A Publication of the EDHEC Infrastructure Institute-Singapore

Data Collection for Infrastructure Investment Benchmarking

Objectives, Reality Check and Reporting Guidelines

June 2016

EDHEC*infra*
Singapore Infrastructure Investment Institute

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Executive Summary

Executive Summary

The growing interest of investors for infrastructure investment has been motivated by what Blanc-Brude (2013) calls the "infrastructure investment narrative": the notion that infrastructure projects uniquely combine the following characteristics:

- Low price-elasticity of demand for service, hence low correlation with the business cycle
- Monopoly power, hence pricing power, hence an inflation hedge
- Predictable and substantial free cash flow
- Attractive risk-adjusted cash flows, available over long periods
- Access to unlisted, illiquid financial assets

That is, investing in infrastructure *implies:*

- Improved diversification
- Better liability-hedging, including inflation protection
- Less volatility than capital market instruments

Unfortunately, adequate benchmarks that could assess the validity of this intuition do not exist today, as 94 percent of the respondents of a new EDHEC/Global Infrastructure Hub Survey of asset owners involved in infrastructure investing attests (Blanc-Brude et al., 2016).

In recent years, frequent calls have been made in policy fora for data collection efforts to be stepped-up with respect to infrastructure investment, but it is often unclear which data should be collected to achieve what end and how.

In this paper, we propose guidelines for collecting and reporting infrastructure investment data for the purpose of building investment benchmarks of private infrastructure debt or equity. To establish what data needs to be collected, we start from the reasons why infrastructure investment benchmarks are in demand and list the key questions that such benchmarks should be expected to answer.

What are the relevant questions?

- Asset allocation: investors need risk-adjusted measures of performance;
- Prudential regulation: regulators want measures of extreme risks;
- Liability-driven investment: some investors also want to understand the "liability-friendliness" of infrastructure investing.

Why these questions cannot be answered today

These questions are important to the future of infrastructure investment by long-term investors, such as investors with a liability profile and subjected to prudential rules. However, the current state of investment knowledge does not allow answering them for the following reasons:

1. Market proxies are ineffective;
2. Existing research using private investment data is too limited;
3. Reported financial metrics are inadequate.

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Recent progress: from definitions to data collection

Blanc-Brude (2014) put forward a five-step roadmap for the creation of infrastructure investment benchmarks, including:

1. Achieving clear instrument definitions;
2. Developing adequate asset pricing methods;
3. Arriving at simple yet comprehensive data collection guidelines;
4. Populating a global database of infrastructure investment data;
5. Aggregating individual investments into reference portfolios of private infrastructure debt and equity.

This roadmap integrates the question of data collection upfront, including the requirement to collect information known to exist in a reasonably standardised format and limited to what is necessary to implement robust asset pricing and cash flow models.

Since them the first two steps recommended in this roadmap have been taken, and with this paper a framework required to define and launch the data collection process (step 3) now exists.

Step 1: Definition

Defining infrastructure investments from a financial perspective —the only relevant perspective to build investment benchmarks —was a necessary first step.

For the purpose of building investment benchmarks, **the point of defining infrastructure investment is not to declare once and for all what tangible infrastructure is, but to clearly define what we are interested to observe and what it is representative of as an empirical phenomenon.**

For this purpose, a clear distinction must be made between infrastructure as a matter of public policy, in which case the focus is rightly on industrial functions (water supply, transportation, etc.) and that of financial investors who may be exposed to completely different risks through investments providing exactly the same industrial functions (e.g a real toll road and an availability payment road).

Moreover, firms delivering infrastructure services may branch out in new business areas that are altogether different: For instance, a number of utilities have had a tendency to look into the media business. Likewise, from a business model point of view, some airports are more akin to shopping malls than infrastructure.

When observing infrastructure investments, we aim to collect data that is not too "noisy": corresponding to an investments as close as possible to the intuition that we called the "infrastructure investment narrative", the existence of which we are trying to assess.

In the respect, substantial progress has now been made towards identifying those characteristics that can be expected to *systematically* explain the financial performance of infrastructure investments.

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In particular, the growing consensus around the limited role of industrial sector categories in explaining and predicting performance, and the much more significant role played by contracts and by different infrastructure "business models" such as "merchant" or "contracted" infrastructure, or different forms of utility regulation, is encouraging.

A number of corporate forms can thus be included in the definition of infrastructure investing as long as, from the perspective of observing the phenomenon of interest, we can ensure that a "pure" infrastructure business is being observed and not a combination of, say, seaport operations and a real estate income.

Step 2: Valuation

Once the financial instruments that correspond to infrastructure investment are usefully defined, the second necessary step is to design a performance and risk measurement framework that can compute robust estimates of the metrics needed to understand infrastructure investment in an asset allocation and prudential context.

A two-step approach to measuring performance is necessary:

1. Documenting cash flow distributions (debt service and dividends) in order to address the fundamental problem of unreliable or insufficiently reported NAVs or losses given default (LGDs);
2. Estimating the relevant (term structure of) discount rates, or required rates of returns, and their evolution in time.

Here too, progress has been made and recent research reviewed in this paper provides a framework addressing both aspects, taking into account the availability of data, while applying best-in-class models of financial performance measurement.

These advances allow us to define a list of required data items to implement these improved methodologies.

Guidelines for data collection

We propose a data collection framework respecting the following first principles:

1. The financial instruments used to invest in infrastructure must be well-defined;
2. Benchmarking results must be based on best-in-class models of financial performance and economic impact measurement;
3. The required data must already exist and be sufficiently standard to be observable on a large scale; and
4. It must be limited to a parsimonious list to keep the collection process efficient and realistic.

We argue that realised and forecast cash flow and event data, adequately categorised by "physical" and "business model" attributes, and corresponding to a clear set of financial instruments and their attributes, is sufficient to measure

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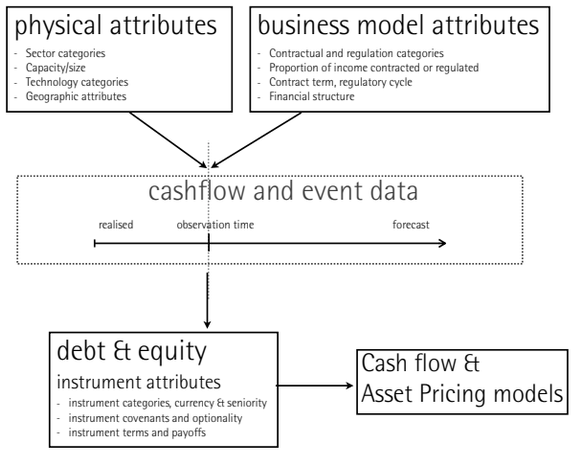
Figure 1: Data types and attributes of private infrastructure investments



the performance of portfolios of private infrastructure investments.

A first step consists in the identification of all *investable infrastructure* in a given country, and the attribution of a unique identifier to each firm corresponding to a potential investment in either equity or different kinds of debt.

For each identified firm, two types of observable data points are of interest:

1. Cash flows (and cash flow ratios, which may or may not be derived from balance sheet items)
2. Events (or milestones) in the development of the firms and, possibly, the evolution of its risk profile

Next, cash flow and event data need to be categorised according to economically meaningful attributes. These fall into three categories:

1. Physical attributes of the firm: *what* and *where* the firm is as an infrastructure investment
2. Business model attributes of the firm: sources of *revenues* and *costs* of the firm and whether or not the risk inherent in these exposures is insured against via contracts with third parties.
3. Attributes of available financial instruments: type of payout structure, control rights and terms applicable to the claimants to the firms liabilities and equity

Figure 1 provides an illustration.

All firm and instrument attributes should also be reported and recorded dynamically. For instance, a loan may change interest rate over time (and this may be known in advance), or a firm may see it's take-or-pay off-take contract expire before the end of the investment's life. Capturing realised and forecast changes in time of the attributes of either firms or instruments

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is of particular importance in the case of infrastructure investments because of the path-dependency and sequential resolution of uncertainty, which characterises these type of investments. For example project debt may change its maturity date post-restructuring, which is instrumental in the context of asset pricing and computing duration.

Applying the framework detailed in this paper, we propose the following data collection guidelines:

1. Building investment benchmarks of highly illiquid private assets like private infrastructure debt and equity requires collecting data reported at the underlying firm level;
2. These firms should be categorised according to a limited set of 'attributes' which can be expected to *systematically* explain the risk profile of individual investments: not only the variance but, most importantly, the co-variance of cash flows and of returns; these include:
   - Physical attributes: investment size, technology, sector, location, lifecycle stage
   - Business model attributes: nature of income and cost streams, role of contracts and regulation
3. Individual financial instruments used to invest in such firms should also be recorded and documented to be in a position to predict the payoffs to different investors
   - Instruments should be categorised by type of payoff profile (fixed, variable)
   - Any conditions (covenants, embedded options, prepayment) should be documented to properly model the expected payoff to investors
4. The two main types of data to collect relating to the relevant firms and instruments are **standardised events and cash flow items**
   → Firm and instrument attributes are control variables that explain the dynamics of different stream of cash flows to different claimants (investors)
5. Each data point should be reported using a dual timeframe, capturing both the time of observation/reporting and that of occurrence (past, present or future)

Applying these guidelines to collect the relevant data allows implementing the type of asset pricing and risk models that, in turn, can be used to compute the metrics needed to better benchmark infrastructure investments in private debt and equity. This framework for collection data about private investment in infrastructure is illustrated in further details in the companion spreadsheet to this paper, which can be downloaded at the address indicated in the footnote. [1]

Populating the database

Having progressed towards clear definitions of underlying assets, and built robust, state-of-the-art pricing and risk models that avoid the pitfalls of existing practices, it

1 - http://edhec.infrastructure.institute/wp-content/uploads/documents/EDHECinfra_example_template.xlsx

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is now time to collect the relevant information.

The data collection framework and template proposed in this paper have been designed to correspond to the requirements of the relevant asset pricing and risk models. Hence, a rationale exists to collect data effectively and efficiently to build infrastructure investment benchmarks.

Collecting this information now requires large-scale cooperation between investors, creditors, academic researchers and the regulators that can help make such reporting part of a new standard approach to long-term investment in infrastructure by institutional players.

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1. Introduction

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In recent years, frequent calls have been made in policy fora for data collection efforts to be stepped-up with respect to infrastructure investment, but it is often unclear which data should be collected to achieve what end and how.

In this paper, we propose guidelines for collecting and reporting infrastructure investment data for the purpose of building investment benchmarks of private infrastructure debt or equity.

The current demand for infrastructure investment benchmarks springs from three sources:

- Long-term investors who need to formulate investment beliefs before they can make asset allocation decisions, require benchmarks to evaluate their infrastructure investment managers or strategies, and also want to evaluate the social and environmental impact of their investments;
- Prudential regulators who are required to adequately calibrate long-term infrastructure equity and debt investment within their respective risk-based frameworks such as Solvency-II;
- Policy makers who have been calling for a greater use of long-term savings to invest in capital projects that can have a positive impact on economic growth.

These actors have in common the goal to properly frame infrastructure investment so that long-term capital can be *adequately* deployed in the infrastructure sector.

To establish what data needs to be collected, we take the following approach: we start from the reasons why infrastructure investment benchmarks are in demand and list the key questions that such benchmarks should be expected to answer in section 2.

1. Introduction

The answers to these questions (about the *risk-adjusted performance, extreme risks and liability friendliness* of infrastructure investments) represent different aspects of the project to create infrastructure investment benchmarks.

Unfortunately, as we discuss in section 3, it remains very difficult to answer such questions today, for lack of the relevant information.

We thus propose data collection guidelines respecting the following principles:

1. the financial instruments used to invest in infrastructure must be well-defined;
2. benchmarking results must be based on best-in-class models of financial performance and economic impact measurement;
3. the required data must already exist and be sufficiently standard to be observable on a large scale;
4. it must be limited to a parsimonious list to keep the collection process efficient and realistic.

Section 4 discusses the first two principles and reviews recent progress made with clarifying the definition and valuation of infrastructure investments. In particular, the definition of important principles when approaching the asset pricing and performance measurement of privately-held infrastructure has a direct impact on the requirement for data collection.

Section 5 describes a framework capturing the financial data that is both necessary and sufficient to answer investors', regulators' and policy-makers' questions, using robust and transparent techniques, while keeping the data collection process realistic and efficient.

We argue that all relevant data should be collected at the firm level, focusing on two types of data points: *events* and *cash flows*, each of which can be given a number of standardised *attributes* corresponding to different "physical" or "business model" characteristics of the firm.

These data also correspond to a set of *financial instruments* found on the liability side of each firm's balance sheet, which have their own attributes explaining the payoffs received by investors.

These data then constitute the necessary and sufficient inputs to implement a class of generic cash flow forecasting and asset pricing models to measure the performance of portfolios of private infrastructure debt and equity investments.

1. Introduction

2. What are the relevant questions?

2. What are the relevant questions?

Privately-held infrastructure equity and debt can play a more significant role in institutional investors' portfolios once it is better understood from the point of view of:

- Asset allocation
- Prudential regulation
- Liability-driven investment

We discuss each dimension in turn below.

2.1 Asset allocation: finding the infrastructure bucket

For institutional investor, infrastructure investment can be a performance-seeking allocation to (very) illiquid alternatives. Whether infrastructure has its own "bucket" or is a sub-bucket in a broader group of assets, the decision to have a *specific* allocation to infrastructure implies that it has its own unique risk-adjusted profile, and can contribute to diversify total portfolio risk.

Documenting the risk-adjusted performance of infrastructure investments compared to other public or private assets is necessary to make it a relevant question at the strategic asset allocation level. It allows assessing the contribution of an infrastructure allocation to investment objectives, as well as monitoring internal or external infrastructure managers relative to expectations.

For asset allocation and monitoring purposes, investors need answers to the following questions:

1. What is the *expected return* profile of a relevant portfolio of infrastructure investments, and what investment factors or *betas* can it be decomposed into?
2. What is the current *value* of the portfolio? (to compute realised returns)
3. What is the reward-to-risk ratio (e.g. the Sharpe Ratio) of this portfolio?
4. What are the correlations of realised portfolio returns or factors with those of other relevant groups of assets?

Answering these questions determines whether there is an infrastructure "asset class" in its own right, which could be included in asset allocation decisions, or whether infrastructure investment corresponds to a persistent and unique combination of investment factors (for investors making allocation decisions on a factor-basis and across asset classes).

In the positive, privately-held infrastructure equity or debt may warrant having own buckets. In the negative, the risk adjusted performance of infrastructure investments can effectively be reproduced by combining other assets. While this would not exclude infrastructure assets from allocation decisions, it would not justify any particular focus on them.

2.2 Prudential regulation: documenting extreme risks

Prudential regulation is the second context within which benchmarking infrastructure

2. What are the relevant questions?

investments can make an important contribution.

Regulators are interested in systemic risk (the risk of collapse of the financial system). As such, they require an clear understanding of the likelihood of very large losses for investors in privately-held infrastructure equity or debt, especially in states of the world where other investments also exhibit very large losses.[2] It is on the basis of such assessments that prudential regulation sets "capital buffers" that aim to prevent cascading bankruptcies.

Today, privately-held infrastructure equity and debt tend to be considered high-risk by regulators because they are illiquid, long-term assets with no documented track record of their risk-adjusted performance.

Hence, without adequate calibration of existing prudential regulatory frameworks, institutional investors are less likely to invest in infrastructure, due to its high regulatory cost.

Still, certain regulatory treatments of privately-held infrastructure, such as Solvency-2 in Europe or RBC-2 in Singapore, are debatable and certainly contradicts the investment beliefs that draw investors to infrastructure in the first place: the "investment narrative" we suggested in section 1.

To improve current calibrations, the following questions require answering:

1. What is the *value-at-risk* (VaR) and *conditional value-at-risk* (cVaR or expected shortfall[3]) of relevant portfolios of infrastructure equity or debt?
2. What is the maximum draw-down of such reference portfolios?
3. What are the different measures of *dependence* including non-linear correlations (e.g. correlations in very bad states of the world) of the returns of relevant portfolios of infrastructure investments with other financial assets?

Answering these questions will allow better calibrations of prudential frameworks.

2.3 ALM: understanding the "liability-friendliness" of infrastructure investments

Third, numerous investors approach infrastructure investment because of its expected ability to help meet liability-hedging objectives. Privately-held infrastructure equity and debt can have long tenors, and are expected to provide predictable cash flows that are at least in part linked to a domestic price index. For these reasons, infrastructure investments may have the potential to contribute to liability-driven investment objectives, *even if they do not correspond to a well-identified asset class from a pure asset allocation perspective*, as discussed above.

Moreover, because most infrastructure investments correspond to a fixed-term concession contract, even the equity stake

2 - In other words, the role of prudential regulation is not to stop investors from taking risk and potentially loosing money; rather, it is to understand to what extent investors face the risk of all loosing a lot of money at the same time.

3 - cVaR is a so-called coherent risk measure and benefits from properties such as additivity which make it an adequate measure of portfolio risk

2. What are the relevant questions?

in infrastructure projects has an end date and therefore a well-defined *duration* or sensitivity to interest rate risk. In other words, private infrastructure project equity is potentially "liability-friendly".

The questions that require answering to document the potential role of infrastructure in a liability-driven investment context include:

1. What is the *effective* (option-implied) *duration* of senior infrastructure debt, taking into account the role of covenants and refinancing in project finance?
2. What is the *modified duration* of infrastructure equity and quasi-equity?
3. What is the *correlation with the relevant rate of inflation* of privately-held infrastructure equity returns?

Such metrics can play a key role in the integration of infrastructure investments in the asset-liability management of institutional investors, *and are fully part of the objective to benchmark such investments*. Indeed, the potential liability-hedging properties of infrastructure investment stand out as some of its most unique and attractive characteristics.

3. Why these questions cannot be answered today

3. Why these questions cannot be answered today

The questions listed above are important for the future of infrastructure investment by long-term investors, in particular investors with a liability profile and subjected to prudential rules, such as insurance firms. However, the current state of investment knowledge does not allow answering them.

Next, we discuss three key reasons why this is the case: first, the absence of reliable market proxies, second, the substantial limitations of existing private databases and the corresponding studies, and third, the tendency in private investment to focus on investment metrics that are inadequate to answer the questions listed above.

3.1 Market proxies are ineffective

The first place to look for estimates of expected performance and risk in privately-held infrastructure investments is the market for publicly traded securities, including stocks and bonds.

A number of thematic infrastructure indices have been created in recent years that include stock or bonds corresponding to issuers associated with specific industrial sectors (e.g. transport, energy, etc.) and deriving a certain proportion of their income from the same list of "infrastructure" sectors.

As reported before, this approach has so far failed to arrive at meaningful results (Blanc-Brude, 2013): listed infrastructure equity and debt indices tend to exhibit higher risk than broad market indices (higher maximum drawdown, higher VaR) because they are highly concentrated in a few large constituents and, crucially, do not create any *persistent* improvement of investors' existing portfolios.

In a forthcoming paper, Blanc-Brude et al. (2015) show that the mean-variance frontier of efficient portfolios available to investors allocating to asset classes (stocks, bonds, commodities, etc.) or to factors (value, growth, etc.) is not improved by the addition of a listed infrastructure index, whether provided by an indexer or by directly selecting all stocks corresponding to "infrastructure" sectors and deriving most of their income from infrastructure. [4]

In effect, focusing on industrial sectors is ineffective because what explains the performance of underlying infrastructure investments is to be found elsewhere. Indeed, infrastructure investments should not be conceived as "real" assets since the value of investors' claims is almost entirely determined by the contractual and legal aspects of each infrastructure project (see Blanc-Brude, 2013, for a detailed discussion).

The main difficulty with finding listed proxies of privately-held infrastructure investments is the small number of stocks and bonds that solely correspond to a *pure* exposure to the performance of underlying infrastructure equity or debt.

Blanc-Brude et al. (2015) discuss such a rare natural experiment in the form of

4 - Rothballer and Kaserer (2012) develop such an approach which Blanc-Brude et al. (2015) replicate to test the mean-variance spanning properties of listed infrastructure.

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a portfolio of five stocks listed on the London Stock Exchange: firms that happen to solely buy and hold the equity and quasi-equity of infrastructure projects corresponding almost exclusively to a single type of long-term contract used by governments to delegate investment in public infrastructure: the so-called "availability payment" model. [5]

5 - In this model, the public sector pays a pre-agreed income to the project firm on a regular basis in exchange for the construction/development, maintenance and operations of a given infrastructure project given a pre-agreed output specification and for several decades.

In this specific case, a basket of listed equity is shown to exhibit unique and persistent characteristics that can be considered to partially proxy the performance profile of equity invested in a basket of several hundred "availability payment" infrastructure projects, also known as PFI/PPP projects.

This is however, a small exception, which would not persist if these firms change investment strategy, and it is not clear how other forms of underlying infrastructure investments might be proxied in a meaningful manner using public stocks or bonds.

Other approaches involving the use of public market data to benchmark private investments include the public market equivalent (PME) of Ljungqvist and Richardson (2003), Kaplan and Schoar (2005) or Phalippou and Gottschalg (2009) which consists of using the cash flows into and out of private investment as if they represented buying and selling a public index.

A second version of the PME consists of matching private investments with listed industry betas, deriving the un-levered industry betas using industry averages and re-leveraging them using investment specific information (see Kaplan and Ruback, 1995; Ljungqvist and Richardson, 2003; Phalippou and Zollo, 2005, for various applications).

However, these approaches imply that the market *beta* of infrastructure equity and debt is *already known*, which is at odds with our the starting point i.e. the objective to discover its true value.

3.2 Existing studies of private investment data are too limited

Next, several databases exist that have been used in studies of the performance of private equity investments in infrastructure (see for instance Peng and Newell, 2007; Newell et al., 2011). However, such sources of data suffer from major limitations.

First, like listed stocks, they are not categorised according to what actually explains volatility and performance in infrastructure (contracts, risk-sharing mechanisms, revenue support agreements, etc.) but according to private equity (venture capital and leveraged by-outs) and industrial categories.

Second, they report the cash flows and asset values of private equity infrastructure funds: typically ten-year ventures with high fees and additional fund-level leverage. But infrastructure PE funds tend to behave like

3. Why these questions cannot be answered today

other PE funds and aim to exit their investments after a few years.

Infrastructure PE funds are found to be larger and to keep assets for a few more years than other PE funds; they are also very concentrated in a few investments (see Blanc-Brude, 2013, for a review of existing studies).

This approach, while perfectly legitimate as an alternative, albeit aggressive, investment strategy, cannot be considered representative of the performance of underlying infrastructure investments Databases of private funds also suffer from the usual sampling and survivorship biases.

In fact, it is because they are not representative of such performance that a number of large asset owners have gradually opted to exit infrastructure PE funds, to internalise infrastructure asset management, and to invest directly in underlying assets in order to gain the exposure to the long-term, predictable cash flows they expect to find in such firms.

In a forthcoming EDHEC Survey of investors' expectations and perceptions of infrastructure investments, three quarters of respondents declared that such traditional infrastructure PE funds did not add value but were 'obsolete' (see Blanc-Brude et al., 2016).

Thus, there is little to learn about the risk-adjusted performance of portfolios of infrastructure equity from the historical performance of PE infrastructure funds, let alone about the calibration of their prudential treatment or their role in an LDI context. Such products may also not be representative of the future of infrastructure investing by large institutional investors.

On the debt side, the main body of evidence has been collected by rating agencies. These entities have provided numerous ratings for individual issues, both listed and private bonds as well as private loans. However, rating methodologies do not constitute a fully-fledged valuation framework, and rank issues relative to each other but never consider the portfolio-level, which is the relevant one to answer the questions identified above. Moreover, individual credit ratings thus cannot be aggregated to create an infrastructure debt benchmark.

More quantitative studies by rating agencies exist that document incidences of default and recovery as reported by creditors (see for instance Moody's, 2015). These reports are by far the most informative studies conducted today but also remain insufficient to answer the questions highlighted above.

First, this information is still categorised by industrial sector, which makes it difficult to quantify the impact of the main drivers of credit risk, such as differences in revenue risk in infrastructure projects.

Second, these studies rely on the so-called "reduced form" approach to modelling

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credit risk: incidences of default and recovery are observed and assumed to be the result of some exogenous stochastic process, which is considered to be known once a large sample has been obtained.

However, sample biases are likely to persist (Blanc-Brude and Ismail (2013) document several such biases in the Moody's (2013) study) and the absence of controls for project level factors vs. external ones (credit and business cycle) gives little predictive power to such results. Moreover, in existing studies, while observations of defaults are plenty, losses given default (LGD) reported by different creditors are too few to arrive at a full distribution of losses, let alone control for differences in LGD of different types of infrastructure projects.

Thus, information available from rating agencies about infrastructure debt, while richer than what exists on the private equity side, is insufficient to benchmark the risk adjusted performance, extreme risk and effective duration of private infrastructure debt.

3.3 Reported financial metrics are inadequate

Finally, because most existing information about private investment in infrastructure equity is inherited from the PE universe, reported performance metrics tend to be limited to net asset values (NAVs) and internal rate of return (IRRs). [6]

However, the academic literature on private equity documents again and again the tendency of private equity managers to report NAVs opportunistically (see Jenkinson et al., 2013, for a recent study). Appraisal-based NAVs also suffer for the usual stale pricing issues which leads to smoothing returns and underestimating the volatility of returns.

More generally, IRRs as a performance metric are inadequate: the finance literature has long argued that using such constant and deterministic discount rates can be problematic. The standard corporate finance textbook examples (Brealey and Myers, 2014, see) show that the use of a single risk-adjusted discount rate for long-lived assets is defective if projects have multiple phases and project risk changes over time as real-options are exercised by asset owners.

Indeed, a constant risk premium does not measure risk properly on a period by period basis, but rather implies that cash flows occurring further in the future are riskier than cash flows occurring earlier (Haley, 1984), which may not be the case, especially given the kind of sequential resolution of uncertainty which characterises infrastructure projects. The use of constant discount rates then leads to biased NPV calculation (Ben-Horim and Sivakumar, 1988).

Examples of the inadequacy of IRRs abound in the literature: Phalippou (2008) highlights that the use of IRRs to measure

6 - The constant discount rate that makes an investor's Net Present Value (NPV) since the date of investment equal zero

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fund performance, allows fund managers to time their cash flows and boost reported performance measures without increasing investors' effective rate of return.[7] (Ang and Liu, 2004) present multiple examples of erroneous valuations resulting from the use of a constant discount rate compared to the use of a term structure of time-varying discount rates.

7 - Phalippou (2013) also shows that the Yale endowment's return since inception on its private equity fund stays close to 30% due to a few large capital distributions in early years, and is almost completely insensitive to later performance, making the metric economically meaningless.

When it comes to building investment benchmarks, the use of a constant discount rate is also inadequate for other reasons:

- The IRRs of individual investments cannot be easily used to estimate performance at the portfolio level, as the IRR of a portfolio is not the same as the weighted average IRRs of individual investments;
- IRR-based valuation methodologies cannot be used to identify different sources of return, which requires identifying period returns and decomposing them into systematic and idiosyncratic components. In fact, it is possible to build two streams of cash flows with the same IRR but diametrically opposed market betas;
- In the case of a finite-life investment, using the IRR does not lead to correct duration measure if the risk profile changes over time.

Hence, the metrics currently reported in privately-held infrastructure investments are not fit-for-purpose to answer the key questions highlighted above, from asset allocation, to prudential calibrations, to asset-liability management.

4. Recent progress: the roadmap

4. Recent progress: the roadmap

Blanc-Brude (2014) put forward a five-step roadmap for the creation of infrastructure investment benchmarks, including:

1. Achieving clear instrument definitions;
2. Developing adequate asset pricing methods;
3. Arriving at simple yet comprehensive data collection guidelines;
4. Populating a global database of infrastructure investment data;
5. Aggregating individual investments into reference portfolios of private infrastructure debt and equity.

This roadmap integrates the question of data collection upfront, including the requirement to collect only the information that is necessary to implement robust asset pricing and risk models.

Next, we review recent progress made with this agenda.

4.1 Definitions of infrastructure investment

A decade ago, investors, regulators and policy-makers were thinking about infrastructure in terms of industrial sectors and a coherent definition was nowhere in sight. Indeed, most papers on the subject started with the caveat that "there is not widely-agreed definition of infrastructure". Energy or telecoms were equally likely to be included or excluded in definitions that went from the very narrow ("infrastructure equals roads") to the very broad (from the rails to the rolling stock).

Still, defining infrastructure investments from a financial perspective —the only relevant perspective to build investment benchmarks —was a necessary first step.

For the purpose of building investment benchmarks, **the point of defining infrastructure investment is not to declare once and for all what tangible infrastructure is, but to clearly define what we are interested to observe and what it is representative of as an empirical phenomenon.**

For this purpose, a clear distinction must be made between infrastructure as a matter of public policy, in which case the focus is rightly on industrial functions (water supply, transportation, etc.) and that of financial investors who may be exposed to completely different risks through investments providing exactly the same industrial functions (e.g a real toll road and an availability payment road).

Moreover, firms delivering infrastructure services may branch out in new business areas that are altogether different: For instance, a number of utilities have had a tendency to look into the media business. Likewise, from a business model point of view, some airports are more akin to shopping malls than infrastructure.

When observing infrastructure investments, we aim to collect data that is not too "noisy": corresponding to an investments as close as possible to the intuition that we called the

4. Recent progress: the roadmap

"infrastructure investment narrative", the existence of which we are trying to assess.

In the most recent round of industry consultations led by EIOPA (EIOPA, 2015), substantial progress has been made towards identifying those characteristics that — on the basis of financial economics — can be expected to *systematically* explain the financial performance of infrastructure investments.

In particular, the growing consensus around the limited role of industrial sector categories in explaining and predicting performance, and the much more significant role played by contracts and by different infrastructure "business models" such as "merchant", "contracted" or "regulated" infrastructure, or different forms of utility regulation, is encouraging.

Two recent papers (Blanc-Brude et al., 2016b,a) using newly collected, large datasets of infrastructure firms cash flows find that the business model and lifecycle attributes of infrastructure firms explain the dynamics of their cash flows well, when sector categorisations do not.

These papers show the existence of well-defined stochastic processes for cash flow data belonging to similar business model "families", while there exist significant differences between the cash flows corresponding to different groups. For example, Blanc-Brude et al. (2016b) show that the volatility of revenues is different between different types of infrastructure business models (and also that it is different from non-infrastructure firms). Likewise, Blanc-Brude et al. (2016a) show that mean and variance of the debt service cover ratios of infrastructure projects follow a different path in each family of business models.

In the debate about defining infrastructure investment, non-recourse infrastructure project finance has become a first and useful point of reference in terms of capturing the expected behaviour of infrastructure investments (see Blanc-Brude, 2014, for a detailed discussion). While project finance equity or debt cannot be said to represent all investable infrastructure, it offer the opportunity observe the cash flows of long-term instruments created solely for the purpose of financing individual infrastructure project companies that are dedicated dedicated to delivering a single infrastructure projects. Project finance also presents the advantage of having a clear and widely accepted definition since the Basel-2 Accords.

Of course, a number of businesses can be project-financed that are not strictly speaking infrastructure investments delivering public services, such as casinos or heavy industry. Conversely, infrastructure services can also be delivered by more common forms of corporations such as utilities or private airport or port companies. These firms have their own business models and characteristics, but they may also create a lot of noise around the "infrastructure investment phenomenon" that we are trying to observe. For instance, and contrary to

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project finance SPVs, they may change their financial structure as they see fit, embark on overseas investment adventures, receive income from technology licences or consulting services. They may also branch out in new business areas that have nothing to do with infrastructure altogether (e.g. a number of utilities have had a tendency to look into the media business.)

But as suggested above, the objective of benchmarking infrastructure investment can only start with the possibility to observe a corporate phenomenon which as close as possible to the intuition justifying infrastructure investment in the first place (which we called the "infrastructure investment narrative").

Project financing, as an observable phenomenon, provides us with this opportunity. Benchmarking project finance debt and equity by broad categories of concession contracts, financial structures and life-cycle stage is thus a first concrete step towards creating reference portfolios that can be used as infrastructure benchmarks benchmarks.

Other types of underlying infrastructure business models (e.g. "RPI-X" vs. "rate of return" utility regulation) can be integrated in a broader benchmarking exercise of privately-held infrastructure investments, as long as, from the perspective of observing the investment phenomenon of interest, we can ensure that a "pure" infrastructure business is being observed and not a combination of, say, airport operations and a shopping mall.

The conclusion of the industry consultations led by EIOPA in 2015-16 is – for the most part – congruent with our argument. In a first step, EIOPA proposed to define infrastructure investment for the purpose of re-calibrating Solvency-II as a combination of characteristics that equated infrastructure with project finance (EIOPA, 2015). In a second step, in an attempt to widen the scope and number of qualifying investments, EIOPA considered recognising as qualifying infrastructure assets a number of "corporates" as long as they can be clearly identified as corresponding to the infrastructure business model (EIOPA, 2016).

4.2 Asset pricing principles

Once the financial instruments that correspond to infrastructure investment are usefully defined, the second necessary step is to design a performance and risk measurement framework, that can provide robust answers the questions identified above.

Of course, measuring the performance of privately-held infrastructure debt and equity requires deriving the appropriate discount rates for a given estimate of future cash flows, as for any other financial asset.

But these instruments are not traded frequently and cannot be expected to be fully "spanned" by a combination of publicly traded securities. It follows that they are

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unlikely to have unique prices that all investors concur with at one point in time. Instead, individual investors can arrive at different valuations of the same infrastructure debt or equity depending on their attitudes towards risk, liquidity, inflation, duration, etc, and large bid/ask spreads may persist.

Asset pricing models applied to such investments should be able to measure a *range* of applicable valuations for certain types of infrastructure investments. Indeed, the average realised performance or required returns corresponds to a "representative" investor that many actual investors may not recognise themselves in. Capturing this range of valuations and how it evolves in time is an integral part of benchmarking privately-held investments like infrastructure equity or debt.

This point highlights the fact that in private markets, cash flow volatility and discount rate volatility must be treated as separate (albeit related) phenomena.

In other words, while the pricing of publicly-traded securities implicitly combines a cash flow forecast with a required rate of return, [8] valuing privately-held investments requires explicitly forecasting cash flows and then deriving the required discount factors.

Hence, a two-step approach is necessary:

1. first documenting the cash flow distributions (debt service and dividends) found in underlying infrastructure investments, taking into account their characteristics (e.g. covenants), and
2. estimating the relevant (term structure of) discount rates or required rates of returns and their evolution in time, given the risk of teh payoff and the initial value paid by private investors.

4.2.1 Understanding cash flow dynamics

In order to address the fundamental problem of unreliable reported NAVs in private investment discussed above, it is essential to develop an independent view of the *statistical distribution* of cash flows to creditors and asset owners that can serve as the basis for a valuation of privately-held infrastructure investments.

Forecasts of future cash flows spanning the entire life of the investment in infrastructure projects are in fact available for both debt and equity investors. Such "base case" scenarii of debt service, dividends and free cash flow are the result of significant due diligence at the time of investment and duly documented at the time. Moreover, investors and creditors regularly revise these forecasts and these new forecasts are documented as well.

Base case and revised dividend and debt service forecasts may however vary between investors for comparable projects and *substantially deviate from the true statistical expectation of dividends*. Still, they are *observable*.

8 - This is the essence of the Gordon growth model of stock pricing.

4. Recent progress: the roadmap

In two recent papers, Blanc-Brude et al. (2014) and Blanc-Brude and Hasan (2015) show that the combination of base case scenarios with the *well-documented statistical distribution of two types of financial ratios* (the debt service cover ratio or DSCR, and the equity service cover ratio or ESCR) [9] is sufficient to derive robust estimated of expected cash flows (in the statistical sense) and their volatility.

9 - DSCR: ratio of current debt service to free cash flow or cash flow available for debt service; ESCR: ratio of realised to base case dividends, as presented in Blanc-Brude and Hasan (2015)

Regarding future debt service, Blanc-Brude et al. (2014) show analytically and empirically that knowledge of the distribution of DSCRs in time is sufficient to compute the credit metrics required by a structural credit risk model *e.g. distance to default* and to predict technical [10] and hard defaults in infrastructure debt.

10 - Default under the Basel-2 definition

They also show that adequate debt service forecast should integrate the "embedded options" available to senior lenders in the event of default, because they have a significant impact on the different debt service scenarii.

Indeed, infrastructure projects demand large amounts of sunk capital and most of these funds are typically provided by senior creditors that require significant control-rights in the event of covenant breach. Such contingent control rights (or embedded options), can lead to the restructuring of senior debt, can have a large impact on expected losses and thus on expected and realised performance.

In practice, infrastructure project loans have a "tail" (often described as the number of years beyond the original maturity of the debt during which the firm is still generating an operating income) and failing to value the option to restructure senior debt into the tail is likely to lead to overestimating LGD and VaR and underestimating recovery rates. [11]

11 - Conversely, loans with very short tails can see a sharp rise in expected losses towards the end of the loan life, even with very low default probabilities.

The authors show that a standard model of debt restructuring applying simple, rational rules can determine the potential outcome of predictable credit events and provide an complete estimation of future cash flows to creditors in all states of the world.

Likewise, a full distribution of future dividends can be derived from the combination of the expected value and volatility of the ESCR (the tendency to meet the base case) throughout the life of the investment.

Blanc-Brude and Hasan (2015) show that documenting ESCRs requires observing realised and base case dividends, as well as expected and realised project status (e.g. dividend lock-up) and milestones (e.g. construction completion).

Hence, the statistical distribution (mean and variance) of cash flows to creditors and equity investors at each point in the life of the investment can be modelled by relying in a limited number of data points, as long as basic information about payment priority, covenants and control-rights are also known.

4. Recent progress: the roadmap

Key data points required to properly document these distributions include:

- base case and revised cash flow forecasts for equity and debt investors;
- actual realised debt service and dividends;
- Key financial ratios, in particular the DSCR, and *the determinants of their distributions*: this requires documenting the factors driving the levels and volatility of these ratios in infrastructure projects, including revenue risk models and other risk-sharing or revenue support mechanisms, financial structure, etc but also jurisdictions, sectors and any other factor which may be included in a model of DSCR and ESCR ratios;
- loan covenants and tail, to estimate the value of embedded options to senior creditors;
- Expected and realised milestones and status of the firm.

The technical implementation of such cash flow models may vary and depends largely on the quantity and quality of data available. Blanc-Brude et al. (2014) and Blanc-Brude and Hasan (2015) provide illustrations of how a limited amount of existing and reasonably standardised data may be used to estimate the expected value and volatility of cash flows to creditors and equity investors in privately-held infrastructure investments. Once this data has been collected, future research can also lead to new cash flows model designs.

4.2.2 Understanding pricing dynamics

Once, the expected value and volatility of cash flows to creditors and investors is known as best as current information allows, the relevant term structure of discount rates needs to estimated to derive past and forward-looking measures of performance, risk and liability-hedging.

Indeed, in light of the perils of using constant discount rates for infrastructure investments discussed above, a *term-structure of expected returns* (discount factors) must be derived.

This is instrumental to:

- measure current asset values and realised performance and build forward-looking measures of performance for asset allocation;
- derive the full (conditional) distribution of expected losses and be in a position to predict VaR or LGD levels for prudential regulation;
- compute duration properly using the correct future discount rates for liability-hedging purposes.

To derive this term structure, two (equivalent) approaches can be used:

1. Factor extraction: for a given future distribution of cash flows (including conditional volatility), a term structure of implied discount rates (required returns) can be derived by observing initial investment values (prices). Ang et al. (2013) use this approach in the case

4. Recent progress: the roadmap

of private equity funds and Blanc-Brude and Hasan (2015) provide an application to infrastructure project equity using a Kalman filter (other techniques are available depending on the quantity and quality of the data).

2. Risk-neutral valuation: given expected cash flows to investors, a new "shifted" distribution of cash flows can be obtained that integrates the (range of) required reward/risk ratio of investors at the time of investment (e.g. basis points per standard deviation of cash flow distribution), that can then be discounted at the relevant risk-free rate. This approach is a standard application of the structural model of credit risk developed by Merton (1974), is described in (Kealhofer, 2003). Blanc-Brude et al. (2014) provide an application to private infrastructure debt that integrates the Black and Cox (1976) framework of structural models allowing for debt restructuring.

Both approaches allow deriving the average required returns of a representative investor but also capturing a range of such values, which is the result of the range of prices (investment values) observed in each period and corresponding to similar cash flow processes (same distributions of DSCR or ESCR)

Thus, initial investment values, which are observable, are required to be collected to implement the first approach, while risk-neutral pricing requires collecting credit spreads to compute the required reward per unit of risk of infrastructure creditors.

As project cash flows are realised and observed, the relevant DSCR/ESCR distributions or buckets can be determined for each investment and realised/expected performance re-assessed, as is the case with public stocks announcing dividends and earnings forecasts.

Of course, once individual debt and equity investments can be priced, they can be combined in series of portfolios representing "infrastructure" and their performance, extreme risk measures and liability-hedging properties can be derived as well.

5. Data collection guidelines

5. Data collection guidelines

5.1 First principles

Our approach to defining the necessary data started with the benchmarking questions that are relevant to investors, regulators and policy-makers, we also aim to follow a number of principles that maximise the chances of success of any data collection effort:

1. The information required should be known to exist in a reasonably standardised format
2. It should be a subset of the information available to investors and creditors either at the moment of the investment or during the monitoring of its financial performance
3. It should only consist of information that is necessary to implement known, robust asset pricing techniques and risk models
4. Given the focus on building portfolios and capturing average effects, data collection should focus on the systematic drivers of risk and performance in privately-held infrastructure investments. Data which is too specific to certain types of infrastructure (say, wind forecast for renewable energy projects) is not relevant to the estimation of volatility of certain cash flow ratios for example.

5.2 Observable data types and attributes

Each investment in private infrastructure debt or equity relates to an individual firm – often a project-specific firm – hence the individual firm is *the relevant level of observation*.

Firms have a name and a location (of their tangible assets), a registration number and other fixed characteristics that make them uniquely identifiable. While this information is not always fully available (e.g. certain data contributors are required by law to anonymise any contributed data) it can also be recouped from multiple sources. It is important to ensure that individual observations are not double-counted or duplicated, hence arriving at unique identifiers for the firm data being collected matters significantly.

A first step consists in the identification of all *investable infrastructure* in a given country, and the attribution of a unique identifier to each firm corresponding to a potential investment in either equity or different kinds of debt. Given this universe of uniquely identified firms a number of other information sources can be used to match source-specific identifiers to the original list of unique firm identifiers, using a series of algorithms or manual data validation procedures.

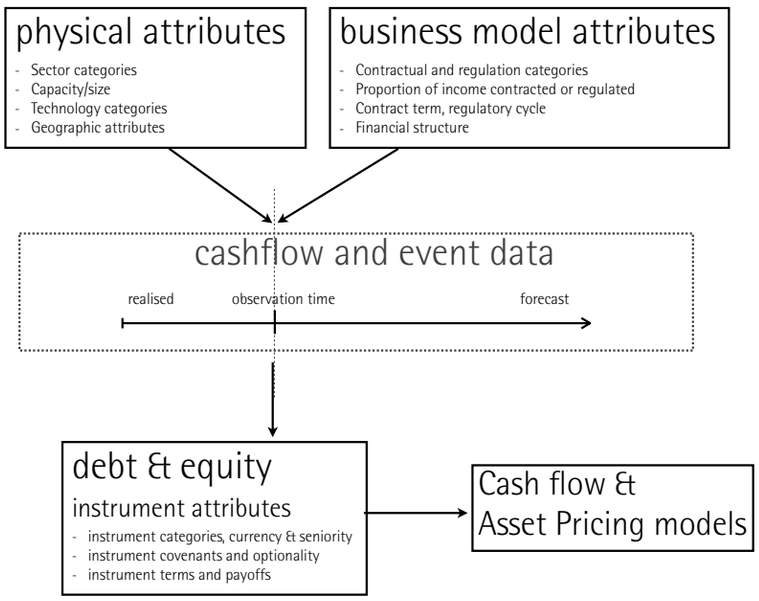
Having crossed-referenced the different available sources, for each identified firm, two **types of observable data** points are of interest:

1. **Cash flows** (and cash flow ratios)
2. **Events** (or milestones) in the development of the firms and, possibly, the evolution of its risk profile

Next, cash flow and event data need to be categorised according to economically

5. Data collection guidelines

Figure 2: Data types and attributes of private infrastructure investments



meaningful *attributes*. These fall into two main categories:

1. **Physical attributes** of the firm: *what* and *where* the firm is as an infrastructure investment
2. **Business model** attributes of the firm: sources of *revenues* and *costs* of the firm and whether or not the risk inherent in these exposures is insured against (transferred) via contracts with third parties.

Finally, the investable character of each firm is represented by a set of **financial instruments** found on the firms' balance sheet (on the liability side). These instruments also have **attributes**: type of payout structure, control rights and terms applicable to the different claimants to the firms' free cash flow.

Figure 2 provides a summarised illustration: the "event" and "cash flow" data of the firm, as well as its attributes and those of its instruments, can be collected at different points in time and may also change each time they are collected.

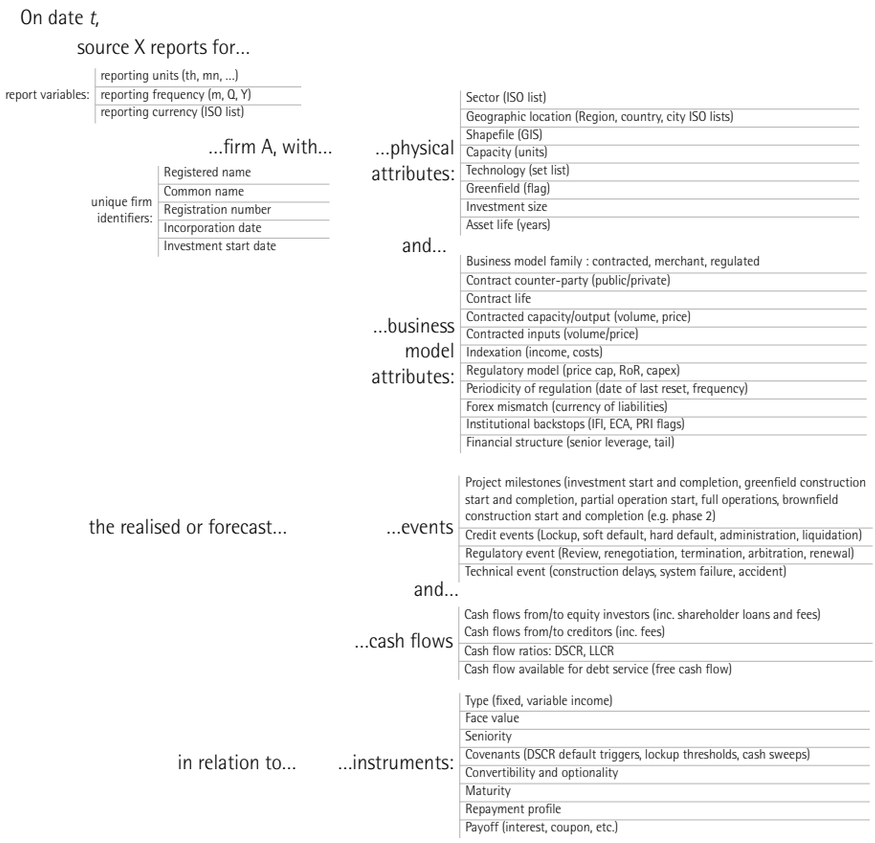
5.3 Dynamically reported data

As proposed above, all relevant observations have to be reported at the firm level; hence, the primary unit of observation is called a **report**, as illustrated by figure 3.

Here, a report simply reflects the fact that some information about a previously identified investable infrastructure firm is reported at some point in time by a given source, and includes information about events or cash flows, or the physical and business model attributes of the firm, or any

5. Data collection guidelines

Figure 3: Data types and attributes of private infrastructure investments



of the relevant financial instruments and what their attributes are **at that time**.

Moreover, at the time of the report, this information can be either realised or predicted. Hence, to ensure consistency between sources and timeframes, each reported data point must be placed on a double time scale: 1/ the time of reporting, and 2/ the reported time of occurrence (which can be in the past, present or future relative to the time of reporting).

Hence, the latest annual accounts report today which cash flows and events occurred last year; likewise, the financial close cash flow model reports which cash flows and events are predicted to occur over the next 25 years, at that point in time.

In other words, all firm and instrument attributes should be reported and recorded dynamically. For instance, a loan may change interest rate over time (and this may be known in advance), or a firm may see it's take-or-pay off-take contract expire before the end of the investment's life.

If this contract expiry date is also known in advance, *future* contract expiration event can be reported, until the event occurs, at which point it becomes a *realised* observation.

5. Data collection guidelines

Capturing realised and forecast changes in time of the attributes of either firms or instruments is of particular importance in the case of infrastructure investments because of the path-dependency and sequential resolution of uncertainty, which characterises these type of investments. For example project debt may change its maturity date post-restructuring, which is instrumental in the context of asset pricing and computing duration.

Importantly, because of the long-term nature and large sunk costs implied by such investments, long-range cash flow projections and detailed financial models are well documented and frequently revised. Hence, all such data points are observable.

The rest of the data collection process flows from the sequencing of individual reports, which are cross-referenced across sources of information, for each identified investable infrastructure firm.

Individual reports can correspond to a single data point, realised or forecast, at one point in time, or to the entire set of accounts of the firm in a given year, or to the base case cash flows corresponding to a single instrument for the next two decades.

This framework is flexible enough all such types of observations.

As table 3 illustrates, each report is made in a given unit, currency and for a given periodicity of the data, allowing future manipulation of any contributed data while ensuring consistency and comparability.

Next, to each report corresponds a detailed set of *physical* and *business model* attributes of the firm, which can be reported again if they change in time. For instance, once the off-take contract of the firm expires (an event), the firm's business model classification can be changed from contracted to merchant (see table in apppendix).

Each report includes either event or cash flow data (or both), according to a **standardised nomenclature** of relevant events (investment milestones, credit, technical and regulatory events) and cash flow items and ratios (equity and debt cash flows) of interest.

Finally, each reported data point and their attributes are related to specific instruments. These instruments have their own attributes, such as loan covenants, which have to be taken into account when calibrating cash flow models and projecting future cash flows for the purpose of asset pricing.

5.4 Data collection guidelines

This framework for collection data about private investment in infrastructure is illustrated in further details in the companion spreadsheet to this paper, which can be downloaded at the address indicated in the footnote. [12]

12 - http://edhec.infrastructure.institute/wp-content/uploads/documents/EDHECinfra_example_template.xlsx

5. Data collection guidelines

Illustrations of required data tables are also provided in the appendix.

Applying the above framework, we propose the following data collection guidelines (which are the building blocks of the companion spreadsheet):

1. Building investment benchmarks of highly illiquid private assets like private infrastructure debt and equity requires collecting data reported at the underlying firm level;
2. These firms should be categorised according to a limited set of 'attributes' which can be expected to *systematically* explain the risk profile of individual investments: not only the variance but, most importantly, the co-variance of cash flows and of returns; these include:
   - Physical attributes: investment size, technology, sector, location, lifecycle stage
   - Business model attributes: nature of income and cost streams, role of contracts and regulation
3. Individual financial instruments used to invest in such firms should also be recorded and documented to be in a position to predict the payoffs to different investors
   - Instruments should be categorised by type of payoff profile (fixed, variable)
   - Any conditions (covenants, embedded options, prepayment) should be documented to properly model the expected payoff to investors
4. The two main types of data to collect relating to the relevant firms and instruments are **standardised events and cash flow items**
   → Firm and instrument attributes are control variables that explain the dynamics of different stream of cash flows to different claimants (investors)
5. Each data point should be reported using a dual timeframe, capturing both the time of observation/reporting and that of occurrence (past, present or future)

Following these guidelines allows creating of a powerful framework for reporting, aggregating and analysing investment data for highly illiquid, private assets for which little transaction data is available, making the use of a combination of cash flow models and discounting models necessary to arrive at fully-fledged performance benchmarks.

6. Conclusion: populating the database

6. Conclusion: populating the database

Data collection and investment benchmarking currently are at the top of the policy agenda, because a number of important questions about asset allocation, prudential regulation and asset-liability management need to be answered effectively and efficiently if infrastructure investment is to become a mainstay of long-term investing.

Today, these questions are very hard to answer given the current state of investment knowledge and a comprehensive effort is required to address this issue.

We have defined a simple roadmap that requires agreeing on clear definitions of underlying assets, building robust, state-of-the-art pricing and risk models that avoid the pitfalls of existing practices (e.g. average IRRs) and go beyond the limitations of existing studies, but are instead designed to deliver risk-adjusted measures of the performance of private infrastructure debt or equity from the perspective of investors, regulators and policy-makers.

To implement such approaches, cash flow and discount rate models can be built, requiring a parsimonious set of data points that can realistically be collected from investors and lenders.

In this paper, we put forward a set of guidelines for collecting this data and propose a template to do so (see companion spreadsheet).

To collect this information and populate a global database of infrastructure investment performance data (the 4th step on the roadmap), large scale cooperation is required between investors and creditors, organisations that can collect this information and the regulators that can help make such reporting part of a new standard approach to long-term investment by institutional players.

The EDHEC Infrastructure Institute is currently engaging with public and private organisations that are willing to help develop this project. By the end of 2016, the EDHEC*infra* database will include more than one thousand individual and uniquely identified infrastructure firms, including cash flow data going back ten to twenty years. The business model and evolution of each firm in this system is described using a standardised set of attributes that are captured as they evolve in time, as described in this paper.

The continued support and involvement and support of public and private contributors to this data collection platform will allow delivering robust investment benchmarks for infrastructure investors and regulators from 2016 and in the years to come.

7. Appendix

7. Appendix

Figure 4: EDHECinfra Data Collection Tables: List of firm attributes

	Basic Firm Attributes	Description
1	Registered Name	official company name
2	Investment Period	time for the investment
3	Asset Life	life of the asset may be different to the investment period
4	Capacity	output or service capacity
	Basic Risk Attributes	**Description**
6	Senior Debt Term	the term of the senior debt
7	InitialSenior Leverage	the initial leverage of the project once debt is fully drawn down
8	ADSCR	the average debt service reserve coverage ratio
9	Contracted Construction Cost	the contracted construction cost
10	Outturn Construction Cost	the actual construction cost
11	Greenfield	whether or not the project is a greenfield development
12	Forex	flag for whether there is a mismatch between debt and earnings
13	Forex Currency	the currency code for the mismatch if it exists
	Business Model Attributes	**Description**
14	Business Model ID	the business model for the project
15	Contracted	flag for whether the project has a contract supporting revenue
16	Public contract	flag for public counterparty
17	Contract Term	The term of the revenue contract
18	Pct Contracted	the proportion of output contracted
19	Pct Indexed	the proportion of the contract that is indexed to inflation
20	Inputs Contracted	flag as to whether the inputs are contracted
21	Tariff Regulated	flag as to whether the tariff is regulated
22	CapexRegulated	flag which indicates whether the capex is regulated
23	Return Regulated	flag indicated if rate of return is regulated
24	Periodic Regulation	flag indicating if there is periodic resets in regulation
25	Frequency Regulation	how many years between regulation resets
26	Last Determination	what year was the last regulatory determination
27	ECA	flag for export credit agency involvement
28	PRI	flag for political risk insurance
29	IFI	flag for development bank involvement
30	Gov Ownership	firm is owned by government in excess of 50 percent
	Covenants	**Description**
32	DSRA proportion	Debt service reserve account or sinking fund with a min amount to be maintained as a proportion of next payment
33	DSRA absolute	Debt service reserve account or sinking fund requiring a minimum an absolute amount to be maintained
34	Sweep proportion	Requirement that a certain proportion of the CFADS be paid to lenders
35	Sweep absolute	Requirement that an absolute value be paid to lenders
36	Refi time limit	Requirement not to refinance a loan before a number of years
37	Refi cap	Requirement not too refinance more than a certain proportion of senior debt
38	Refi penalties	Penalties for prepayment of the senior debt
39	Soft default DSCR	Technical or Basel2 default triggered by breaching a DSCR threshold
40	Soft default EBIT	Technical or Basel2 default triggered by breaching an EBIT or EBITDA/debt threshold
41	Lockup DSCR	Dividend lockup triggered by breaching a DSCR threshold
42	Lockup EBIT	Dividend lockup triggered by breaching an EBIT or EBITDA/debt threshold
43	Soft default construction	Technical default (Basel2) triggered by failure to complete construction on time or budget

7. Appendix

Figure 5: EDHECinfra Data Collection Tables: List of events

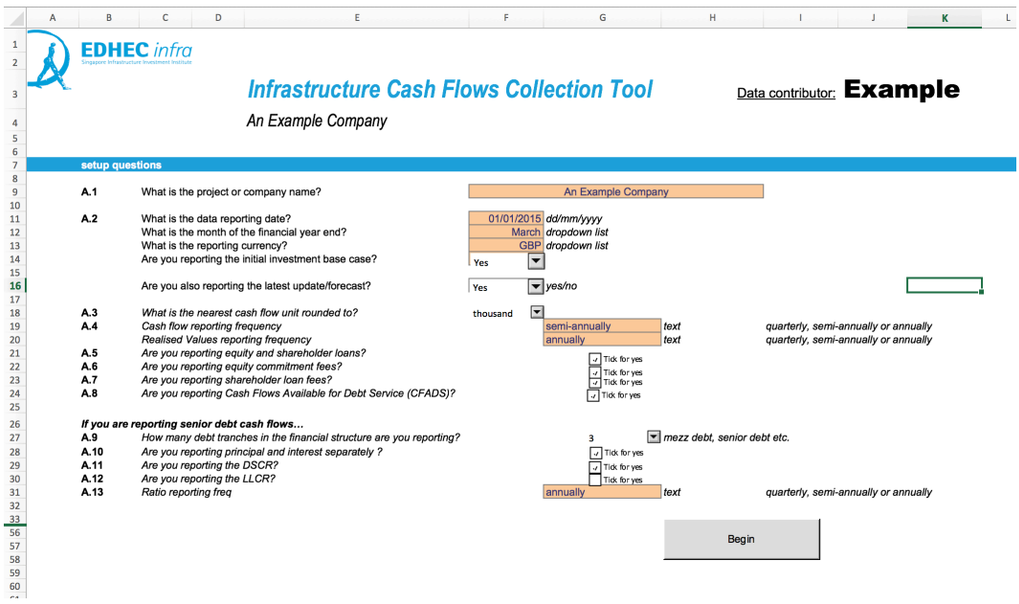
	Bidding event	Description
1	Auction date	Offcial date of auction start
2	BAFO due	Best and final offer
3	Contract award	Contract awarded to sponsor
4	Contract/Concession signing	Contract signed between sponsor/grantor
5	Selection of preferred bidder	Prefered bidders selected
	Credit event	**Description**
6	Administration	the firm is bankrupt
7	Emergence from default	end of default period
8	Emergence from lockup	end of lockup period
9	Hard default	the firm cannot pay its debt and creditors can claim the control of the firm
10	Liquidation	the firm is liquidated/sold
11	Lockup	shareholders are not allowed to disitrbute dividends
12	Prepayment	early repayment of all senior debt
13	Refinancing	New debt facility replaces previous one
14	Soft default	the firm can still pay its debt but creditors can exercise step-in rights
15	Supplier terminates contract	A key supplier to the project either terminates the contract or enters administration impacting on the viability of the project
16	Swap counter party default	The swap counterparty defaults impacting on the debt service of the project
	Legal event	**Description**
17	Litigation against construction company	as a result of the construction company failures the SPV has commenced legal action
18	Litigation against government	as a result of the government changes or non compliance the SPV has commenced legal action
19	Litigation against off taker	as a result of the offtaker non compliance the SPV has commenced legal action
20	Litigation against suppliers	as a result of the supplier non compliance the SPV has commenced legal action
	Milestone	**Description**
21	Brownfield construction completion	Completion of new construction phase in brownfield investment
22	Brownfield constrution start	new construction phase in brownfield investment
23	Full operations begin	project is fully operational
24	Greenfield construction start	breaking ground in greenfield projects
25	Greenfield construction completion	completed greenfield construction
26	Initial investment	date of financial close, acquisition or privatisation
27	Investment end	diverstement or end of the contract (concession)
28	Partial operations start	start of the first phase of operations
	Regulatory event	**Description**
29	Arbitration	dispute resolution through arbitration
30	New off-take contract signed	the spv has signed a new off take agreement
31	Off-take contract expires	the off take contract has expired
32	Penalties	the spv incurs penalties as a result of failure to meet standards
33	Regulatory intervention	The economic regulator has intervened
34	Renegotiation	renegotiation of the original contract
35	Renewal	Renewal of the original contract
36	Review	next regulatory review or determination
37	Termination	termination of the original contract
	Technical event	**Description**
38	Accident	Large accident (eg fire) causing material technical disruption
39	Construction faults discovered	Faults that significantly impact on the cash flows to the project are discovered
40	Construction warranty called	in order to mitigate faults discovered the project calls the warranty protection provided by the EPC
41	Construction delays	Delays in constrution completion
42	Delayed acceptance of facilities	The independent verifier refuses to agree that the facilities are completed
43	Environmental approvals delayed	the project is delayed due to a failure to obtain environmental approvals or the approvals are withdrawn
44	Facilities suffer a catastrophic failure	the facilities are shut down due to a major breakdown in the facilities either as a result of fire etc or construction problems
45	Force majeure	force majeure is called in the contract
46	Insurance claim for construction faults	to cover construction faults insurance policies are called
47	Liquidated damages	construction delays have resulted in liquiditated damages being enforced
48	System failure	Technical failure causing material technical disruption

7. Appendix

Figure 6: EDHECinfra Data Collection Tables: List of instrument attributes

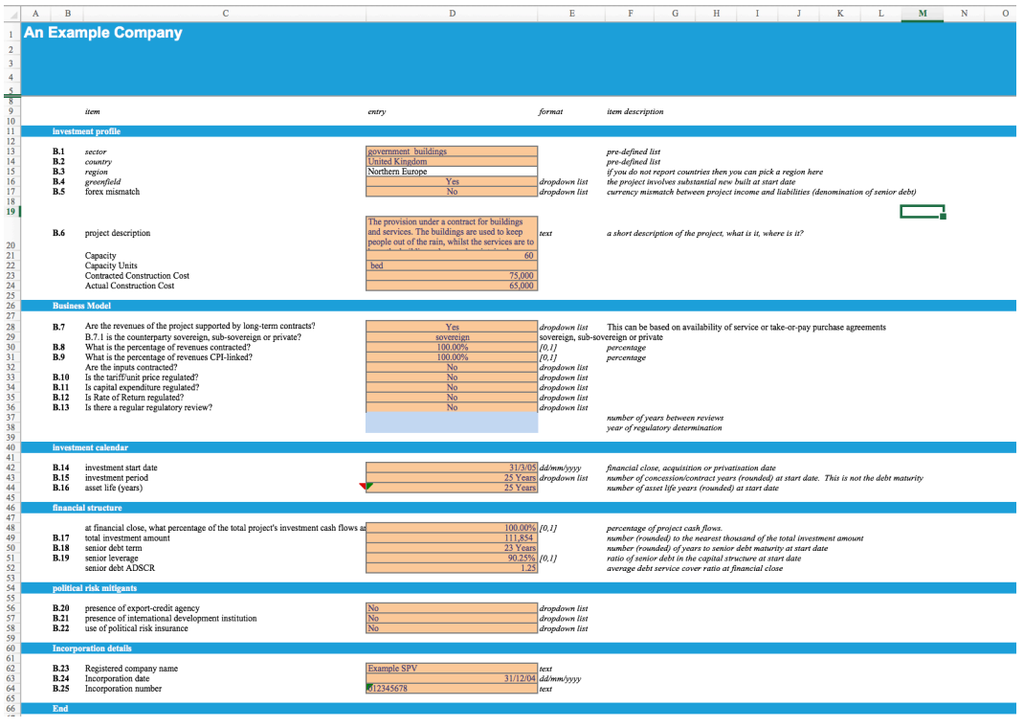
	InstrumentAttribute	Description
1	Seniority	The seniority of the debt instrument
2	Currency	The currency of the instrument
3	Ammortisation	The ammortisation profile of the instrument
4	Face Value	The face value of the instrument
5	Effective Rate	The effective interest rate of the instrument
6	Benchmark Rate	The benchmark rate of the instrument
7	Credit Spread	The credit spread above the benchmark rate of the instrument
8	Final Maturity	The final maturity date of the instrument
9	Facility Limit	The facility limit of the instrument
10	Repayment Freq	The repayment frequency of the instrument

Figure 7: EDHECinfra Data Collection Tool: initial setup



7. Appendix

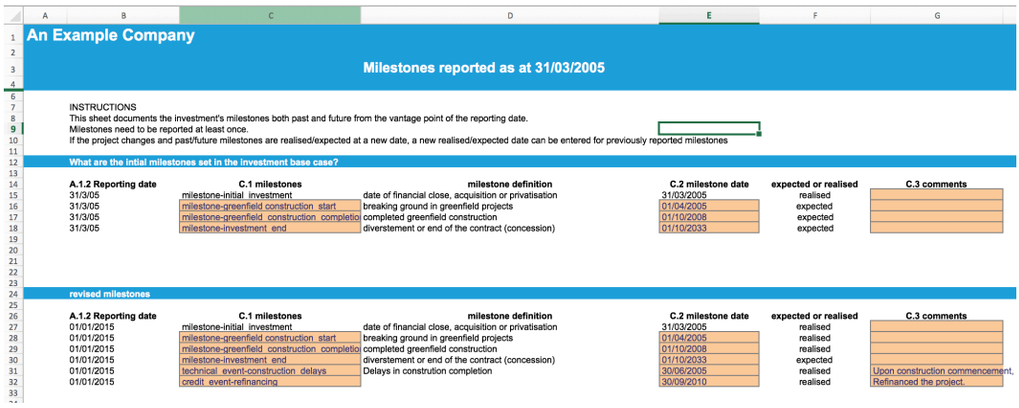
Figure 8: EDHECinfra Data Collection Tool: company entry information



An Example Company

	item	entry	format	item description
investment profile				
B.1	sector	government_buildings		pre-defined list
B.2	country	United Kingdom		pre-defined list
B.3	region	Northern Europe		if you do not report countries then you can pick a region here
B.4	greenfield	Yes	dropdown list	the project involves substantial new built at start date
B.5	forex mismatch	No	dropdown list	currency mismatch between project income and liabilities (denomination of senior debt)
B.6	project description	The provision under a contract for buildings and services. The buildings are used to keep people out of the rain, whilst the services are to	text	a short description of the project, what is it, where is it?
	Capacity	60		
	Capacity Units	bed		
	Contracted Construction Cost	75,000		
	Actual Construction Cost	65,000		
Business Model				
B.7	Are the revenues of the project supported by long-term contracts?	Yes	dropdown list	This can be based on availability of service or take-or-pay purchase agreements
	B.7.1 is the counterparty sovereign, sub-sovereign or private?	sovereign	sovereign, sub-sovereign or private	
B.8	What is the percentage of revenues contracted?	100.00%	[0,1]	percentage
B.9	What is the percentage of revenues CPI-linked?	100.00%	[0,1]	percentage
	Are the inputs contracted?	No	dropdown list	
B.10	Is the tariff/unit price regulated?	No	dropdown list	
B.11	Is capital expenditure regulated?	No	dropdown list	
B.12	Is Rate of Return regulated?	No	dropdown list	
B.13	Is there a regular regulatory review?	No	dropdown list	
				number of years between reviews
				year of regulatory determination
investment calendar				
B.14	investment start date	31/3/05	dd/mm/yyyy	financial close, acquisition or privatisation date
B.15	investment period	25 Years	dropdown list	number of concession/contract years (rounded) at start date. This is not the debt maturity
B.16	asset life (years)	25 Years		number of asset life years (rounded) at start date
financial structure				
	at financial close, what percentage of the total project's investment cash flows ar	100.00%	[0,1]	percentage of project cash flows.
B.17	total investment amount	111,854		number (rounded) to the nearest thousand of the total investment amount
B.18	senior debt term	23 Years		number (rounded) of years to senior debt maturity at start date
B.19	senior leverage	90.25%	[0,1]	ratio of senior debt in the capital structure at start date
	senior debt ADSCR	1.25		average debt service cover ratio at financial close
political risk mitigants				
B.20	presence of export-credit agency	No	dropdown list	
B.21	presence of international development institution	No	dropdown list	
B.22	use of political risk insurance	No	dropdown list	
Incorporation details				
B.23	Registered company name	Example SPV	text	
B.24	Incorporation date	31/12/04	dd/mm/yyyy	
B.25	Incorporation number	12345678	text	
End				

Figure 9: EDHECinfra Data Collection Tool: events



An Example Company

Milestones reported as at 31/03/2005

INSTRUCTIONS
This sheet documents the investment's milestones both past and future from the vantage point of the reporting date.
Milestones need to be reported at least once.
If the project changes and past/future milestones are realised/expected at a new date, a new realised/expected date can be entered for previously reported milestones

What are the intial milestones set in the investment base case?

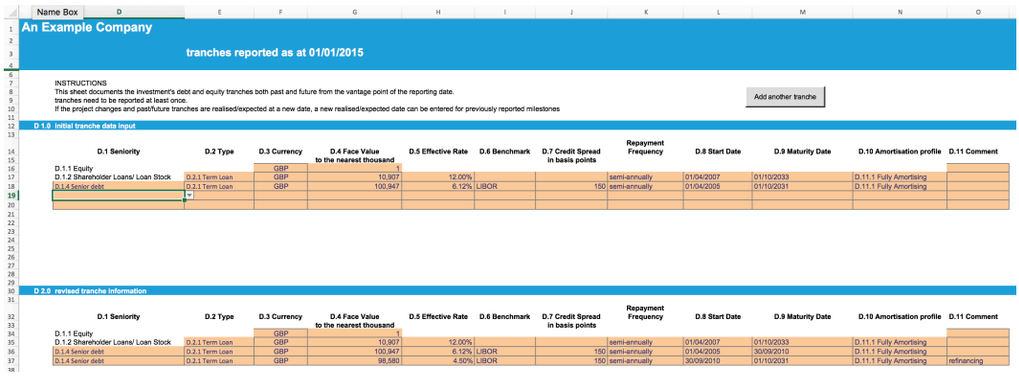
A.1.2 Reporting date	C.1 milestones	milestone definition	C.2 milestone date	expected or realised	C.3 comments
31/3/05	milestone-initial_investment	date of financial close, acquisition or privatisation	31/03/2005	realised	
31/3/05	milestone-greenfield_construction_start	breaking ground in greenfield projects	01/04/2005	expected	
31/3/05	milestone-greenfield_construction_completio	completed greenfield construction	01/10/2008	expected	
31/3/05	milestone-investment_end	diverstement or end of the contract (concession)	01/10/2033	expected	

revised milestones

A.1.2 Reporting date	C.1 milestones	milestone definition	C.2 milestone date	expected or realised	C.3 comments
01/01/2015	milestone-initial_investment	date of financial close, acquisition or privatisation	31/03/2005	realised	
01/01/2015	milestone-greenfield_construction_start	breaking ground in greenfield projects	01/04/2005	realised	
01/01/2015	milestone-greenfield_construction_completio	completed greenfield construction	01/10/2008	realised	
01/01/2015	milestone-investment_end	diverstement or end of the contract (concession)	01/10/2033	expected	
01/01/2015	technical_event-construction_delays	Delays in constrution completion	30/06/2005	realised	Upon construction commencement,
01/01/2015	credit_event-refinancing		30/09/2010	realised	Refinanced the project.

7. Appendix

Figure 10: EDHECinfra Data Collection Tool: financial structure



An Example Company

tranches reported as at 01/01/2015

INSTRUCTIONS
This sheet documents the investment's debt and equity tranches both past and future from the vantage point of the reporting date.
tranches need to be reported at least once.
If the project changes and past/future tranches are realised/expected at a new date, a new realised/expected date can be entered for previously reported milestones

Add another tranche

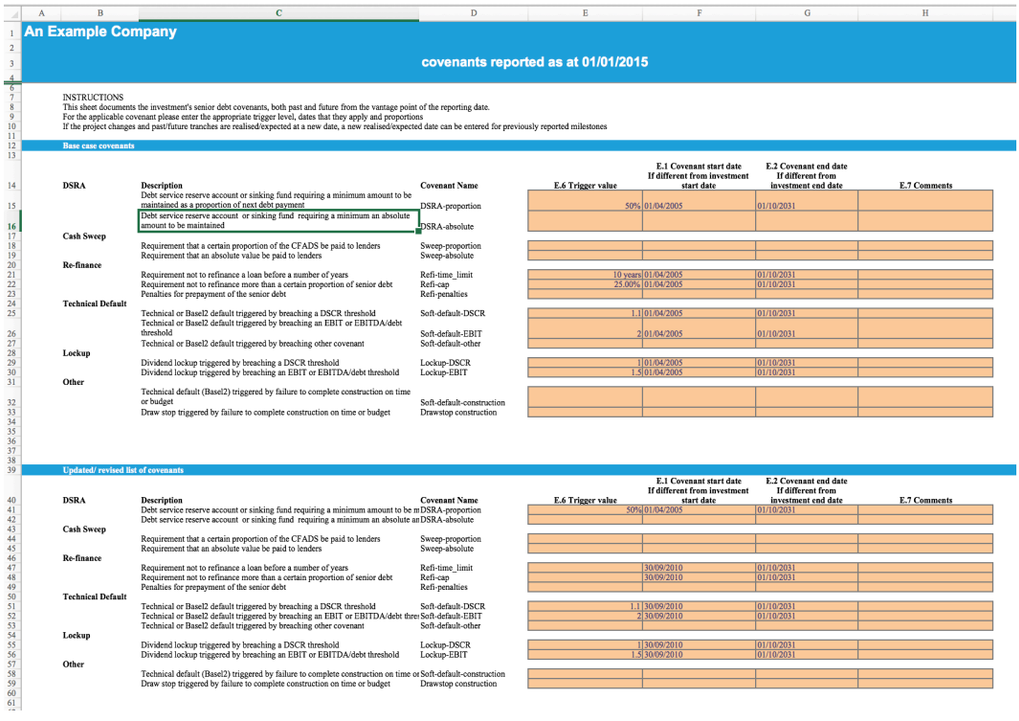
D 1.0 Initial tranche data input

D.1 Seniority	D.2 Type	D.3 Currency	D.4 Face Value to the nearest thousand	D.5 Effective Rate	D.6 Benchmark	D.7 Credit Spread in basis points	Repayment Frequency	D.8 Start Date	D.9 Maturity Date	D.10 Amortisation profile	D.11 Comment
D.1.1 Equity		GBP	1								
D.1.2 Shareholder Loans/ Loan Stock	D.2.1 Term Loan	GBP	10,907	12.00%			semi-annually	01/04/2007	01/10/2033	D.11.1 Fully Amortising	
D.1.4 Senior debt	D.2.1 Term Loan	GBP	100,947	6.12%	LIBOR	150	semi-annually	01/04/2005	01/10/2031	D.11.1 Fully Amortising	

D 2.0 revised tranche information

D.1 Seniority	D.2 Type	D.3 Currency	D.4 Face Value to the nearest thousand	D.5 Effective Rate	D.6 Benchmark	D.7 Credit Spread in basis points	Repayment Frequency	D.8 Start Date	D.9 Maturity Date	D.10 Amortisation profile	D.11 Comment
D.1.1 Equity		GBP	1								
D.1.2 Shareholder Loans/ Loan Stock	D.2.1 Term Loan	GBP	10,907	12.00%			semi-annually	01/04/2007	01/10/2033	D.11.1 Fully Amortising	
D.1.4 Senior debt	D.2.1 Term Loan	GBP	100,947	6.12%	LIBOR	150	semi-annually	01/04/2005	30/09/2010	D.11.1 Fully Amortising	
D.1.4 Senior debt	D.2.1 Term Loan	GBP	98,580	4.50%	LIBOR	150	semi-annually	30/09/2010	01/10/2031	D.11.1 Fully Amortising	refinancing

Figure 11: EDHECinfra Data Collection Tool: covenants



An Example Company

covenants reported as at 01/01/2015

INSTRUCTIONS
This sheet documents the investment's senior debt covenants, both past and future from the vantage point of the reporting date.
For the applicable covenant please enter the appropriate trigger level, dates that they apply and proportions
If the project changes and past/future tranches are realised/expected at a new date, a new realised/expected date can be entered for previously reported milestones

Base case covenants

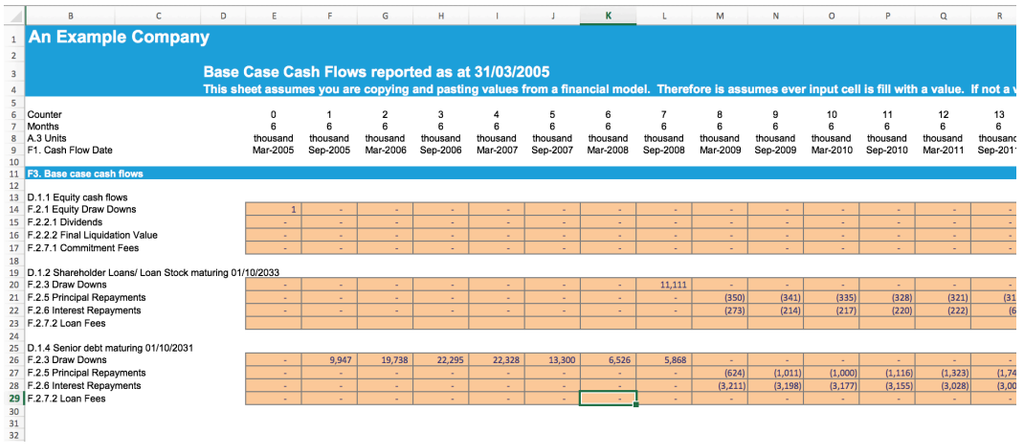
	Description	Covenant Name	E.6 Trigger value	E.1 Covenant start date If different from investment start date	E.2 Covenant end date If different from investment end date	E.7 Comments
DSRA	Debt service reserve account or sinking fund requiring a minimum amount to be maintained as a proportion of next debt payment	DSRA-proportion	50%	01/04/2005	01/10/2031	
	Debt service reserve account or sinking fund requiring a minimum an absolute amount to be maintained	DSRA-absolute				
Cash Sweep	Requirement that a certain proportion of the CFADS be paid to lenders	Sweep-proportion				
	Requirement that an absolute value be paid to lenders	Sweep-absolute				
Re-finance	Requirement not to refinance a loan before a number of years	Refi-time_limit	10 years	01/04/2005	01/10/2031	
	Requirement not to refinance more than a certain proportion of senior debt	Refi-cap	25.00%	01/04/2005	01/10/2031	
	Penalties for prepayment of the senior debt	Refi-penalties				
Technical Default	Technical or Basel2 default triggered by breaching a DSCR threshold	Soft-default-DSCR	1.1	01/04/2005	01/10/2031	
	Technical or Basel2 default triggered by breaching an EBIT or EBITDA/debt threshold	Soft-default-EBIT	2	01/04/2005	01/10/2031	
	Technical or Basel2 default triggered by breaching other covenant	Soft-default-other				
Lockup	Dividend lockup triggered by breaching a DSCR threshold	Lockup-DSCR	1	01/04/2005	01/10/2031	
	Dividend lockup triggered by breaching an EBIT or EBITDA/debt threshold	Lockup-EBIT	1.5	01/04/2005	01/10/2031	
Other	Technical default (Basel2) triggered by failure to complete construction on time or budget	Soft-default-construction				
	Draw stop triggered by failure to complete construction on time or budget	Drawstop construction				

Updated/ revised list of covenants

	Description	Covenant Name	E.6 Trigger value	E.1 Covenant start date If different from investment start date	E.2 Covenant end date If different from investment end date	E.7 Comments
DSRA	Debt service reserve account or sinking fund requiring a minimum amount to be m	DSRA-proportion	50%	01/04/2005	01/10/2031	
	Debt service reserve account or sinking fund requiring a minimum an absolute an	DSRA-absolute				
Cash Sweep	Requirement that a certain proportion of the CFADS be paid to lenders	Sweep-proportion				
	Requirement that an absolute value be paid to lenders	Sweep-absolute				
Re-finance	Requirement not to refinance a loan before a number of years	Refi-time_limit		30/09/2010	01/10/2031	
	Requirement not to refinance more than a certain proportion of senior debt	Refi-cap		30/09/2010	01/10/2031	
	Penalties for prepayment of the senior debt	Refi-penalties				
Technical Default	Technical or Basel2 default triggered by breaching a DSCR threshold	Soft-default-DSCR	1.1	30/09/2010	01/10/2031	
	Technical or Basel2 default triggered by breaching an EBIT or EBITDA/debt thres	Soft-default-EBIT	2	30/09/2010	01/10/2031	
	Technical or Basel2 default triggered by breaching other covenant	Soft-default-other				
Lockup	Dividend lockup triggered by breaching a DSCR threshold	Lockup-DSCR	1	30/09/2010	01/10/2031	
	Dividend lockup triggered by breaching an EBIT or EBITDA/debt threshold	Lockup-EBIT	1.5	30/09/2010	01/10/2031	
Other	Technical default (Basel2) triggered by failure to complete construction on time or	Soft-default-construction				
	Draw stop triggered by failure to complete construction on time or budget	Drawstop construction				

7. Appendix

Figure 12: EDHECinfra Data Collection Tables: base case or forecast cash flows



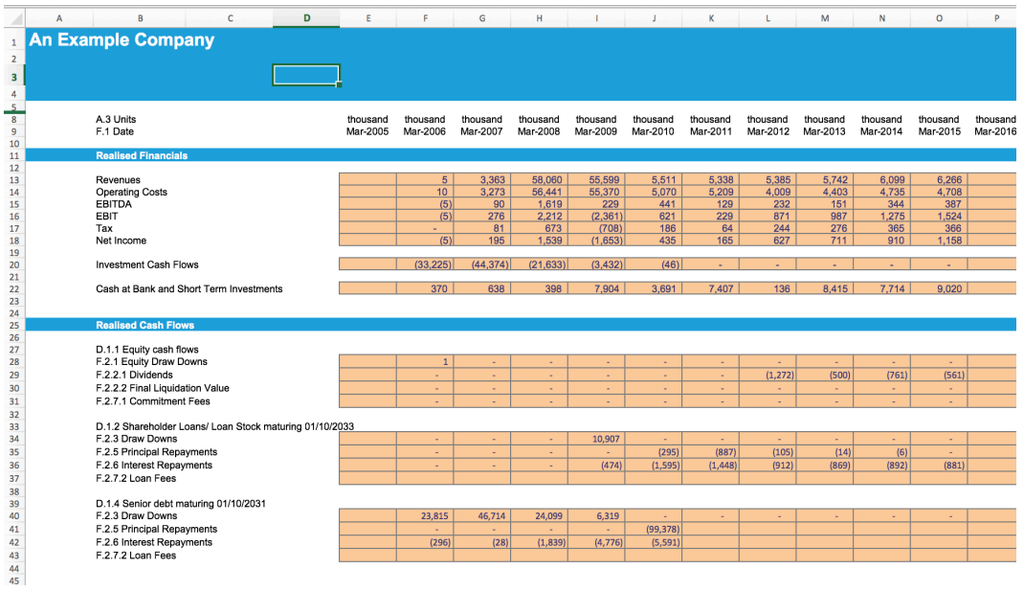
An Example Company

Base Case Cash Flows reported as at 31/03/2005

This sheet assumes you are copying and pasting values from a financial model. Therefore is assumes ever input cell is fill with a value. If not a v

Counter	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Months	6	6	6	6	6	6	6	6	6	6	6	6	6	6
A.3 Units	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousanc
F1. Cash Flow Date	Mar-2005	Sep-2005	Mar-2006	Sep-2006	Mar-2007	Sep-2007	Mar-2008	Sep-2008	Mar-2009	Sep-2009	Mar-2010	Sep-2010	Mar-2011	Sep-201
F3. Base case cash flows														
D.1.1 Equity cash flows														
F.2.1 Equity Draw Downs	1	-	-	-	-	-	-	-	-	-	-	-	-	-
F.2.2.1 Dividends	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F.2.2.2 Final Liquidation Value	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F.2.7.1 Commitment Fees	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D.1.2 Shareholder Loans/ Loan Stock maturing 01/10/2033														
F.2.3 Draw Downs	-	-	-	-	-	-	-	11,111	-	-	-	-	-	-
F.2.5 Principal Repayments	-	-	-	-	-	-	-	-	(350)	(341)	(335)	(328)	(321)	(31
F.2.6 Interest Repayments	-	-	-	-	-	-	-	-	(273)	(214)	(217)	(220)	(222)	(6
F.2.7.2 Loan Fees														
D.1.4 Senior debt maturing 01/10/2031														
F.2.3 Draw Downs	-	9,947	19,738	22,295	22,328	13,300	6,526	5,868	-	-	-	-	-	-
F.2.5 Principal Repayments	-	-	-	-	-	-	-	-	(624)	(1,011)	(1,000)	(1,116)	(1,323)	(1,74
F.2.6 Interest Repayments	-	-	-	-	-	-	-	-	(3,211)	(3,198)	(3,177)	(3,155)	(3,028)	(3,00
F.2.7.2 Loan Fees	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 13: EDHECinfra Data Collection Tables: realised cash flows



An Example Company

A.3 Units	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand	thousand
F.1 Date	Mar-2005	Mar-2006	Mar-2007	Mar-2008	Mar-2009	Mar-2010	Mar-2011	Mar-2012	Mar-2013	Mar-2014	Mar-2015	Mar-2016
Realised Financials												
Revenues		5	3,363	58,060	55,599	5,511	5,338	5,385	5,742	6,099	6,266	
Operating Costs		10	3,273	56,441	55,370	5,070	5,209	4,009	4,403	4,735	4,708	
EBITDA		(5)	90	1,619	229	441	129	232	151	344	387	
EBIT		(5)	276	2,212	(2,361)	621	229	871	987	1,275	1,524	
Tax		-	81	673	(708)	186	64	244	276	365	366	
Net Income		(5)	195	1,539	(1,653)	435	165	627	711	910	1,158	
Investment Cash Flows		(33,225)	(44,374)	(21,633)	(3,432)	(46)	-	-	-	-	-	
Cash at Bank and Short Term Investments		370	638	398	7,904	3,691	7,407	136	8,415	7,714	9,020	
Realised Cash Flows												
D.1.1 Equity cash flows												
F.2.1 Equity Draw Downs		1	-	-	-	-	-	-	-	-	-	
F.2.2.1 Dividends		-	-	-	-	-	-	(1,272)	(500)	(761)	(561)	
F.2.2.2 Final Liquidation Value		-	-	-	-	-	-	-	-	-	-	
F.2.7.1 Commitment Fees		-	-	-	-	-	-	-	-	-	-	
D.1.2 Shareholder Loans/ Loan Stock maturing 01/10/2033												
F.2.3 Draw Downs		-	-	-	10,907	-	-	-	-	-	-	
F.2.5 Principal Repayments		-	-	-	-	(295)	(887)	(105)	(14)	(6)	-	
F.2.6 Interest Repayments		-	-	-	(474)	(1,595)	(1,448)	(912)	(869)	(892)	(881)	
F.2.7.2 Loan Fees												
D.1.4 Senior debt maturing 01/10/2031												
F.2.3 Draw Downs		23,815	46,714	24,099	6,319	-	-	-	-	-	-	
F.2.5 Principal Repayments		-	-	-	-	(99,378)						
F.2.6 Interest Repayments		(296)	(28)	(1,839)	(4,776)	(5,591)						
F.2.7.2 Loan Fees												

7. Appendix

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About the EDHEC Infrastructure Institute-Singapore

About the EDHEC Infrastructure Institute-Singapore

EDHEC*infra* addresses the profound knowledge gap faced by infrastructure investors by collecting and standardising private investment and cash flow data and running state-of-the-art asset pricing and risk models to create the performance benchmarks that are needed for asset allocation, prudential regulation and the design of new infrastructure investment solutions.

A Profound Knowledge Gap

Institutional investors have set their sights on private investment in infrastructure equity and debt as a potential avenue towards better diversification, improved liability-hedging and reduced drawdown risk.

Capturing these benefits, however, requires answering a number of difficult questions:

1. **Risk-adjusted performance measures** are needed to inform strategic asset allocation decisions and monitoring performance;
2. **Duration and inflation hedging properties** are required to understand the liability-friendliness of infrastructure assets;
3. **Extreme risk measures** are in demand from prudential regulators amongst others.

Today none of these metrics is documented in a robust manner, if at all, for investors in privately-held infrastructure equity or debt. This has left investors frustrated by an apparent lack of adequate investment solutions in infrastructure. At the same time, policy-makers have begun calling for a widespread effort to channel long-term savings into capital projects that could support long-term growth.

To fill this knowledge gap, EDHEC has launched a new research platform, EDHEC*infra*, to collect, standardise and produce investment performance data for infrastructure equity and debt investors.

Mission Statement

Our objective is the creation a global repository of financial knowledge and investment benchmarks about infrastructure equity and debt investment, with a focus on delivering useful applied research in finance for investors in infrastructure.

We aim to deliver the best available estimates of financial performance and risks of reference portfolios of privately-held infrastructure investments, and to provide investors with important insights about their strategic asset allocation choices to infrastructure, as well as support the adequate calibration of the relevant prudential frameworks.

We are developing unparalleled access to the financial data of infrastructure projects and firms, especially private data that is either unavailable to market participants or cumbersome and difficult to collect and aggregate.

We also bring advanced asset pricing and risk measurement technology designed to answer investors' information needs about long-term investment in privately-held infrastructure, from asset allocation to prudential regulation and performance attribution and monitoring.

What We Do

The EDHECinfra team is focused on three key tasks:

1. **Data collection and analysis**: we collect, clean and analyse the private infrastructure investment data of the project's data contributors as well as from other sources, and input it into EDHECinfra's unique database of infrastructure equity and debt investments and cash flows. We also develop data collection and reporting standards that can be used to make data collection

About the EDHEC Infrastructure Institute-Singapore

more efficient and reporting more transparent.
This database already covers 15 years of data and hundreds of investments and, as such, is already the largest dedicated database of infrastructure investment information available.

2. **Cash flow and discount rate models**: Using this extensive and growing database, we implement and continue to develop the technology developed at EDHEC-Risk Institute to model the cash flow and discount rate dynamics of private infrastructure equity and debt investments and derive a series of risk and performance measures that can actually help answer the questions that matter for investors.

3. **Building reference portfolios of infrastructure investments**: Using the performance results from our asset pricing and risk models, we can report the portfolio-level performance of groups of infrastructure equity or debt investments using categorisations (e.g. greenfield vs brownfield) that are most relevant for investors' investment decisions.

Partners of EDHEC*infra*

Monetary Authority of Singapore

In October 2015, the Deputy Prime Minister of Singapore, Tharman Shanmugaratnam, announced officially at the World Bank Infrastructure Summit that EDHEC would work in Singapore to create "usable benchmarks for infrastructure investors."

The Monetary Authority of Singapore is supporting the work of the EDHEC Singapore Infrastructure Investment Institute (EDHEC infra) with a five-year research development grant.

Sponsored Research Chairs

Since 2012, private sector sponsors have been supporting research on infrastructure investment at EDHEC with several research Chairs that are now under the EDHEC Infrastructure Investment Institute:

1. The EDHEC/NATIXIS Research Chair on the Investment and Governance Characteristics of Infrastructure Debt Instruments, 2012-2015
2. The EDHEC/Meridiam/Campbell Lutyens Research Chair on Infrastructure Equity Investment Management and Benchmarking, 2013-2016
3. The EDHEC/NATIXIS Research Chair on Infrastructure Debt Benchmarking, 2015-2018
4. The EDHEC/Long-Term Infrastructure Investor Association Research Chair on Infrastructure Equity Benchmarking, 2016-2019
5. The EDHEC/Global Infrastructure Hub Survey of Infrastructure Investors' Perceptions and Expectations, 2016

Partner Organisations

As well as our Research Chair Sponsors, numerous organisation have already recognised the value of this project and have joined or are committed to join the data collection effort. They include:

- The European Investment Bank;
- The World Bank Group;
- The European Bank for Reconstruction and Development;
- The members of the Long-Term Infrastructure Investor Association;

About the EDHEC Infrastructure Institute-Singapore

- Over 20 other North American, European and Australasian investors and infrastructure managers.

EDHEC*infra* is also :

- A member of the Advisory Council of the World Bank's Global Infrastructure Facility
- An honorary member of the Long-term Infrastructure Investor Association

Origins and Recent Achievements

In 2012, EDHEC-Risk Institute created a thematic research program on infrastructure investment and established two Research Chairs dedicated to long-term investment in infrastructure equity and debt, respectively, with the active support of the private sector.

Since then, infrastructure investment research at EDHEC has led to more than 20 academic publications and as many trade press articles, a book on infrastructure asset valuation, more than 30 industry and academic presentations, more than 200 mentions in the press and the creation of an executive course on infrastructure investment and benchmarking.

Testament to the quality of its contributions to this debate, EDHEC infra's research team has been regularly invited to contribute to high-level fora on the subject, including G20 meetings.

Likewise, active contributions were made to the regulatory debate, in particular directly supporting the adaptation of the Solvency-2 framework to long-term investments in infrastructure.

This work has contributed to growing the limited stock of investment knowledge in the infrastructure space.

Significant **empirical findings** already include:

- The first empirical estimates of construction risk for equity and debt investors in infrastructure project finance;
- The only empirical tests of the statistical determinants of credit spreads in infrastructure debt since 2008, allowing controlling for the impact of market liquidity and isolating underlying risk factors;
- The first empirical evidence of the diversification benefits of investing in greenfield and brownfield assets, driven by the dynamic risk and correlation profile of infrastructure investments over their lifecycle;
- The first empirical documentation of the relationship between debt service cover ratios, distance to default and expected default frequencies;
- The first measures of the impact of embedded options in senior infrastructure debt on expected recovery, extreme risk and duration measures;
- The first empirically documented study of cash flow volatility and correlations in underlying infrastructure investment using a large sample of collected data covering the past fifteen years.

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Key **methodological advances** include:

- A series of Bayesian approaches to modelling cash flows in long-term investment projects including predicting the trajectory of key cash flow ratios in a mean/variance plane;
- The first fully-fledged structural credit risk model of infrastructure project finance debt;
- A robust framework to extract the term structure of expected returns (discount rates) in private infrastructure investments using conditional volatility and initial investment values to filter implied required returns and their range at one point in time across heterogenous investors.

Recent **contributions to the regulatory debate** include:

- A parsimonious data collection template to develop a global database of infrastructure project cash flows;
- Empirical contributions to adapt prudential regulation for long-term investors.

About the EDHEC Infrastructure Institute-Singapore

Infrastructure Research Publications at EDHEC

Infrastructure Research Publications at EDHEC

EDHEC Publications

- Blanc-Brude, F., T. Whittaker and M. Hasan. Cash Flow Dynamics of Private Infrastructure Debt (March 2016).
- Blanc-Brude, F., T. Whittaker and M. Hasan. Revenues and Dividend Payouts in Privately-Held Infrastructure Investments (March 2016).
- Blanc-Brude, F., and M. Hasan. The Valuation of Privately-Held Infrastructure Equity Investments (January 2015).
- Blanc-Brude, F., M. Hasan and O.R.H. Ismail. Performance and Valuation of Private Infrastructure Debt (July 2014).
- Blanc-Brude, F., Benchmarking Long-Term Investment in Infrastructure (June 2014).
- Blanc-Brude, F., and D. Makovsek. How Much Construction Risk do Sponsors take in Project Finance. (August 2014).
- Blanc-Brude, F. and O.R.H. Ismail. Who is afraid of construction risk? (March 2013)
- Blanc-Brude, F. Towards efficient benchmarks for infrastructure equity investments (January 2013).
- Blanc-Brude, F. Pension fund investment in social infrastructure (February 2012).

Books

- Blanc-Brude, F. and M. Hasan, Valuation and Financial Performance of Privately-Held Infrastructure Investments. London: PEI Media, Mar. 2015.

Peer-Reviewed Publications

- F. Blanc-Brude, S. Wilde, and T. Witthaker, "Looking for an infrastructure asset class Definition and mean-variance spanning of listed infrastructure equity proxies", 2016 (*forthcoming*)
- Blanc-Brude, F., M. Hasan, and T. Witthaker, "Benchmarking Infrastructure Project Finance - Objectives, Roadmap and Recent Progress", Journal of Alternative Investments, 2016 (*forthcoming*)
- R. Bianchi, M. Drew, E. Roca and T. Whittaker, "Risk factors in Australian bond returns", Accounting & Finance, 2015

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- Blanc-Brude, F. "Long-term investment in infrastructure and the demand for benchmarks," JASSA The Finsia Journal of Applied Finance, vol. 3, pp. 57–65, 2014.
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- Blanc-Brude, F. , H. Goldsmith, and T. Valila, "A comparison of construction contract prices for tradition- ally procured roads and public–private partnerships," Review of Industrial Organization, vol. 35, no. 1-2, pp. 19–40, 2009, ISSN: 0889-938X. DOI: 10.1007/s11151-009-9224-1.
- Blanc-Brude, F. , H. Goldsmith, and T. Valila, "Public-private partnerships in europe: an update," EIB Economic & Financial Reports, p. 24, 2007.
- Blanc-Brude, F. and R. Strange, "How banks price loans to public-private partnerships: evidence from the european markets," Journal of Applied Corporate Finance, vol. 19, no. 4, pp. 94–106, 2007.
- Blanc-Brude, F. , H. Goldsmith, and T. Valila, "Ex ante construction costs in the european road sector: a comparison of public-private partnerships and traditional public procurement," EIB Economic & Financial Reports, vol. 2006/1, 2006.
- O. Jensen and F. Blanc-Brude, "The handshake: why do governments and firms sign private sector participation deals? evidence from the water and sanitation sector in developing countries," World Bank Working Papers, Wold Bank Working Paper Series, no. October 2005, p. 25, 2006.

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