financing by banks, along with the proposed Solvency II reforms, will make the regulatory environment in the UK an enabling one for insurers to step in and finance infrastructure projects, given their regular cash flow and long-dated, liability-matching requirements.

3. Social

In recent years, we have witnessed a significant increase in social movements which have impacted the infrastructure sector. This has been largely driven by environmentalism, demanding higher standards of air, land and water quality and waste management, and requiring huge investments in new and existing infrastructure. For example, following the Fukushima nuclear disaster and massive social protests in Germany, the German government decided to phase out all the country's nuclear power plants by 2022. In 2017, the Swiss voted in a referendum to phase out nuclear power in favour of renewable energy. Perceptions of growing social inequalities will increase the pressures for price and rent controls, and for the provision of affordable housing of adequate standards.

4. Technological

Technological innovation has been revolutionising the infrastructure sector, impacting virtually every aspect of infrastructure and thus the investment returns. Infrastructure assets which cannot be adapted for these and future (at present unknown) developments are likely to become prematurely redundant, causing losses for their investors. High streets in the UK are an example, where many shops have been closed because their business has gone to online competitors. To mitigate technological risks for new projects, the design of the new assets will need to allow for a high degree of flexibility to give the best chance of being able to adapt the asset to new technologies as they emerge in future, including the possibility of alternative uses if necessary.

Traditionally technological risks have been associated with repercussions of technology failure but today the risks are also associated with operational inefficiencies in existing technology, thus challenging the businesses to adapt. For example, sensors and data analytics systems are making it possible for power companies to predict failures and carry out remote maintenance within their distribution network, thus increasing the oversight of the condition and the capacity of their network. Businesses must also recognise changing consumption patterns as residential customers reduce consumption by use of smart meters and industrial customers optimise consumption by applying the Internet of Things (IOT) to improve operational efficiencies (PWC, 2020).

New forms of infrastructure may have technological risks for which there is no past experience on which the risks can be assessed. This might apply, for example, to new technologies such as green hydrogen or carbon capture and storage, where there may be risks about safety or premature obsolescence. Investors might wish to seek guarantees against such risks.

Building a digitised infrastructure also leaves businesses vulnerable to cyber attacks. Therefore, it is important to build a unified integrated cyber defence to protect every kind of infrastructure asset. Investors should ensure that their assets are sufficiently protected and that this protection will be updated as the threat changes.

New technologies are also set to transform the construction phase of an infrastructure project. This could improve confidence in delivering efficiencies or a project successfully and present more attractive opportunities for investment. For example, the use of mass timber in constructions can reduce construction time by up to 25% and be significantly less carbon-intensive than steel and concrete (Losavio, 2019).

Maintenance risks in structures can now be reduced by installing instruments which monitor their condition and send automatic reports on any actions needed.

5. Climate Change

Climate risks have hugely influenced the infrastructure sector. They shape not only government policies, regulations, consumer demands, business models and technologies but also the speed at which changes are taking place. Even portfolios that appear to be diversified by geography and asset class may in fact be exposed to systemic risks. In time, climate risks could depress returns on some infrastructure assets.

A growing concern is the risk of stranded assets i.e. assets that cease to earn an economic return much before the end of their economic life. For example, one of the biggest changes we are witnessing is the phasing out of fossil fuel in many major countries. Looking at the coal industry alone, some estimate that the quantum of stranded assets globally could be as high as US$900 billion and could present serious financial consequences to those locked into these assets (Sarma, 2020).

It is the known unknown of the impact of climate change that presents great challenges to both existing and new infrastructure. We cannot assume that climate patterns will follow those of the past and industry players will want to assess against a range of climate scenarios. A very helpful recent publication (Bank of England, 2022) describes in detail three scenarios that have been explored about the possible impacts of climate change, and this would provide an excellent starting point for any investor wishing to study the possible impacts of climate change on its own investments.

Note: The Sustainability Volunteer Group of the IFoA is currently preparing a climate change guide to help investment actuaries. It will cover such subjects as the measurement of current exposure, the allocation of monies to fields with positive environmental impacts, and the setting of targets for improvement. Sections which are likely to be of particular interest to infrastructure investors will cover stress tests and scenario analysis, and the choice of managers with sufficient climate capabilities, as well as how managers can be influenced by the investors themselves.

Existing assets are typically built to withstand a certain climate threshold. However, as climate risk increases, these thresholds can be exceeded, unleashing significant damages to the physical and socio-economic systems. It is therefore imperative for industry players to prepare for the growing vulnerability of today's infrastructure assets, and to adapt and mitigate these risks, from re-conceiving flood defences to re-thinking business and funding models. It may also be worth considering re-purposing assets which may otherwise be stranded.

Resilience is the order of the day. Increasingly new builds are expected to incorporate climate-change resilience in their design and construction process. For example, there are parks in Shanghai that serve as drainage and road tunnels in Kuala Lumpur that double as flood tunnels.

One of the most important considerations when thinking about climate change risks is the geography of the asset's site, for example its height above sea level and its vulnerability to flooding far beyond past levels. Since so much is unknown about the extent to which the climate will change during the predicted lifetime of an asset, and the possibility of more extreme changes than is currently envisaged, assets in some locations may need much more protection against storms and excessive heat than has been common in the past. Investors in new projects will need to think about whether such protection should be built in from the outset or whether it is sufficient to take an adaptive pathway, building in lower levels of protection initially but designing the asset in such a way that additional layers of protection can be added later if necessary. It will need to be decided before investment takes place which party will bear the cost of these additional layers of protection if these later turn out to be needed.

6. Economic and financial

Global market and economic conditions and the performance of infrastructure assets are correlated. Consumer demand, interest rates, inflation, access to liquidity or re-financing, exchange rates, guarantor's credit worthiness and supply-chain performance can have direct and varying impacts on infrastructure.

The Covid-19 lockdown in 2020 was a real-life stress scenario on the transport infrastructure as it shut down key transport links. Major airports, roads, ports and rail saw significant reduction in traffic and revenues from these assets suffered. This and future pandemics may change the type and level of economic activities over the longer term and impact the performance of these assets. Investors have also increased the risk premia expected of illiquid assets.

Economic risks can also emerge from government and regulatory intervention and the microeconomic behaviour of consumers. For example, the European renewables sector received large subsidies from governments and regulators and experienced rapid take-up by environmentally- and cost-conscious consumers and investors. However, this created overcapacity in the power markets and drove down wholesale prices which subsequently led to the closure of many thermal plants. This had knock-on impacts on the overall cost of capital and returns.

7. Governance

Infrastructure poses a big governance challenge. From conception to construction and commissioning, to operation and eventual exit, infrastructure investment is a long road fraught with risks, as discussed above. Poor governance is a major reason why infrastructure projects often fall behind schedule, face cost overruns and fail to meet service delivery objectives. Corruption is one symptom of failed governance.

To address this challenge, in 2020, the Organisation for Economic Co-operation and Development (OECD) recommended a framework for the governance of public infrastructure to assist governments to invest in infrastructure projects in a way that is cost effective, affordable and trusted by investors, citizens and other stakeholders (OECD, 2020). Whilst it is aimed at governments, the principles underlying the framework can be applied to any organisation investing in infrastructure and these cover the entire life cycle of infrastructure projects (OECD, 2017):

- Develop a long-term strategic vision for infrastructure
- Guard fiscal sustainability, affordability, and value for money
- Ensure efficient and effective procurement of infrastructure projects
- Ensure transparent, systematic and effective stakeholder participation
- Co-ordinate infrastructure policy across levels of government
- Promote a coherent, predictable, and efficient regulatory framework
- Implement a whole of government approach to manage threats to integrity
- Promote evidence-informed decision making
- Make sure the asset performs throughout its life
- Strengthen critical infrastructure resilience

Advanced technologies are also helping owners and management to improve governance. For example, Building Information Modelling (BIM) software programs can help deliver construction projects on time and on budget. BIM not only enables 3D computer-generated design but also provides insight into functional considerations such as time, costs and environmental impact. It allows professionals at all stages from architects to engineers to building managers, to collaborate on a construction project in real time. This optimises design, reduces errors and gives greater cost predictability.

8. Revenue Uncertainty

The risks above affect the biggest driver for investment, that is, revenue certainty. However, generally they can be managed or mitigated through regulation, government support such as guarantees, contract design to allocate specific project risks and asset portfolio construction to diversify risks. Where an asset has not yet commenced operation, there is often a very large degree of uncertainty about the net revenue level which will be achieved, and it cannot be assumed that forecasts will be even approximately accurate.

Risk management methodology

6.4 When tackling complex situations and risks, the initial barrier to progress is that the complexity and uncertainty can often feel overwhelming. Use of a step by step approach, such as the CRisALIS™ methodology developed by Milliman[1], will help practitioners to make sense of it all and enable everyone to focus on the more important outcomes which might arise in future.

Front-end Thinking

6.5 The riskiest period for an individual infrastructure project is right at the start, when it is first being conceived and developed. There are many temptations for project sponsors to take short cuts in the thinking process, at a stage before investors normally become involved. For a checklist of the front end thinking which ought to take place during this initial period, the IFoA and the Institution of Civil Engineers have published a guide[2]. Investors will want to satisfy themselves that a process similar to this has been followed by the sponsor and that all the major risks and implications of the project have been properly assessed and disclosed.

Summary

6.6 There are numerous risks to consider; many of which are complex. The above risks can be linked to the following which in turn impact the valuation and assessment of the assets in different phases (project development, construction, and operation):

- delays and cost overruns, particularly in the construction phase;
- actual consumer demand or usage different from forecast which may have arisen from level of competition, changes in social preferences or lack of complementary services to support or promote usage. This may impact revenue, and reputation if the asset fails to deliver expected services;
- rising or falling operational costs such as labour, raw materials, shipping, power supplies;
- performance of financial hedges such as against movements in inflation, interest rates, currency exchange rates or commodity prices;
- impact of leverage within the capital structure of the asset;
- contractual risks arising from counterparties' failure to perform;
- availability or cost of insurance e.g. to cover catastrophic events such as fires, earthquakes, adverse weather conditions, war and terrorist attacks;
- ability to protect one's commercial interest, control or influence the management of an asset such as to remove and replace key personnel;
- ability to sell or secure favourable exit terms or price;
- resilience of an asset to shocks or systemic changes, for example, ability to re-purpose or adopt adaptive pathways;
- reliability and robustness of any due diligence carried out, valuation models and assumptions, expert advice and/or technology applied; and
- the possibility of premature obsolescence.

[1] https://www.milliman.com/en/Products/Complexriskanalysis
[2] Major Infrastructure Projects: Key Front-end Issues, available at https://www.actuaries.org.uk/system/files/field/document/ICE_Front%20End%20Issues_Web%20Version.pdf

The risks can impact the valuation and assessment of the assets in different phases (project development, construction, and operation) and in an extreme case could cause the investment to become worthless.

6.7 For indirect investors in infrastructure funds, there are additional considerations such as:

- the risk profile of the underlying investments e.g. sectors, geographies, concentration or diversification;
- credible operating history, expertise and experience of the management team;
- level of asset managers' fees and expenses arising from managing the assets, carried interest, transactions or aborted activities, performance-related fee structure;
- increasing investor demand which may reduce the number of attractive investment opportunities;
- liquidity or illiquidity of assets held by the different funds; and
- extra costs due to possible refinancing of a fund's borrowings.

Section 7 - ESG and SDG Considerations

7.1 Asset owners, such as insurance companies and pension funds, have a key role to play in providing private capital to support sustainable infrastructure development. The UN-supported Principles for Responsible Investment (PRI) initiative has defined **sustainable infrastructure** as 'infrastructure assets and systems that may achieve positive real-world outcomes' (2020b, p.8). Such outcomes are most commonly measured against global goals or frameworks, such as the United Nations Sustainable Development Goals (UN SDGs) adopted as part of the 2030 Agenda for Sustainable Development. The 17 SDGs came into effect in 2016 and define global goals that serve to integrate economic, social and environmental sustainability over the longer term.

7.2 This section draws from the PRI's 2020 report, *"Bridging the Gap: How Infrastructure Investors Can Contribute to SDG Outcomes"*, and further discusses ways in which institutional investors might apply an Environmental, Social and Governance (ESG) lens to infrastructure investing for the purpose of contributing to positive SDG outcomes.

The Landscape

7.3 Responsible investing, or ESG-driven asset allocations, grew to USD 40 trillion globally in 2020 (Baker, 2020). The Global Impact Investors Network (GIIN) estimated the full impact-investing market size at USD 715 billion at the end of 2019 (2020, p.40), where impact investing is investing with a *specific objective* of achieving positive social and / or environmental impact that is measurable, in addition to a financial return. GIIN also estimated that pension funds and insurance companies managed only 3% of impact-investing capital at the end of 2019 (2020, p.41).

7.4 Considering that total investment needs for achieving the SDGs at a global level are estimated to be between USD 5 trillion and USD 7 trillion per year until 2030 (and USD 2,5 trillion per year in developing countries alone) (UNCTAD, 2014, p.140), then there is ample opportunity for institutional investors to contribute to sustainable development and achieve positive outcomes for society and the planet through infrastructure investments.

PRI Principles

7.5 The UN-supported PRI recognizes that ESG issues can affect the performance of investment portfolios. Its six Principles for Responsible Investment highlight different ways in which investors can incorporate ESG factors into investment practice, which may also better align investors with broader objectives of society (PRI, 2017):

1. We will incorporate ESG issues into investment analysis and decision-making processes.
2. We will be active owners and incorporate ESG issues into our ownership policies and practices.
3. We will seek appropriate disclosure on ESG issues by the entities in which we invest.
4. We will promote acceptance and implementation of the principles within the investment industry.
5. We will work together to enhance our effectiveness in implementing the principles.
6. We will each report on our activities and progress towards implementing the principles.

ESG considerations

7.6 Broadly, there are four approaches to ESG-driven responsible investing:

1. **Screening**: screening can be negative, positive or norms-based. Negative screening excludes certain countries, sectors, companies, issuers or projects based on ESG factors, or that score poorly on ESG issues relative to industry peers. Positive screening focuses on including countries, sectors, companies or issuers based on ESG factors, or that score well on ESG issues relative to industry peers. Norms-based screening uses an existing international framework as a benchmark for minimum standards of business practice e.g., the UN International Labour Organisation (ILO), UN Global Compact (PRI, 2020a).
2. **Active ownership:** the exercising of ownership rights. This is typically achieved through voting and engaging with the management of the investee entity.
3. **Thematic:** selecting investments with the intention to contribute to certain environmental, social or governance outcomes. These can include investments that address the UN SDGs.
4. **ESG integration**: incorporating ESG criteria throughout the investment process and in assessing the investment's risk and return profile.

7.7 In private markets, ESG data disclosure is limited, ESG factors considered are investment-specific and furthermore, these are likely to differ from those considered in public markets. Along with screening and thematic approaches, ESG integration is commonly used for alternative assets, including infrastructure.

7.8 With ESG integration, ESG considerations are embedded into the investment process, starting from the deal origination and due diligence process, to the post-investment management of the infrastructure asset. Due to the longevity and illiquidity of infrastructure investments, it is important that institutional investors consider ESG issues throughout the lifecycle of the asset's life.

7.9 Examples of ESG risks that apply to infrastructure assets are listed in Table 6.

Table 6. Examples of ESG risks

Environmental factors	Social factors	Governance factors
Air quality	Vulnerable labour	Stakeholder engagement
GHG emissions	Minimum wage and workers' conditions	Business ethics
Ecological impacts and biodiversity	Employee engagement, diversity and inclusion	Supply-chain management
Water efficiency	Worker representation	Cyber security
Waste management	Supply chain (sub-contractors)	Protection of shareholders' rights
Fines and track record	Health and safety	Whistle-blower policy
Environmental permits and compliance	Local community consultations	Board composition
Resource conservation	Road safety	Control and risk management function
Land clearance	Use of security force	Transparency and disclosure
Climate change	Customer privacy	Dealings with government

Supporting frameworks for assessing and managing ESG risks

7.10 The PRI has published a number of guides and tools for integrating ESG factors into infrastructure investments. In addition, investors may also consider some of the following initiatives or frameworks related to elements of responsible investment when making and managing infrastructure investments:

- British International Investment Toolkit
- GRESB
- Global Reporting Initiative (GRI)
- IFC Performance Standards on Environmental and Social Sustainability
- International Organization for Standardization (ISO)
- International Framework for Integrated Reporting (IR)
- Taskforce on Climate related Financial Disclosure (TCFD)
- The Equator Principles
- United Nations Global Compact
- United Nations Guiding Principles on Business and Human Rights
- United Nations Sustainable Development Goals (SDGs).

How SDG outcomes relate to infrastructure assets

7.11 '…an [ESG] risk assessment determines the impact of the world on a portfolio or asset; whereas considering [SDG-related] outcomes should determine the impact of a portfolio or asset on the world' (PRI, 2020b, p.10).

7.12 Good ESG-risk management can still lead to (unintentional) negative outcomes for society and / or the planet. An approach that also focuses on shaping real-world outcomes, will help mitigate negative outcomes, as well as provide an indication of future potential risks associated with the investment.

7.13 Examples of negative outcomes and some of the actions which investors and developers might take to mitigate negative environmental and social impacts include:

- The generation of noise pollution and additional road traffic both during the construction and operational phases of the infrastructure development project. Developers might consider offering financial compensation to people who will be severely impacted.
- In the context of climate change, the infrastructure project might increase the risk of floods to nearby properties and the ensuing destruction of historic buildings, woodlands and animal habitats. In such a case, investors may want to consider building strong flood protection around the asset or constructing it more robustly than is strictly necessary for today's climate. Investors will also want to consider whether such expenditure is necessary at the outset, or whether it would make sense to defer the expenditure until the climate change outlook becomes clearer.
- Divisiveness within the community (due to some people deriving greater benefit than others, or to particular sub-groups being particularly affected in adverse ways). Investors will want to maintain excellent liaison with the local community throughout the development process and after operation commences, so as to identify fears, objectives and desired improvements. Establishing a working group on which community leaders and other stakeholders are represented may also help mitigate this risk, in addition to hosting public meetings where appropriate.
- Protests against the development, leading to financial loss and reputational damage for the investor. Investors might manage this risk by establishing a targeted programme to invest in additional social features for the infrastructure as and when these can be

afforded; or by setting up a community fund to finance social improvements for meeting places, transport services, cycleways, footpaths, schools, hospitals, etc.

- Of course, investors may just decide to avoid investing in the infrastructure project where there is insufficient mitigation against these risks, unless there is action which the investors can take to finance mitigation in a financially viable way, like taking out insurance against some of these risks.

7.14 Incorporating an outcomes assessment into the initial investment decision-making process will give investors the opportunity to identify outcomes the infrastructure asset is likely to have, set outcome targets in line with SDGs, and then monitor and manage actual impact post-investment relative to the targeted outcomes. The PRI showcases a number of case studies on their website, presenting approaches that have been used to avoid, mitigate or compensate for negative outcomes associated with various infrastructure projects[3].

Greenfield and brownfield infrastructure

7.15 New infrastructure projects - ***greenfield infrastructure*** - present an opportunity for investors to shape SDG outcomes prospectively from the outset of the project, by embedding SDG objectives in the construction of the infrastructure asset. For example, sensors were fixed into the construction of India's Orange Smart City - a sustainable greenfield development near Mumbai - in order to be able to monitor impact indicators and track progress relative to SDG outcome objectives (PRI, 2020b, p.14).

7.16 Historically, investors have preferred infrastructure assets that have been previously developed - ***brownfield infrastructure*** - that may even be operational, with limited capital expenditure requirements and construction risk. However, the extent to which an investor is able to mitigate negative outcomes and/or promote positive outcomes in brownfield projects is also limited, given that the outcomes assessment is carried out retrospectively.

7.17 An obstacle to investing in greenfield infrastructure has been the ongoing lack of bankable projects. Government subsidies for new projects, blended finance solutions driven by development finance institutions, and public-private partnerships can all play key roles in de-risking greenfield infrastructure and mobilizing private-sector capital, particularly in emerging markets. This will become more important as institutional investors adopt the *Just Transition* approach and support emerging initiatives that require significant investment in new infrastructure (PRI, 2020b, p.23).

Supporting tools for assessing and managing SDG outcomes

7.18 There are several tools available that investors can use to help identify the outcomes associated with their investments, assist in setting outcome objectives relative to SDGs, and track progress against these objectives. Some of the tools suitable for *corporate* investors include:

- CDSB Framework for environmental and climate change reporting
- Future-fit benchmark
- GRESB
- Milliman's CRisALIS™ risk management methodology
- Science-based targets
- SDG Action Manager
- SDG Compass
- Toward Common Metrics and Consistent Reporting of Sustainable Value Creation
- Transition Pathways Initiative
- UNDP SDG Impact Standards
- UNEP-FI Positive impact tool (and Impact Radar).

[3] SDG Infrastructure case studies, available at <https://www.unpri.org/sustainability-issues/sustainable-development-goals>

An up-to-date repository of free-to-use, globally applicable tools for investors, corporates and governments, is maintained by the PRI and is available on their website.[4]

For infrastructure investments, specifically rating and reward schemes and verifications, include:

- CEEQUAL (an evidence-based sustainability assessment, rating and awards scheme)
- ISCA (Infrastructure Sustainability Council of Australia) Infrastructure Sustainability (IS) rating scheme
- Envision (for use throughout project life cycle, includes a focus on social impact of project)
- SuRe (Standard for Sustainable and Resilient Infrastructure - a global voluntary standard developed by the Global Infrastructure Basel Foundation and Natixis).

7.19 A challenge commonly faced by infrastructure investors, is how to meaningfully compare impact across different projects. Interestingly, BlackRock Asset Management has addressed this by quantifying impact (e.g., number of jobs created, amount of water saved, tons of CO_2 emissions avoided) in dollar values, so that like-for-like comparisons across investments can be made (PRI, 2020b, p.17).

Further areas of development

7.20 There remains much work to be done in using the UN SDGs as a lens for infrastructure project selection. The PRI has outlined seven areas that need to be addressed, as listed below (2020b, pp. 20-23). Actions as recommended by the PRI, as well as additional suggestions are discussed:

1. **Data gathering**. Although the UN SDGs can be used to measure impact outcomes, there are no industry-accepted guidelines nor is there a standardized reporting framework for how this data is currently disclosed. Europe has made some progress in this space through the introduction of the Sustainable Finance Disclosure Regulation (SFDR) in 2021 and the initial implementation of the EU Taxonomy in 2022. The SFDR promotes transparency in ESG disclosure obligations, and hence aims to prevent greenwashing. The EU Taxonomy supports the SFDR, as well as the upcoming Corporate Sustainability Reporting Directive (CSRD), and classifies the economic activities that are deemed environmentally sustainable (a social Taxonomy may follow in time as well). The CSRD will specify disclosure obligations for reporting companies and is likely to be adopted in 2022 with reporting effective from 2024 (FTI Consulting, 2022).
2. **Aligning SDG outcomes and financial considerations**. Changing regulatory environments and a growing focus on sustainable finance and a just transition to a green economy, will mean a greater focus on SDG outcomes for investors. Investors in turn, can consider tying performance incentives to impact performance outcomes as a means of ensuring asset manager interests are appropriately aligned.
3. **Setting consistent outcome objectives along the investment chain**. Here, investors need to ensure that there is consistency in the understanding and prioritization of impact objectives by stakeholders across the investment chain.
4. **Government-investor engagement**. This is necessary in order to align public and private sustainability interests and obtain private sector support in developing new public infrastructure. Development and infrastructure banks can play a key role in enabling this engagement.
5. **Internal and external skillsets**. In general, there is still a lack of infrastructure-investing skills and expertise in ESG and SDG issues amongst corporate investors. This can be developed internally or outsourced.
6. **Greenfield versus brownfield investing**. With a renewed focus on sustainable infrastructure initiatives, and a greater opportunity for investors to shape SDG outcomes with new infrastructure projects, it is likely that the demand for green infrastructure may grow in the years ahead - but only if the expected risk-adjusted returns are market related. Here, blended finance

[4] Appendix 1: Tools across the five-part framework, available at <https://www.unpri.org/sustainable-development-goals/investing-with-sdg-outcomes-a-five-part-framework-appendix-1-3-tools-and-investor-examples/5907.article>

solutions may have a role to play in de-risking greenfield investments and rendering these more palatable for corporate investor appetites, particularly in emerging markets.

7. **Investor collaboration**. The PRI emphasizes '…the need for collective investor action to achieve the SDGs, not just action at the individual investor level' (2020b, p.23). Infrastructure initiatives include the *Global Infrastructure Forum* and *FAST-Infra*; whilst infrastructure investment associations, such as the *Long Term Infrastructure Investors Association (LTIIA),* also work to drive stronger uptake of ESG principles within the industry. Infrastructure investors are encouraged to join these initiatives and associations where these are aligned with their investment objectives.

Ongoing ESG-risks and SDG-outcomes management

7.21 Once an institution has an infrastructure investment it is important that ESG risks and impact opportunities should continue to be explored throughout its life. For instance, continuing engagement with local communities may point to some positive facilities which could be installed at low cost, for example cycle stands or information screens, or some work which needs to be done, for example, to improve a path where rainwater collects. Such changes, small in themselves, may lead not only to social benefit but to building relationships where local people might be able to point out emerging risks for the asset while there is still time for these to be addressed.

Conclusion

7.22 There is an opportunity for investors to contribute to sustainable development and achieve positive outcomes for society and the planet through infrastructure investments. Applying an ESG lens to infrastructure investing will help to identify ESG-related risks early on, and ESG risks are less likely to materialize in the longer term if appropriately managed over time. Applying an SDG lens will help to manage impact, and may additionally broaden the investment universe and point to areas of potential growth in the years ahead (PRI, 2020b, p.13). Therefore, an investment approach that uses both SDG-outcomes and ESG-risks assessments pre-investment, may contribute towards *intentional* positive impact, alongside improved *risk-adjusted* performance returns over time.

Section 8 - Historical performance

8.1 We have tried to discover how investment in infrastructure has performed in comparison with other types of investment over the past 20 years, but unfortunately we are only able to draw limited conclusions because of the lack of sufficient data suitable for this purpose. This section uses historical risk and return data but we must emphasise that past performance is not necessarily a good guide to the future. This is especially true for the infrastructure asset class, because of the repricing upwards of infrastructure assets in the last 10 years due to the emergence of institutional investor interest which was previously close to non-existent. In this section we briefly describe our investigations and what we found. We looked only at the "equity ownership" of infrastructure, not infrastructure bonds. Our figures ignore expenses, which may to some extent distort comparisons.

8.2 We divide this section into four parts:

Part 1 - Unlisted Infrastructure Assets

Part 2 - Direct ownership of infrastructure

Part 3 - Comparative Performance

Part 4 - Using infrastructure to diversify total portfolio risk.

Part 1 - Unlisted Infrastructure Assets

8.3 Unlisted infrastructure investments are not available for investment in public markets. Some consist of the direct ownership of infrastructure assets, which may have their own tied borrowings, and some of them are funds of the "venture capital" type, where investors place money in the fund and the managers use it to buy the ownership of several underlying infrastructure assets, which again may have their own tied borrowings. In addition, the managers of the infrastructure funds will often raise additional moneys by their own borrowings, to supplement the sums raised from investors and with the intention of increasing investors' returns. It is usually impossible to disentangle how much of the reported performance is due to the performance of the infrastructure assets and how much is due to the positive or negative gearing effects of the borrowings.

8.4 There are several databases which give an indication of the aggregated returns reported by large numbers of these assets. We have looked particularly at the EDHEC infra300 unlisted infrastructure equity index (EDHEC infra300). This is an index based on 300 constituents which aims to provide a framework or classification standard that is not inherited from other asset classes, but rather specifically created for infrastructure investments. The index had a market capitalisation of more than $250 billion at year-end 2021 (EDHEC, 2022b). It is important to recognise that this index is an asset level index, not a fund index. In essence EDHEC estimates a market price for 300 infrastructure projects and aggregate them. It is not reflective of the performance of venture capital funds nor infrastructure funds as such but of the underlying asset class.

8.5 Investments are categorised according to EDHEC's own taxonomy called TICCS (The Infrastructure Company Classification Standard) (2020) by the following factors:

1. Business Risk: is the investment in a contracted, merchant, or regulated structure?
2. Industrial Activity: 95 different types of tangible assets (e.g., Data, Transport, Renewables, etc.)
3. Geography: Global or country specific exposure?
4. Corporate Governance: Is the investment in a one-off project (project finance) or a corporate carrying out multiple infrastructure investments?

8.6 EDHEC aims to avoid three major biases that normally affect infrastructure investment indices: selection bias, survivorship bias, and backward-looking bias. It does this through deploying a “bottom-up” approach to generate its universe, to ensure it makes for a representative sample of all investable infrastructure assets.

8.7 However, the data does have other limitations, including a heavy European emphasis and the unavoidable need for assumptions to update the market values of constituents (using a discounted

cashflow method) each month. A limited number of risk factors per constituent firm is priced quarterly to obtain updated risk premia. Furthermore, investors looking to use the EDHEC infra300 as a benchmark to their performance must take some other key drivers of actual returns into account, such as currency movements and the types of corporate structure that feature in their own portfolio. In addition, the index gives returns in gross terms, before allowing for management costs.

8.8 The EDHEC infra300 uses EDHEC's own systematic model (see Appendix) every month to arrive at a "fair value" of each index component. While this attempt to identify up-to-date valuations is to be commended, since it goes some way to overcoming reporting delays due to infrequent market valuations of the underlying assets held, it of course does not exactly mirror the actual returns made by investors. Where this Index is particularly useful for investors is that it does subdivide the data into eight industry subsectors, and since the same methods are used to make estimates of fair values in all the subsectors it can be regarded as providing, at least to some extent, a measure of the comparative performance of each subsector. As can be seen from figure 3 and table 7, there was strong performance across all subsectors of infrastructure since 2008. Power Generation excluding Renewables stood out as the best-performing subsector, with Energy and Water Resources lagging behind the other subsectors.

8.9 Figure 3 shows the index value movements of six sectors (since 2008 Q3) used by EDHEC. The data was sourced from EDHEC's infraMetrics® online data platform (2022a).

- Power Generation x-Renewables (excluding renewables)
- Social Infrastructure
- Energy and Water Resources
- Transport
- Renewable Power
- Network Utilities

Two sectors used are not featured on the graph due to a lack of sufficient performance data as of 2021 Q4:

- Environmental Services
- Data Infrastructure

Note that a further breakdown is also available for industry subsectors - for example airport companies and car park companies are subsectors of the transport sector.

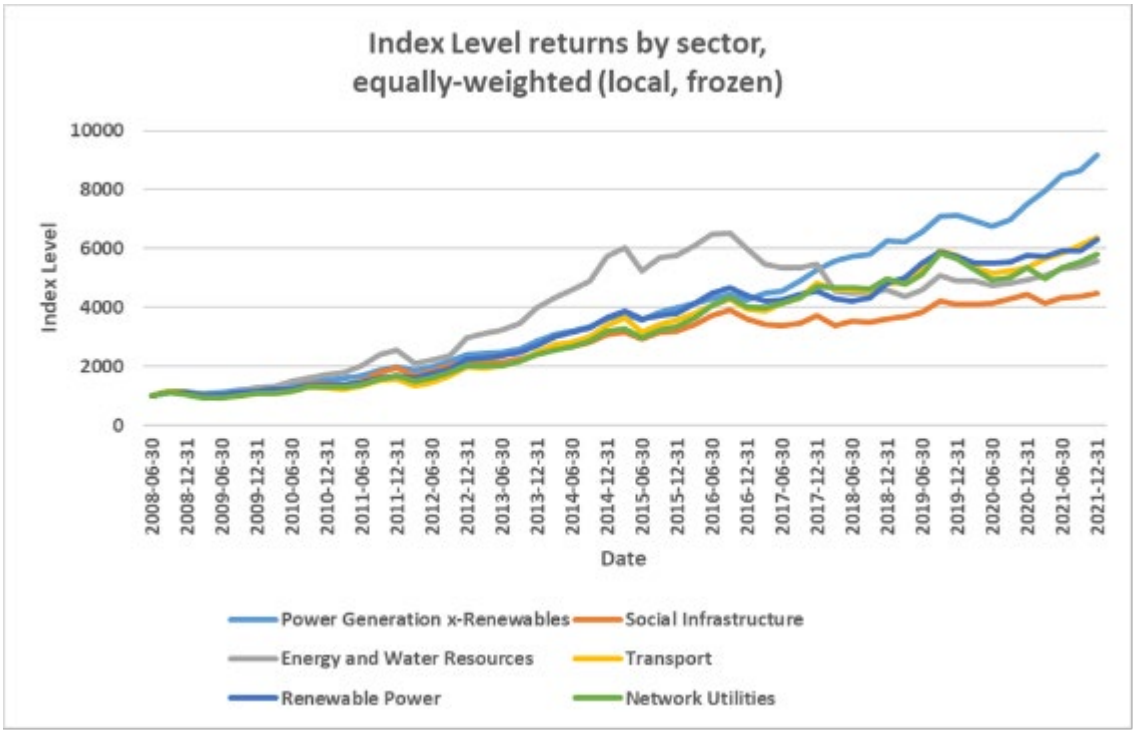

Figure 3: Index Level Returns by industry sector since 2008. (Source: EDHECinfra infraMetrics®)

Note: "x-Renewables" means "excluding Renewables"

8.10 Table 7 gives an indication of the size and performance of the various industrial sectors with sufficient performance data. These relate to the last 10 years only, rather than the whole period since 2008 on which figure 3 is based.

Market capitalisation and number of constituents is at YE 2021. Total Returns, Value at Risk (VaR) and Sharpe Ratio are all measured over the last 10 years (YE 2011 to YE 2021). VaR in the table is the one-year VaR measured at the 99.5% confidence level.

Table 7: Characteristics of six sectors used by EDHEC (Source: EDHECinfra infraMetrics®)
Note: Total Returns (10-year) are annual figures.

	Power Generation x-Renewables	Social Infrastructure	Energy and Water Resources	Transport	Renewable Power	Network Utilities
Market Cap (USD)	26.5 bn	7.6 bn	34.7 bn	152.4 bn	25.8 bn	83.7 bn
Number of constituents	63	67	33	180	130	52
Total Returns (10-Year)	16.5%	8.6%	8.1%	15.0%	14.2%	13.1%
Value at Risk (10-Year)	6.5%	20.3%	37.9%	25.5%	13.5%	22.0%
Sharpe Ratio (10-Year)	1.87	0.69	0.47	0.98	1.17	0.96

8.11 Figure 3 and Table 7 allow us to make some high-level comments on historical unlisted sector performance since 2008. The Total Returns shown in Table 7 for the last 10 years have shown considerable variation between the sectors, with Social Infrastructure and Energy and Water Resources showing much lower returns than the other four sectors. Since the performance figures for all six sectors will have been calculated on the same basis, we can be reasonably confident that these returns do indicate different underlying performances of the unlisted infrastructure assets in the different sectors during this 10-year period. Table 7 shows there were considerable differences in the sizes of the different sectors in 2021, as well as big differences in their VaR and Sharpe Ratios. We note from figure 3 the expected dip in the Index Level graph during the Covid-19 market crash of 2020.

8.12 Transport is clearly the dominant sector in terms of size. Consequently, it is the biggest contributor to overall benchmark returns.

8.13 One notable feature is the suggested risk-adjusted outperformance in the EDHEC infra300 data of Renewable Power versus Energy and Water Resources, as measured by the Sharpe Ratio. None of the listed MSCI nor S&P infrastructure indices appear to feature renewables at all. Outsized risk-adjusted returns have occurred in Power Generation x-Renewables. Energy and Water Resources appears to have been the riskiest sector.

Part 2 - Direct ownership of infrastructure

8.14 We have looked at some of the infrastructure performance reported by large investors. Their portfolios rely heavily on the direct ownership of infrastructure assets but may also include infrastructure funds and other forms of investment in infrastructure, including property. Some examples are summarised below:

ABP

8.15 ABP is the largest pension fund for employees in government and education sectors in the Netherlands and has one of the largest funds in the world. At the end of 2020, the total actual capital held was roughly EUR495 billion (2021b, p.9). The office is based out of Heerlen and Amsterdam. As per the 2020 annual report, investment in infrastructure was just 3.3% of the total funds under management and during the same year the rate of return in infrastructure was -1.3% (2021b, p.62).

Table 8: ABP investment infrastructure returns (Source: ABP, 2021a, p. 3.)

2020		2019	
Return (%)	Return (€, bn)	Return (%)	Return (€, bn)
-1.3%	-0.2	13.3%	1.6

OMERS

8.16 OMERS is the defined-benefit public pension plan for municipal employees of the province of Ontario, Canada, and on 31 December 2021 its assets under management totalled C$121 billion, and infrastructure represented 20% of its assets (2021). It reported that its net average performance for infrastructure was 10.2% per annum over the five years ending 31 December 2021 (OMERS, 2021). This period included 2019 (8.7%), 2020 (8.6%), 2021 (10.7%). These performance figures were not, of course, based on market values, since many of the investments had no market. In Part 4 we look at how their infrastructure performance compared with that of their other investments.

USS

8.17 The UK's Universities Superannuation Scheme (USS) has £80 billion of global assets, of which £22 billion is invested in a category described as "Private Markets including property" (2021, p.3). This category includes Energy from Waste, Heathrow Airport, National Air Traffic Services (NATS), Property, Wind Farms, 60 motorway service stations and 35 crematoria locations. A glimpse into the relative stability of the valuations of this category comes from the Annual Report for the year ending 31 March 2021 which states: "Our private assets, though values contracted, did not fall in line with public markets. However, as markets recovered, the reverse was also true and private asset values did not keep pace with their global counterparts" (USS, 2021, p.22).

KNPS

8.18 The National Pension Service of the Republic of Korea (KNPS) had KRW 834 trillion (c.$749bn) of assets at year-end 2020 (KNPS, 2020, p.6). This included approximately $82bn in the alternative assets category. These alternative investments included real estate, infrastructure, private equity, hedge funds, and private debt. Infrastructure made up c.3% of the total fund and c.29% of the total alternatives allocation at year end 2020.

8.19 KNPS began investing in domestic infrastructure in 2005, moving into global infrastructure two years later. The 2020 annual report highlights focus on transportation, energy, and digitisation. Core/core+ are the primary assets invested in - these are seen to create stable cash flow and sufficient joint investment overseas opportunities with other global pension funds. The infrastructure allocation is split into domestic and global holdings. The five-year average time-weighted rates of returns between 2016-2020 were 5.69% for domestic infrastructure and 7.88% for global infrastructure (KNPS, 2020, p.41).

Part 3 - Comparative Performance

8.20 In Part 3 we investigate the comparative performances of infrastructure and other classes of investment.

8.21 Starting with our direct owners of global infrastructure from Part 2, we note the healthy five-year annual returns given by OMERS (10.2%) and KNPS (7.98%).

8.22 We also look to some of the well-known indices which show how investments in infrastructure companies listed on a stock exchange have performed, and here we show comparative performances for each index in relation to unlisted infrastructure (see part 1) and other classes of investment.

8.23 Several indices that feature listed infrastructure securities with differing degrees of focus on their definition of infrastructure are available: for example, the MSCI World Infrastructure Index (MSCI World Infra) and S&P Global Infrastructure Index (S&P Global Infra). Additionally, the MSCI World Core Infrastructure Index (MSCI World Core Infra) focuses on "industrial" infrastructure only (i.e., utilities, energy and transportation). More details of each listed infrastructure index used are available in the Appendix.

8.24 Bringing all these indices together, we can look at the returns and volatilities shown by various indices for different classes of investment since 2004, as shown in figure 4. The asset classes under consideration are represented as follows: developed market equities by the MSCI World Index, bonds by the Bloomberg Global Aggregate Bond Index, properties by the FTSE EPRA NAREIT Developed Index, emerging market equities by the MSCI Emerging Markets Index, and cash by the US 3-month Treasury Yield. Unlisted infrastructure is represented by EDHEC's Infra300 Index; whilst listed infrastructure is measured by the MSCI World Infrastructure Index, S&P Global Infrastructure Index and the MSCI World Core Infrastructure Index. Quarterly total return index values in USD are sourced from Bloomberg and are used to calculate the annualised returns and volatilities per index over the period January 2004 to June 2021.

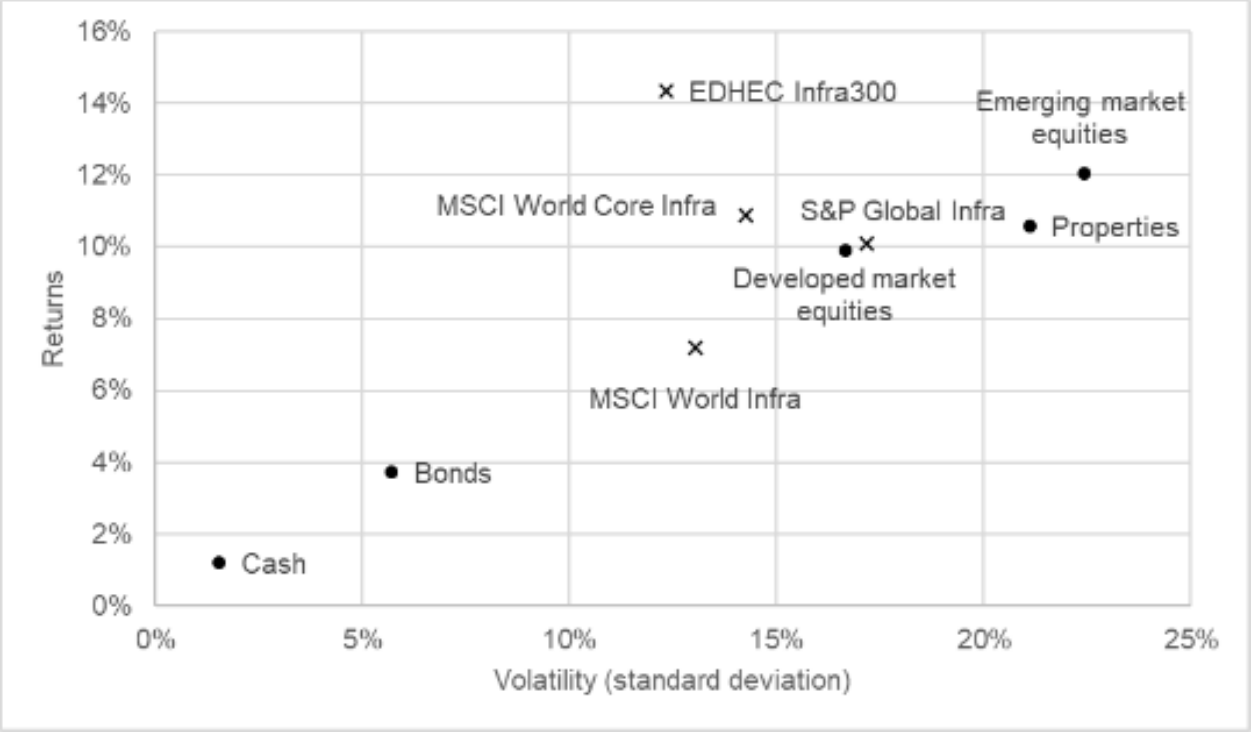

Figure 4: Risk-Return Profile of Different Asset Classes between January 2004 and June 2021

8.25 From figure 4, we observe that the EDHEC Infra300 shows excellent absolute and relative performance over the 17-year period in question. The total returns shown are greater than those derived from investment in equities or properties, and at a lower level of risk, as measured by the annualised standard deviation of quarterly returns. One factor in this apparent good performance was probably a "once only" increase in the demand for infrastructure investments after the first 10 years, which cannot be expected in future.

8.26 The performance of infrastructure in more recent years has been somewhat adversely affected by Covid 19 (especially its large impact on transport) and increasing interest rates prior to the Covid market crash and during 2021 (EDHEC, 2021b, p.3). However, infrastructure assets are observed to broadly perform robustly during times of market distress such as the Great Financial Crisis and the March 2020 turbulence. This is caused by infrastructure assets having low levels of default over this period, delays in reporting value changes, and high cash yields (the EDHEC Infra300 had a 10-year moving average cash yield of 8.68% at year-end 2021, compared to the MSCI World equity index's 1.87% dividend yield at the end of February 2022).

8.27 The various listed infrastructure indices performed quite similarly to each other. The MSCI World Core Infra index appears to slightly outperform its listed counterparts and comes closest to replicating the superior performance of the EDHEC Infra300. This would seem to be consistent with what would be expected if the claim of superior infrastructure performance is assumed to be true, given that it is exclusively focused on "industrial" infrastructure. From this viewpoint, the less outstanding performances of the S&P Global Infra and MSCI World Infra indices could be attributed to the inclusion of companies with more tenuous links to infrastructure (EDHEC addressed this extensively in their paper: The Rise of Fake Infra (2017)).

Part 4 - Using infrastructure to diversify total portfolio risk

8.28 One of the motivations for including infrastructure within a portfolio containing other asset classes may be to diversify the overall portfolio risk (as measured by volatility). We have conducted an analysis to show what might have happened in the past if this had been done, using the same indices as proxies for the different asset classes as those used to produce the risk-return profile shown in Figure 4. We start by showing a correlation matrix for these categories:

Table 9. Correlation matrix using quarterly total returns, January 2004 - June 2021 (Index values from Bloomberg)

	EDHEC Infra300	S&P Global Infra	MSCI World Infra	MSCI World Core Infra	Properties	Developed market equities	Bonds	Emerging market equities	Cash
EDHEC Infra300	1.00								
S&P Global Infra	0.13	1.00							
MSCI World Infra	0.17	0.94	1.00						
MSCI World Core Infra	0.13	0.97	0.93	1.00					
Properties	0.23	0.87	0.78	0.87	1.00				
Developed market equities	-0.02	0.89	0.84	0.88	0.85	1.00			
Bonds	0.29	0.42	0.44	0.42	0.34	0.22	1.00		
Emerging market equities	-0.03	0.85	0.76	0.80	0.78	0.87	0.35	1.00	
Cash	0.04	0.20	0.20	0.17	0.08	0.03	0.05	0.18	1.00

8.29 From table 9 it appears that the listed infrastructure (S&P Global Infra, MSCI World Infra and MSCI World Core Infra) has shown a less than perfect, but still relatively high correlation to global developed market equities. In other words, listed infrastructure companies have tended to perform in much the same way as listed equities in general. However, the EDHEC Infra300 has relatively low correlations with all the other asset classes.

Efficient Frontier

8.30 Finally, we investigate the claim that the performance of infrastructure over this period indicates its potential to be a strong diversifying asset class for institutional investors in their portfolios, testing the effectiveness of both listed and unlisted proxy performances in a multi-asset portfolio based on past performance. The asset classes (and retrospective proxies for these) that we consider here, are the same as those used in our analysis so far, viz., developed market equities (MSCI World Index), bonds (Bloomberg Global Aggregate Bond Index), properties (FTSE EPRA NAREIT Developed Index), emerging market equities (MSCI Emerging Markets Index), and cash (US 3-month Treasury Yield). Unlisted infrastructure is represented by EDHEC's Infra300 Index; whilst listed infrastructure is measured by the MSCI World Infrastructure Index, S&P Global Infrastructure Index and the MSCI World Core Infrastructure Index. Quarterly total return index values in USD are sourced from Bloomberg and are used to calculate the annualised expected returns and volatilities per index over the period January 2004 to June 2021.

8.31 We test the diversifying effect of infrastructure by plotting the annualised expected returns against the annualised expected volatility of portfolios of varying possible weights to all asset classes considered, to obtain the minimum-variance frontier (the curve that connects the minimum variance portfolios for given rates of expected return). Risk, or volatility as used here, is measured by the portfolio's standard deviation. We use the Infra300 Index to represent unlisted infrastructure. Using the Monte Carlo method, the expected portfolio returns and corresponding portfolio volatilities are simulated for random combinations of asset class allocations (where the total portfolio is fully invested, asset class allocations can range from 0% to 100%, and normal return distributions for the underlying asset classes are assumed), and plotted to obtain the minimum-variance frontier. In this instance, 10000 random combinations of possible asset class allocations were generated to produce the minimum variance frontier. Different combinations of asset classes sit at different points on the curve: in general, the greater the allocation to riskier assets, the further to the right the total portfolio is on the curve. The efficient frontier is that part of the minimum-variance frontier that represents the maximum expected return for any given level of risk.

8.32 The efficient frontier is derived for a set of portfolios excluding infrastructure and for a set including infrastructure, to demonstrate the effect of including infrastructure on a portfolio's total expected volatility (both systematic and unsystematic risk). Under Modern Portfolio Theory (MPT), investors are only rewarded for bearing systematic risk (market risks that cannot be diversified away) and not for tolerating unsystematic risk (asset-specific risk that can be diversified away when combined with other assets of different levels of risk). Please note that in figure 5 the grey points represent the frontier before the inclusion of the infrastructure asset class. The black points represent the frontier after the inclusion of infrastructure (as represented by the Infra300 Index).

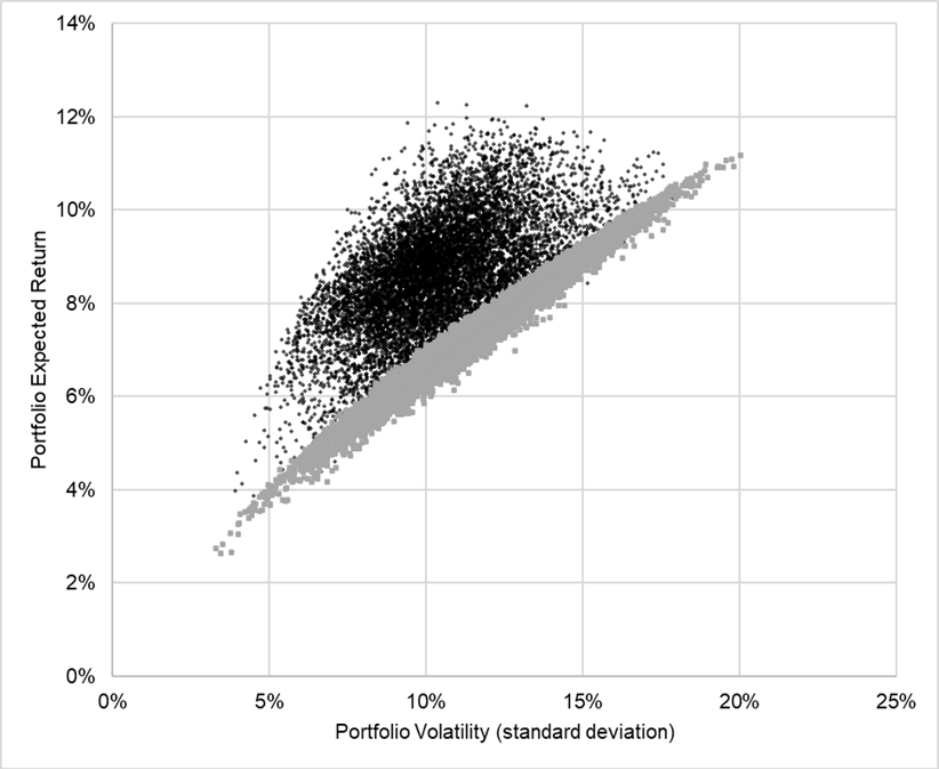

Figure 5: Shift in efficient frontiers with EDHEC Infra300 (IFoA Infrastructure Working Party).

8.33 From figure 5, we observe that including infrastructure shifts the efficient frontier up and to the left i.e., investors can now expect the same level of portfolio return at a lower level of total risk. This serves to illustrate the diversification potential of including infrastructure in a multi-asset class portfolio (where the performance of unlisted infrastructure is represented by the Infra300 Index). We further note that historical performance is no guarantee of future performance - this is especially true for the infrastructure asset class, as discussed earlier in the section.

8.34 The listed infrastructure indices do not suggest the same diversification benefit however. We can see this readily from the beta coefficients of each of these indices relative to the general global equity market (as measured by the MSCI World Index). The betas of the indices as shown in table 10, show how responsive the returns of these are to market volatility. The market beta is 1. A beta value of less than 1 indicates that an asset class is less sensitive to market movements, a beta greater than 1 indicates that the asset class is more responsive to volatility in the market.

Table 10. Beta coefficients relative to market, using quarterly returns from January 2004 to June 2021

Index / asset class	Beta
EDHEC Infra300	-0.01
S&P Global Infra	0.92
MSCI World Infra	0.66
MSCI World Core Infra	0.76
Global developed market equities	1.00
Global bonds	0.08
Global properties	1.07
Global emerging market equities	1.17
US cash	0.01

8.35 We observe that the volatility of the listed infrastructure indices as shown here (S&P Global Infrastructure Index, MSCI World Infrastructure Index, and MSCI World Core Infrastructure Index) can be relatively well-explained by market risk (betas of 0.92, 0.66 and 0.76 respectively). Contrast this with the beta of the unlisted infrastructure index as represented by EDHEC's Infra300 Index (-0.01) and the diversification benefit of unlisted infrastructure is clear - returns are being driven by factors not currently influenced by market volatility, therefore inclusion of this asset class in a multi-asset class portfolio reduces total portfolio risk.

Further considerations

8.36 Our investigation looks at the historical performance and behaviour of asset classes relative to each other. However as discussed above, these trends may not persist going forward. Therefore, it is useful to consider future return estimates as well [EDHEC (2021a, pp. 24-33) produced an analysis using forward-looking data].

Conclusion

8.37 We can conclude that there may be benefit in using infrastructure assets to construct a well-diversified portfolio, were historical asset class return profiles to persist going forward. The optimal allocation to infrastructure in a multi-asset class portfolio is beyond the scope of this investigation; however, the type of infrastructure used does matter. Our findings suggest that the performance of unlisted infrastructure assets is driven by factors sufficiently unique to be uncorrelated with general equity market movements, but accessing these assets is costly, difficult and requires expert insight (these considerations and others, are discussed earlier in this paper). One school of thought suggests that there might be benefit in including listed infrastructure as well as unlisted infrastructure in a portfolio - see two papers[5] written by investment management firms.

[5] "*Listed vs unlisted infrastructure*" by Steven Kempler from Maple-Bown Abbott Investment Managers (2020), and "*Listed vs. private infrastructure: Why not both?"* by Nuveen (2022).

Section 9 - Conclusions

9.1 The attractions of infrastructure to institutional investors include the hope of diversifying risk and achieving lower reported volatility. The prospect of achieving a secure long-term revenue flow once the asset is in full operation is an added attraction, particularly if the revenue offers a reasonable rate of return and keeps pace with inflation. However, it must be recognised that infrastructure may require further investment in the long term in order to sustain revenue cashflows.

9.2 Infrastructure investment can be subject to many risks (see Section 6). If an investor has relatively few infrastructure investments, any risks which materialise could have a disproportionate negative impact on the performance of this asset class.

9.3 For this reason institutional investors tend to want to diversify their infrastructure holdings, which they can do by sharing each investment with other qualified investors, for example through a structure designed for this purpose.

9.4 Another way in which institutional investors can obtain diversified holdings is through holdings in a number of unquoted infrastructure funds, although there will be additional risks due to gearing, arms-length management and mismatched objectives.

9.5 Investors will increasingly want to be satisfied that their infrastructure holdings will achieve desirable social and environmental objectives (see Section 7).

9.6 Our conclusions about historic performance (see Section 8) are necessarily tentative, but can be summarised as follows:

- 9.6.1 For most infrastructure assets there is no recognised marketplace to enable accurate market values to be determined regularly.

- 9.6.2 Hence investors in unlisted infrastructure must normally rely on valuations made by experts from time to time, based on their opinions about current values, which in turn are based on a limited number of sales of other infrastructure assets for which prices are known, with some adjustments to allow for the circumstances of the investment for which a value is being assessed. This process inevitably means that there are delays before fundamental market shifts reflect in valuations, unlike listed infrastructure companies where share sales and purchases are taking place in stock markets continuously. As a result, the reported values of unlisted infrastructure normally show less volatility than those of listed infrastructure.

- 9.6.3 A further issue for unlisted infrastructure is that much of the investment is made by funds of the venture capital type which typically make borrowings to help to fund their purchases. These borrowings may sometimes have to be renewed at different interest rates, or they may be on variable short-term interest rates, but in either case there is a substantial gearing effect, positive or negative, to be added to the performance of the infrastructure itself. It is usually impossible to disentangle these influences to identify the performance of the infrastructure alone.

- 9.6.4 The EDHEC Infra300 Index performance is not calculated by using the returns earned by investors, but by using a methodology that involves some subjective elements – see Part 1 of Section 8. The various contributions to total returns made by the subsectors of infrastructure, point to some interesting historical differences.

- 9.6.5 For listed infrastructure these issues do not exist, and regular market values are available. The correlations shown in table 9 indicate that the performance of listed infrastructure companies is closely correlated with the performances of listed global equities in general. These tend to experience much of the same ups and downs as other equities.

- 9.6.6 It is not surprising, therefore, that we found that adding listed infrastructure companies to a wider portfolio did not provide much diversification of risk, as measured by historic quarterly

volatility. Adding unlisted infrastructure, however, would probably tend to make the overall value of a portfolio appear more stable, in view of the valuation delays for the infrastructure referred to in paragraph 9.6.2.

- 9.6.7 Thus, the historic performance data we have reviewed does not provide a clear picture of whether infrastructure performed better or worse than other classes of equity investment in the long term, though investing in infrastructure funds or through direct ownership may have provided the overall portfolio with an element of stability at times when stock markets fluctuated.

9.7 To summarise, we believe that investors will continue to be attracted to infrastructure investments provided they consider that the prospective returns to be sufficient to counterbalance the undoubted risks, because they will have regard to the desirability of diversifying the risks in their overall investment portfolios. New forms of public-private partnership may be developed, and many tools will be used to evaluate ESG and SDG outcome objectives, and to stimulate benchmarking between the results of different investors. Investments in infrastructure may increasingly come to be seen as a way for investors to strengthen their reputations through achieving intentional positive impacts on society and the planet.

Acknowledgements

We should like to acknowledge the help we received from the EDHEC Business School, who generously gave us access to their extensive database relating to the investment performance of infrastructure over the last 20 years.

References

Baker, S., 2020. *Global ESG-data driven assets hit $40.5 trillion. Pensions & Investments*, [online] Available at: <https://www.pionline.com/esg/global-esg-data-driven-assets-hit-405-trillion> [Accessed on 5 December 2021].

Bank of England (24 May 2022). *Results of the 2021 Climate Biennial Exploratory Scenario (CBES)* [online] Available at: <https://www.bankofengland.co.uk/stress-testing/2022/results-of-the-2021-climate-biennial-exploratory-scenario> [Accessed on 30 July 2022].

BearingPoint Institute, 2013. *Building new bridges - are insurers the new banks for infrastructure investments?* [online] EU: BearingPoint Holding B.V. Available at: <https://www.bearingpoint.com/en/our-success/insights/building-new-bridges-%E2%80%93-are-insurers-the-new-banks-for-infrastructure-investments/#:~:text=As%20Chris%20Manser%20of%20Swiss,the%20length%20of%20investment%20involved.> [Accessed 29 March 2022].

EDHEC Infrastructure Institute (EDHEC), 2017. *The Rise of Fake Infra*. [pdf] EDHEC. Available at: <https://edhec.infrastructure.institute/wp-content/uploads/2018/08/fakeinfra_EDHEC2017.pdf> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2020. *TICCS Infrastructure Investment Taxonomy*, [online] Available at: <https://edhec.infrastructure.institute/ticcs/> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2021a. *Strategic Asset Allocation with Unlisted Infrastructure*. [pdf] EDHEC. Available at: <https://edhec.infrastructure.institute/wp-content/uploads/2021/02/Strategic_Asset_Allocation_EDHECinfra_2021.pdf> [Accessed 5 July 2022].

EDHEC Infrastructure Institute (EDHEC), 2021b. *Factsheet - as of 30 April 2021: infra300 (R) index.* [pdf] Available at: <https://edhec.infrastructure.institute/wp-content/uploads/2021/11/factsheet-infra300.pdf> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2022a. infraMetrics®. [online data platform] Available at: <https://indices.edhecinfra.com/launcher> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2022b. *Q4 2021 Index Data Release – infrastructure equity marches on, while debt faces the tough reality!* [Press release] 10 February 2022. Available at: < https://edhec.infrastructure.institute/announcement/q4-2021-index-data-release-infrastructure-equity-marches-on-while-debt-faces-the-tough-reality/> [Accessed 21 August 2011].

European Commission, 2016. *State-Owned Enterprises in the EU: Lessons Learnt and Ways Forward in a Post-Crisis Context*. [online] European Economy. Available at: < https://economy-finance.ec.europa.eu/publications/state-owned-enterprises-eu-lessons-learnt-and-ways-forward-post-crisis-context_en> [Accessed 21 August 2022].

FTI Consulting, 2022. EU Taxonomy and the Future of Reporting. *Harvard Law School Forum on Corporate Governance*, [blog] 4 April. Available at: <https://corpgov.law.harvard.edu/2022/04/04/eu-taxonomy-and-the-future-of-reporting/> [Accessed 6 July 2022].

Global Impact Investing Network (GIIN), 2020. *Annual Impact Investor Survey*. [online] Available at: <https://thegiin.org/research/publication/impinv-survey-2020> [Accessed 26 April 2021].

HM Treasury, 2022. *Speech by John Glen MP, Economic Secretary to the Treasury, to the Association of British Insurers Annual Dinner.* [press release] 21 February 2022. Available at: < https://www.gov.uk/government/speeches/speech-by-john-glen-mp-economic-secretary-to-the-treasury-to-the-association-of-british-insurers-annual-dinner> [Accessed 29 March 2022].

Institution of Civil Engineers and Institute and Faculty of Actuaries, 2017. *Major Infrastructure Projects: Key Front-end Issues.* [pdf]. ICE Publishing. Available at: <https://www.actuaries.org.uk/system/files/field/document/ICE_Front%20End%20Issues_Web%20Version.pdf> [Accessed 7 April 2022].

Kempler, S., 2020. *Listed vs unlisted infrastructure.* [online] Maple-Brown Abbott. Available at: <https://www.maple-brownabbott.com.au/listed-vs-unlisted-infrastructure> [Accessed 1 April 2022].

Korean National Pension Service (KNPS), 2021. *2020 National Pension Fund Annual Report.* [pdf] Available at: <https://fund.nps.or.kr/jsppage/fund/prs_e/prs_e_04.jsp> [Accessed 1 April 2022].

Linklaters, 2019. *Opportunity plus: 2019 edition*. [online] Linklaters. Available at: < https://www.linklaters.com/en/insights/thought-leadership/investing-europe-infrastructure/understanding-the-opportunities-and-risks-of-core-and-non-core-infrastructure-investment> [Accessed 21 August 2022].

Losavio, J., 2019. *6 innovative technologies about to transform our infrastructure. World Economic Forum*, [online] Available at: <https://www.weforum.org/agenda/2019/09/6-revolutionary-techniques-about-to-transform-our-infrastructure/> [Accessed 21 August 2022].

Milliman. *CRisALIS™ risk management methodology*. [online] Available at: <https://www.milliman.com/en/Products/Complexriskanalysis> [Accessed 4 August 2022].

Nuveen, 2022. *Listed vs. private infrastructure: Why not both?* [online] Nuveen. Available at: <https://www.nuveen.com/global/insights/alternatives/listed-vs-private-infrastructure-why-not-both> [Accessed 1 April 2022].

OECD, 2017. *Getting Infrastructure Right: A framework for better governanc*e, [pdf] Paris: OECD Publishing. Available at: <https://www.oecd.org/gov/getting-infrastructure-right.pdf> [Accessed 21 August 2022].

OECD, 2020. *Recommendation of the Council on the Governance of Infrastructure*. [press release] 17 July 2020. Available at: <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0460> [Accessed 21 August 2022].

OMERS Pension Plans (OMERS), 2022. *OMERS 2021 Annual Report*. [online] Available at: <https://www.omers.com/annual-reporting> [Accessed 1 April 2022].

Principles for Responsible Investment (PRI), 2017. *What are the Principles for Responsible Investment?* [online] Available at: <https://www.unpri.org/pri/what-are-the-principles-for-responsible-investment> [Accessed 7 November 2021].

Principles for Responsible Investment (PRI), 2020. *Screening*. [online] London: PRI Association. Available at: <https://www.unpri.org/an-introduction-to-responsible-investment/an-introduction-to-responsible-investment-screening/5834.article> [Accessed 4 July 2021].

Principles for Responsible Investment (PRI), 2020. *Bridging the GAP: How Infrastructure Investors Can Contribute to SDG Outcomes*. [online] London: PRI Association. Available at: <https://www.unpri.org/sustainable-development-goals/bridging-the-gap-how-infrastructure-investors-can-contribute-to-sdg-outcomes/6053.article> [Accessed 29 May 2021].

PWC, 2020. *Global infrastructure trends Part 3: Developments in technology*. [online] PWC. Available at: < https://www.pwc.com/gx/en/industries/capital-projects infrastructure/publications/infrastructure-trends/global-infrastructure-trends-developments-in-technology.html> [Accessed 21 August 2022].

Sarma, N., 2020. *Future of Coal: The stranded asset problem. Observer Research Foundation (ORF)*, [online] Available at: <https://www.orfonline.org/expert-speak/future-of-coal-the-stranded-asset-problem/> [Accessed 21 August 2022].

Stichting Pensioenfonds ABP (ABP), 2021a. *ABP Quarterly Report Q4 2020*. [online] Available at: <https://www.abp.nl/images/quarterly-report-Q4-2020.pdf> [Accessed 1 April 2022].

Stichting Pensioenfonds ABP (ABP), 2021b. *ABP Annual Report 2020*. [online] Available at: <https://view.publitas.com/cfreport/abp-annual-report-2020> [Accessed 1 April 2022].

The Countryside Charity (CPRE), 2021. *Recycling our land: the state of brownfield report, 2021*. [online] Available at: <https://www.cpre.org.uk/resources/recycling-our-land-the-state-of-brownfield-report-2021/> [Accessed 1 May 2022].

United Nations Conference on Trade and Development (UNCTAD), 2014. *Investing in the SDGs: An action plan for promoting private sector contributions. World Investment Report 2014,* [e-report] Chapter IV, pp.135 - 194. https://doi.org/10.18356/ca95f7ed-en.

Universities Superannuation Scheme (USS), 2021. *USS Report and Accounts 2021*. [pdf] Available at: <https://www.uss.co.uk/about-us/report-and-accounts> [Accessed 1 April 2022].

Bibliography

Baker, S., 2020. Global ESG-data driven assets hit $40.5 trillion. *Pensions & Investments*, [online] Available at: <https://www.pionline.com/esg/global-esg-data-driven-assets-hit-405-trillion> [Accessed on 5 December 2021].

BearingPoint Institute, 2013. *Building new bridges - are insurers the new banks for infrastructure investments?* [online] EU: BearingPoint Holding B.V. Available at: <https://www.bearingpoint.com/en/our-success/insights/building-new-bridges-%E2%80%93-are-insurers-the-new-banks-for-infrastructure-investments/#:~:text=As%20Chris%20Manser%20of%20Swiss,the%20length%20of%20investment%20involved.> [Accessed 29 March 2022].

EDHEC Infrastructure Institute (EDHEC), 2017. *The Rise of Fake Infra*. [pdf] EDHEC. Available at: <https://edhec.infrastructure.institute/wp-content/uploads/2018/08/fakeinfra_EDHEC2017.pdf> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2020. *TICCS Infrastructure Investment Taxonomy*, [online] Available at: <https://edhec.infrastructure.institute/ticcs/> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2021a. *Strategic Asset Allocation with Unlisted Infrastructure*. [pdf] EDHEC. Available at: <https://edhec.infrastructure.institute/wp-content/uploads/2021/02/Strategic_Asset_Allocation_EDHECinfra_2021.pdf> [Accessed 5 July 2022].

EDHEC Infrastructure Institute (EDHEC), 2021b. *Factsheet - as of 30 April 2021: infra300 (R) index.* [pdf] Available at: <https://edhec.infrastructure.institute/wp-content/uploads/2021/11/factsheet-infra300.pdf> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2022. infraMetrics®. [online data platform] Available at: <https://indices.edhecinfra.com/launcher> [Accessed 1 April 2022].

EDHEC Infrastructure Institute (EDHEC), 2022b. *Q4 2021 Index Data Release – infrastructure equity marches on, while debt faces the tough reality!* [Press release] 10 February 2022. Available at: < https://edhec.infrastructure.institute/announcement/q4-2021-index-data-release-infrastructure-equity-marches-on-while-debt-faces-the-tough-reality/> [Accessed 21 August 2011].

European Commission, 2016. *State-Owned Enterprises in the EU: Lessons Learnt and Ways Forward in a Post-Crisis Context*. [online] European Economy. Available at: < https://economy-finance.ec.europa.eu/publications/state-owned-enterprises-eu-lessons-learnt-and-ways-forward-post-crisis-context_en> [Accessed 21 August 2022].

FTI Consulting, 2022. EU Taxonomy and the Future of Reporting. *Harvard Law School Forum on Corporate Governance*, [blog] 4 April. Available at: <https://corpgov.law.harvard.edu/2022/04/04/eu-taxonomy-and-the-future-of-reporting/> [Accessed 6 July 2022].

Global Impact Investing Network (GIIN), 2020. *Annual Impact Investor Survey*. [online] Available at: <https://thegiin.org/research/publication/impinv-survey-2020> [Accessed 26 April 2021].

HM Government (Cabinet Office). *National Risk Register (2020).* National Risk Register 2020 - GOV.UK (www.gov.uk) *[*Accessed 7 April 2022].

HM Treasury, 2022. *Speech by John Glen MP, Economic Secretary to the Treasury, to the Association of British Insurers Annual Dinner.* [press release] 21 February 2022. Available at: < https://www.gov.uk/government/speeches/speech-by-john-glen-mp-economic-secretary-to-the-treasury-to-the-association-of-british-insurers-annual-dinner> [Accessed 29 March 2022].

Institution of Civil Engineers and Institute and Faculty of Actuaries, 2014. *RAMP, Risk Analysis and Management for Projects.* 3rd ed. London: ICE Publishing.

Institution of Civil Engineers and Institute and Faculty of Actuaries, 2017. *Major Infrastructure Projects: Key Front-end Issues.* [pdf]. ICE Publishing. Available at: <https://www.actuaries.org.uk/system/files/field/document/ICE_Front%20End%20Issues_Web%20Version.pdf> [Accessed 7 April 2022].

Kempler, S., 2020. *Listed vs unlisted infrastructure.* [online] Maple-Brown Abbott. Available at: <https://www.maple-brownabbott.com.au/listed-vs-unlisted-infrastructure> [Accessed 1 April 2022].

Korean National Pension Service (KNPS), 2021. *2020 National Pension Fund Annual Report.* [pdf] Available at: <https://fund.nps.or.kr/jsppage/fund/prs_e/prs_e_04.jsp> [Accessed 1 April 2022].

Linklaters, 2019. *Opportunity plus: 2019 edition*. [online] Linklaters. Available at: < https://www.linklaters.com/en/insights/thought-leadership/investing-europe-infrastructure/understanding-the-opportunities-and-risks-of-core-and-non-core-infrastructure-investment> [Accessed 21 August 2022].

Losavio, J., 2019. *6 innovative technologies about to transform our infrastructure. World Economic Forum*, [online] Available at: <https://www.weforum.org/agenda/2019/09/6-revolutionary-techniques-about-to-transform-our-infrastructure/> [Accessed 21 August 2022].

Milliman. *CRisALIS^{TM} risk management methodology*. [online] Available at: <https://www.milliman.com/en/Products/Complexriskanalysis> [Accessed 4 August 2022].

National Infrastructure Commission. *National Infrastructure Assessment*, 2018. National Infrastructure Assessment - NIC [Accessed 7 April 2022]. The Government's response (2020) can be found at National Infrastructure Strategy - GOV.UK (www.gov.uk) [Accessed 7 April 2022].

Nuveen, 2022. *Listed vs. private infrastructure: Why not both?* [online] Nuveen. Available at: <https://www.nuveen.com/global/insights/alternatives/listed-vs-private-infrastructure-why-not-both> [Accessed 1 April 2022].

OECD, 2017. *Getting Infrastructure Right: A framework for better governanc*e, [pdf] Paris: OECD Publishing. Available at: <https://www.oecd.org/gov/getting-infrastructure-right.pdf> [Accessed 21 August 2022].

OECD, 2020. *Recommendation of the Council on the Governance of Infrastructure*. [press release] 17 July 2020. Available at: <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0460> [Accessed 21 August 2022].

OMERS Pension Plans (OMERS), 2022. *OMERS 2021 Annual Report*. [online] Available at: <https://www.omers.com/annual-reporting> [Accessed 1 April 2022].

Principles for Responsible Investment (PRI), 2017. *What are the Principles for Responsible Investment?* [online] Available at: <https://www.unpri.org/pri/what-are-the-principles-for-responsible-investment> [Accessed 7 November 2021].

Principles for Responsible Investment (PRI), 2020. *Screening*. [online] London: PRI Association. Available at: <https://www.unpri.org/an-introduction-to-responsible-investment/an-introduction-to-responsible-investment-screening/5834.article> [Accessed 4 July 2021].

Principles for Responsible Investment (PRI), 2020. *Bridging the GAP: How Infrastructure Investors Can Contribute to SDG Outcomes*. [online] London: PRI Association. Available at: <https://www.unpri.org/sustainable-development-goals/bridging-the-gap-how-infrastructure-investors-can-contribute-to-sdg-outcomes/6053.article> [Accessed 29 May 2021].

PWC, 2020. *Global infrastructure trends Part 3: Developments in technology*. [online] PWC. Available at: < https://www.pwc.com/gx/en/industries/capital-projects-infrastructure/publications/infrastructure-trends/global-infrastructure-trends-developments-in-technology.html> [Accessed 21 August 2022].

Sarma, N., 2020. Future of Coal: The stranded asset problem. *Observer Research Foundation (ORF)*, [online] Available at: <https://www.orfonline.org/expert-speak/future-of-coal-the-stranded-asset-problem/> [Accessed 21 August 2022].

Stichting Pensioenfonds ABP (ABP), 2021a. *ABP Quarterly Report Q4 2020*. [online] Available at: <https://www.abp.nl/images/quarterly-report-Q4-2020.pdf> [Accessed 1 April 2022].

Stichting Pensioenfonds ABP (ABP), 2021. *ABP Annual Report 2020.* [online] Available at: <https://view.publitas.com/cfreport/abp-annual-report-2020> [Accessed 1 April 2022].

The Countryside Charity (CPRE), 2021. *Recycling our land: the state of brownfield report, 2021*. [online] Available at: <https://www.cpre.org.uk/resources/recycling-our-land-the-state-of-brownfield-report-2021/> [Accessed 1 May 2022].

United Nations Conference on Trade and Development (UNCTAD), 2014. Investing in the SDGs: An action plan for promoting private sector contributions. *World Investment Report 2014,* [e-report] Chapter IV, pp.135 - 194. https://doi.org/10.18356/ca95f7ed-en.

Universities Superannuation Scheme (USS), 2021. *USS Report and Accounts 2021*. [pdf] Available at: <https://www.uss.co.uk/about-us/report-and-accounts> [Accessed 1 April 2022].

Weglarz, D., 2015. *What You Need to Know About Solvency II and Reinsurance.* [online] Available at: <https://www.genre.com/knowledge/blog/what-you-need-to-know-about-solvency-ii-and-reinsurance-en.html> [Accessed 29 March 2022].

APPENDIX

Contents

The TICCS classification system - a summary

What is TICCS?

The Global Infrastructure Company Classification standard (TICCS) is designed by EDHEC*Infra* for investors to provide a frame of reference to understand the infrastructure asset class. Broadly TICCS is a class-based taxonomy which consists of the four pillars mentioned below.

Business Risk - It highlights the role of different business models and types of regulation. Here the risk in investable infrastructure can be identified using different forms of long-term contracts. Fundamentally the business risks are the key drivers of the financial structure and the risk profile of the infrastructure companies found across various industrial activities.

Industrial Activity - Industrial sector group classification consists of broad areas of industrial activity and includes transaction and project development expertise. Industrial sector and subsector classification represents specific industrial activities. TICCS uses the following multi- criteria arrangement system with the focus on the industrial activity in the infrastructure segment with varying levels of complexity, size and scale.

- 8 industrial-group classifications (or superclasses)
- 33 industrial classes
- 95 industrial subclasses or asset-level categories

Geo-economic exposure - The third TICCS classification is based on four levels of geo-economic exposure which is important to understand the correlation between different investments in different parts of the world. The EDHECInfra collect data from GIS data of infrastructure assets to understand their exact location in the space. Based on data insights available the following classification of Infrastructure companies are made:

- Subnational infrastructure companies
- National infrastructure companies
- Regional infrastructure companies
- Global infrastructure companies

Apart from Business risk, an additional dimension to capture is the exposure of each company to different geographical locations based on economic profile of the country.

Corporate Governance - The corporate governance structure of the infra companies is segmented into two classes and two sub-classes. The Firm's and its manager behaviour changes, depending upon project size (multi or single). The external debt financing is an important tool to understand the behaviour of the firm.

Source - EDHECInfra

The EDHECInfra 300 Index - description of the calculation method

EDHEC state:

> "*The Infra300 is a calculated index (as opposed to a contributed one). Each month, the market value of its constituents is re-estimated using a DCF method based on revised expected cash flows, changes in the risk-free rate term structure and changes in each constituent's risk premia. The risk premia of each constituent is the result of a linear combination of risk factor exposures and premia which are re-estimated on each quarter-end date based on recent secondary market transactions. Between quarters, the risk premia is linearly interpolated and risk-free data updated to obtain discount rates*."

Source: https://edhec.infrastructure.institute/wp-content/uploads/2021/11/factsheet-infra300.pdf

Listed shares in infrastructure companies - three indices

Several indices that feature listed equity securities with differing degrees of focus on their definition of infrastructure are available: for example, the MSCI World Infrastructure Index (MSCI World Infra) and S&P Global Infrastructure Index (S&P Global Infra). Additionally, the MSCI World Core Infrastructure Index (MSCI World Core Infra) focuses on "industrial" infrastructure only. Details are as follows:

MSCI World Infra

This index aims to capture the global opportunity set of listed companies owning or operating infrastructure assets. Constituents come from the equity universe of the MSCI World Equity index, which features mid and large securities from 23 developed markets. Telecom companies play a large role among the 133 constituents as of end November 2021- a sharp contrast to the S&P Global Infra index below. Examples of constituents with over 2% weighting include Verizon, AT&T, T-Mobile, and Softbank.

Over half of the index's weighting is in the US. MSCI highlights some key features of the index as being a high cash yield and a relatively low level of volatility.

The index was launched in early 2008 - data before this point is back tested. This data may be materially different than actual results that would have been achieved during this time.

S&P Global Infra

This is a modified market capitalisation weighted index. It tracks the performance of 75 listed infrastructure companies across energy, transportation, and utilities. Telecommunication companies are excluded. The index is organised by fixed numbers of constituents, rather than market capitalisation.

To achieve sufficient breadth, 15 emerging market stocks are first included (regardless of infrastructure subsector). Then developed markets are used to fill out the index, with a desired split in terms of number of constituents of 30 stocks in each of transportation and utilities, and 15 in the energy subsector. The latest weightings of this index are approximately: energy 20%, utilities 40%, transportation 40%.

The index had a market capitalisation of approximately $1.65 trillion as at end October 2021.

MSCI World Core Infra

This index aims to capture the global opportunity set of listed companies engaged in core industrial infrastructure activities such as utilities, energy, and transportation. Constituents come from the equity universe of MSCI World Equity index, which features mid and large securities from 23 developed markets. Note that telecom companies (which dominate the MSCI World Infra index featured above) are excluded.

As of end November 2021, over half of the index's weighting is in the US and there are 114 constituents. The weight of each sub-industry is capped at 15% to provide more diversification and the weight of any security is capped at 5% to reduce concentration.

The index was launched in early 2015 - data before this point is back tested. This data may be materially different than actual results that would have been achieved during this time.