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Towards a Scientific Approach to ESG for Infrastructure Investors

Approaching ESG & Infrastructure Within the Portfolio

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This paper explores the role of environmental, social and governance (ESG) issues in an investment context, namely how institutional investors should incorporate ESG elements into the financial management of their portfolios. A growing number of investors are pursuing ESG objectives to directly improve environmental and social outcomes, either to satisfy mandates from their members or to conform to the expectations of society. This is increasingly the case even though these organisations have primarily been created to deliver investment outcomes, in particular retirement income. Consequently, investors may wish to exclude certain types of assets from their universe such as coal-fired power plants or projects mired in social controversy. However, regardless of motivation, ESG-related decision making will have a financial impact on portfolio performance. It is this area that we investigate here - the role of ESG *within* an infrastructure portfolio from a strictly financial standpoint.

Thus we address the following question: **How should we gauge the relationship between ESG and the market value of infrastructure investments?** This is a key question that institutional investors and prudential regulators need answered in order to integrate ESG into their financial decision-making process, e.g. to assess sustainability risks under the Sustainable Finance Disclosure Regulation of the European Union (SFDR).

We review existing ESG reporting and assessment schemes used in the infrastructure sector and find that they are not designed to answer this question, but can provide a basis for a robust scientific framework that would create genuine ESG investment knowledge.

ESG reporting and investors' demand for monitoring

As stated, many investors now include non-financial aspirations in their mandates and mission statements, in which ESG reporting plays a growing role. Beyond the affirmation and realisation of such non-financial objectives, ESG reporting and assessment schemes on infrastructure assets have also developed in a financial context. This is a response to an increasing *demand for monitoring* from investors (Holmström et al., 1993) who need more information than what can be gleaned from the market price of assets to make investment decisions.

There are three motivations for this fast growing interest in the ESG characteristics of infrastructure investments:

- The fact that these characteristics have known consequences on the present value of investments e.g. an infrastructure that pollutes will be fined in most jurisdictions. This knowledge is priced by investors and already reflected in asset values;
- The belief that the ESG characteristics, while they are not currently priced by markets or regulators (i.e. economic externalities), are likely to become priced. In other words, conditional on certain regulatory changes such as a carbon tax or systematic changes of attitude amongst consumers, etc., the present value of infras-

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tructure investments is also a function of their ESG characteristics. The deeper the knowledge about how exposed infrastructure investments might be, the more ESG characteristics can be reflected in asset prices;

- The aim to 'do good' and meet non-financial objectives irrespective of their impact on asset values. This could include excluding certain countries, sectors or assets from a portfolio, irrespective of the likelihood of an impact on asset values or its potential magnitude.

These motives are not exclusive, but they are different in nature. The first two are concerned with the relationship between ESG and investment outcomes, whereas the third motive requires investors to implement non-financial objectives, that is, it imposes constraints on their ability to meet financial objectives. This choice of constraints, while it can be popular and laudable, is necessarily *ad hoc* and does not help investors to understand how to utilise ESG characteristics to meet their financial objectives.

Investors' motives should not be confused or equated with those of public policy bodies such as the European Commission. Policy makers are primarily concerned with public policy objectives e.g. preserving the natural environment for human populations to live in, preventing or mitigating climate change, etc. Investors making decisions based on the third motive may well espouse similar objectives as public policy makers, but the two other motives are at least as important. It should also be noted that for prudential regulators, whose role it is to preserve the stability of the financial system by preventing large cascading losses amongst market participants, the question of the relationship between ESG and asset prices is paramount. Indeed, so-called 'sustainability risks' i.e. the risk of loss of value of underlying assets due to environmental or social events, are one of the main concerns of the SFDR (Regulation 2019/2088, L317/9).

Hence, investors in infrastructure have two sets of decisions to make relating to ESG: First, which assets should they exclude or focus on because of their ESG characteristics? Second, given the characteristics of the acceptable universe, what risks are they exposed to that they should manage within their portfolio, through various forms of diversification, hedging or insurance?

If the impact of ESG characteristics on infrastructure asset prices is not easily gauged from market prices, then additional **investment knowledge** is needed to decide how to invest. Thus, beyond the societal demand for greater ESG content and outcomes of the investments made by investors, the demand for ESG reporting and benchmarking also springs from the second motive described above as does the need to manage risks related to ESG *within* the portfolio.

In the end, the relationship between ESG and the fair market value of assets is determined by the extent to which the ESG profile of a firm creates exposures to risks that materially (systematically) drive the discount rates of the future cash flows of its financial assets.

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This focus on risk may seem at odds with the frequent insistence on the role of the 'impact' of a business or project in the 'green investing' literature or marketing. Of course, any economic activity has an impact and infrastructure companies can have very significant impacts, both positive and negative, on their natural and economic environments. However, these impacts do, in turn, create risks i.e. they increase or decrease the payoff uncertainty of the investment. *In fine*, impacts contribute to the discount rate or expected return that investors require to buy or hold the asset.

Existing ESG reporting frameworks do not create investment knowledge

Next, we ask if existing ESG reporting tools create the investment knowledge that investors require i.e. do ESG schemes created and used by infrastructure investors help clarify the relationship between ESG and infrastructure asset prices? Over the past decade, in response to the increasing appetite of investors for understanding and measuring the ESG characteristics of infrastructure investments, numerous tools and standards have appeared to facilitate the reporting and assessment of ESG metrics. ESG schemes for infrastructure investors are still at the 'proliferation' stage of standard development and a degree of consolidation, as well as integration of these soft rules into more stringent and mandatory regulatory frameworks can be expected.

We propose a framework to integrate the role of ESG in the fundamental relationship between risk and fair value, which takes into account the role of each infrastructure company's impacts on environmental, social and governance matters. To develop this framework, we conduct a comparative analysis of the existing ESG schemes used by infrastructure investors to determine the scope of ESG issues in relation to infrastructure investments, establish a common matrix or taxonomy of their ESG risks and impacts, and determine how the question of (financial) materiality i.e. what factors can be expected to *systematically* impact value, should be approached scientifically.

From the multiple standards available, we build a **parsimonious taxonomy of ESG impacts and risks** that, at the most general level, universally apply to any infrastructure company.

We use this taxonomy, which includes 10 super classes, 24 classes and 67 subclasses of ESG impacts and risks, to categorise 1,659 indicators, including 4,850 disclosures provided by existing schemes. This allows us to understand the scope, level of aggregation, and measurement difference of existing ESG schemes for infrastructure investment.

We find that despite current ESG standards being made for the purpose of infrastructure investing, the centrality of the firm and the importance of asset pricing are often ignored by or lost on existing schemes. These typically do not achieve a clear distinction between impacts and risks, in particular between the *whose* impacts and risks that ESG reporting and assessment should focus on. Instead, they

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tend to be lists of 'things that matter' and do not necessarily focus on trying to measure the risks to which investors in infrastructure companies are exposed in the context of ESG. We argue that such lists, while very useful, fail to meet the standard of a genuine scientific framework: a list of concepts and categories that describe the relationships between them i.e. an *ontology*.

To define infrastructure, we follow the TICCS® classification system of infrastructure companies, which puts the firm at the centre of the approach. Infrastructure companies are what equity investors buy and debt investors lend to. Hence our focus is the ESG impacts **of** an infrastructure company, and what ESG risks it is **exposed to**. It follows that any ESG reporting or scoring, while it may spring from asset-level data, can be evaluated at the firm level, which is the correct unit of account for an investment reporting scheme.

There is little convergence between schemes in terms of scope (what the ESG perimeter includes), weights (what defines or constitutes materiality) and measurement (what data should be used to capture ESG characteristics). From one scheme to the next, the ESG performance of infrastructure companies is currently measured and presented in different and evolving ways. We find:

- Significant scope divergence between schemes as evidenced by the different biases, incomplete coverage and lack of overlap in terms of risk and impact classes, which is also a sign of measurement divergence;
- Measurement bias in the reporting of ESG information with the dominance of qualitative measures reported;
- Impact bias in the reporting of ESG information, and little attention to measuring risk exposures, especially not through quantitative risk reporting;
- Process and input indicator bias in the reporting of ESG information, highlighting the role of proxies in the various scoring and ratings methodologies used since actual impacts are not directly measured or reported.

Because of their lack of focus on the firm and its value, existing schemes focus almost entirely on 'impacts', which may of course be indirect factors of risk, but also do not shed much light on the direct risks that arise from ESG. Some 88% of reviewed disclosures focus on impacts while only 12% aim to capture direct risks.

Our findings point to several likely developments in the area of ESG ratings and certification provision:

1. Infrastructure investment ESG standards will continue to change: the current absence of consistent definitions or approaches means that individual standards need to evolve and redefine their scope and methodologies;
2. This consolidation will be driven by end users: the degree of clarity and consensus around the objectives and the definitions used by ESG schemes, as well as the embedded assumptions that underpin these choices are likely to contribute

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to standard adoption, credibility and, eventually, dominance;

3. Schemes that also address the most pressing questions of policy makers and regulators are more likely to attract users. In the case of infrastructure investment, this is particularly the case with regards to climate change.

Creating an infrastructure ESG domain of knowledge for investors

To support the development of relevant ESG investment knowledge, we explicitly restrict the analytical framework to the link between ESG and asset prices.

Investors recognise that 'externalities have consequences' and, with rapid social and environmental changes over the past decades and the expectation of even more uncertain evolutions, they also anticipate these consequences by demanding better knowledge about their investment choices. This is what they and regulators need to understand in order to manage risks in the portfolio.

In the end, creating ESG investment knowledge does not change or remove economic externalities, it only makes them and their potential consequences for businesses more apparent and better documented. **It is the knowledge of the uncertain consequences of externalities, including on future regulation or cash flows, that can influence asset prices.**

In essence, the current demand for ESG reporting stems from two issues: 1/ a lack of knowledge regarding the ESG impacts and risks of infrastructure companies; and 2/ the fundamental uncertainty that the ESG aspects of their activity create for investors. Addressing the first issue amounts to documenting the exposure (or beta) of a company to certain risks. For the second, the consequences of ESG impacts and risks themselves for the firm remain uncertain, but can inform decision making and become a driver of the cost of capital in infrastructure investment.

We show that the scientific development of a body of ESG investment knowledge (or ontology) requires a number of key building blocks:

1. The clearly stated aim to create knowledge that relates the ESG characteristics of **infrastructure companies** – the entities in that investors decide to buy or hold – to investment decisions made on financial grounds i.e. considerations of risk and reward;
2. This helps clarify that the impacts of interest are those of an infrastructure company and the relevant risks are those to which the same company is exposed. Hence, the relevant **domain of knowledge**: instances of ESG risks and impacts of infrastructure companies. By grounding the approach in this manner, it becomes clearer that impacts are also sources of risks;
3. Next, a **classification system** is needed for the various objects of interest, including of course infrastructure companies and their ESG risks and impacts, but also standard

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classes of attributes and relations that allow the ESG characteristics of infrastructure companies to be described and create this knowledge. The definition of the attributes and relations that create this knowledge can then be science- and theory-based, using the most consistent assumptions or models in order to create a broad user base and maximise potential commitment by users.

4. Finally, this allows the question of **materiality** to be addressed. Materiality is a weak point in existing ESG schemes: they provide lists of potential material information to report or collect, but do not anchor this materiality in objective measures that would relate to the activities of infrastructure companies. Developing science-based materiality profiles for each of the 95 types of infrastructure assets captured in the industrial activity pillar of the TICCS® classification is a key step in the development of a body of ESG investment knowledge for infrastructure investment.

With this paper, we have laid out a roadmap for the scientific development of ESG knowledge for infrastructure investment. Future research and industrial efforts to consolidate and develop ESG investment knowledge can be expected as this knowledge becomes increasingly in demand from investors and their regulators.

Alignment with SFDR

The approach proposed in this paper is aligned with the work of the European Union's SFDR expected to come fully into force in 2022. SFDR requires "financial market participants and financial advisers (...) to disclose specific information regarding their approaches to the integration of sustainability risks and the consideration of adverse sustainability impacts" (SFDR, L317/2).

While its primary public policy objective is to minimise adverse impacts on the environment and society, as mentioned above, SFDR is also about the risks to asset values. It requires the disclosure of so-called sustainability risks that pose "an environmental, social or governance event or condition that, if it occurs, could cause an actual or a potential material negative impact on the value of the investment" (SFDR, L317/9).

In effect, a taxonomy of the ESG impacts and risks of infrastructure companies is an essential step to address the concerns of SFDR. Moreover, one of the foundations of SFDR, is another taxonomy: the EU Taxonomy for Sustainable Activities describes the sustainability characteristics of various forms of industrial activities, including that of infrastructure companies. In other words, the EU Taxonomy is a first attempt at building objective materiality profiles that can be used to assess the ESG characteristics of an infrastructure company objectively.

Finally, this description of what matters from an ESG standpoint is to be documented using Regulatory Technical Standards (RTS) establishing a framework of reporting on principal adverse impacts and risks. A first draft describing the ESG data that will be required by the RTS was published in the

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Final Report on draft Regulatory Technical Standards, of the Joint committee of the European Supervisory Authorities in February 2021, and describes detailed indicators for environmental and social impacts.

To ensure compatibility with the SFDR, the EDHEC*infra* ESG taxonomy allows mapping of the required disclosures to respective impact and risk classes. Given that the EDHEC*infra* taxonomy is an exhaustive list of ESG impacts and risks for the infrastructure sector, 100% of the mandatory disclosures can be mapped to the subclasses of this taxonomy of risks and impacts. To enable measurement, each impact and risk can then be measured as indicators, which in turn will be informed by data collected according to the materiality profiles of each company and asset type as defined by TICCS®.

In the RTS, these indicators are divided into a core set of 18 universal mandatory indicators that will always lead to principal adverse impacts of investment decisions on sustainability factors, irrespective of the result of the assessment by the financial market participant, and additional opt-in indicators for environmental and social factors, to be used to identify, assess and prioritise additional principal adverse impacts.

Future work by EDHEC*infra* focuses on supporting the implementation of the roadmap described in this paper, including documenting the ESG characteristics of infrastructure companies.

1. ESG Impacts, Risks and the Value of Infrastructure Assets

1. ESG Impacts, Risks and the Value of Infrastructure Assets

In this paper, we propose an analysis of the role of environmental, social and governance (ESG) issues in an investment context i.e. as a input in the financial management of the portfolio of institutional investors. ESG objectives are also and increasingly an end in themselves for numerous investors that aim to have a direct impact on environmental and social outcomes. This is important and valid. Investors can be given a mandate by their members and by society to contribute to ESG outcomes as organisations, even though these organisations have primarily been created to deliver investment outcomes, in particular retirement income. As a result of pursuing non-financial objectives, investors may exclude certain types of investments from their universe such a coal-fired power plants or infrastructure projects marred in social controversy. However, once these exclusions have been made, ESG remains a factor in the investment decision process. It is this area that we investigate here: what is the role of ESG for investors in infrastructure within *the portfolio i.e. what can we say about ESG and infrastructure from a strictly financial standpoint. Of course, this does not negate or minimise the importance of ESG assessments considered upstream of the investment process.*

For close to two decades, numerous investors in search of yield and diversification have considered adding infrastructure investments to their portfolio. At the same time, the environmental impact and social responsibility of the owners of infrastructure companies has increasingly become a consideration in their decision to invest.

The very nature of infrastructure puts it at the heart of the debate on the impact of human activities on climate and environmental systems. New infrastructure investments are also important contributors to the transition to a low-carbon economy. Moreover, infrastructure assets and businesses are also threatened by the *consequences* of climate change and environmental degradation.

Likewise, infrastructure has a well-documented track record of enabling human and economic development but is also a potential focus point of social tensions and conflicts. Finally, in the area of governance, infrastructure raises specific questions on the regulation of natural monopolies (whether they are privately owned or not) as well as the possibility of corruption in the procurement of large construction projects, amongst others.

Untangling this web of environmental, social and governance (ESG) issues related to infrastructure investment is increasingly important to investors. In the 2019 edition of the EDHEC/Global Infrastructure Hub survey, 35% of respondents from 150 of the largest asset owners in the world identified achieving ESG objectives as a 'first order question, possibly at the expense of financial performance', almost twice as many as in the 2017 EDHECinfra survey (Blanc-Brude et al., 2017). Likewise, the vast majority of respondents in the 2019 survey considered ESG to be either 'important'

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or 'somewhat important' with only 4% saying that it is 'not important.' Other surveys (MIRA, 2020; HSBC, 2020; Oliver Wyman, WWF, 2020) echo similar levels of engagement and concern amongst infrastructure investors.

There are three motivations for this fast growing interest in the ESG characteristics of infrastructure investments:

- The fact that these characteristics have known consequences on the present value of investments e.g. an infrastructure that pollutes will be fined in most jurisdictions. This knowledge is priced by investors and already reflected in asset values;

- The belief that the ESG characteristics, while they are currently not priced by markets or regulators (i.e. economic externalities), are likely to become priced in at a point in the not too distant future. In other words, conditional on certain regulatory changes such as a carbon tax or systematic changes of attitude amongst consumers, etc., the present value of infrastructure investments is also a function of their ESG characteristics because these affect the uncertainty of the investment payoff. The better and deeper the knowledge about these future conditions, including how exposed any given investment might be, the more ESG characteristics can be reflected in asset prices;

- The aim to 'do good' and meet non-financial objectives irrespective of their impact on asset values. This could include excluding certain countries or sectors from a portfolio irrespective of the likelihood of an impact on asset value or its potential magnitude.

These motives are not exclusive: investors may decide not to invest in coal-fired power plants 1/ because of the cost of current environmental regulations for such assets or the impact on their reputation i.e. a known cost today, 2/ because the same companies are likely to be regulated out of business by future climate change mitigation regulations and i.e. an uncertain cost tomorrow, 3/ these assets are a historically significant source of greenhouse gas emissions and this is considered undesirable as a matter of principle.

Indeed, while the primary fiduciary responsibility of institutional investors such as pension plans or life insurers is to help their plan members meet their long-term investment and consumption objectives in real terms,[1] they may also decide to pursue any number of non-financial objectives. Table 1 shows examples of how ESG-related non-financial objectives such as promoting gender equality exist alongside aspects of ESG that are directly related to the pursuit of financial objectives.

Non-financial objectives are effectively constraints on the ability of investors to meet financial ones. This choice of constraints, while it can be popular, including amongst plan beneficiaries, is necessarily *ad hoc* and does not help in understanding the *role of ESG in the portfolio* or how such characteristics may be managed by investors in meeting their financial objectives.

1 - In fact, this is the first-order social impact of any long-term saving scheme.

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Table 1: ESG-Related Objectives and ESG Aspects of Financial Objectives

ESG-related non-financial objectives	ESG aspects of financial objectives
Promote Environmental Sustainability	Manage climate change-related physical risks
Support Energy Transition	Manage climate transition risks
Promote Human Development	Minimise environmental and social reputation risk
Promote Gender Equality	Minimise reporting and compliance risks
. . .	. . .

In this research on the role of ESG in infrastructure investment, we leave aside the third motive of pursuing purely non-financial goals. While often laudable, these choices remain unfathomable from a financial standpoint. Investors may or may not have certain non-financial constraints as part of their investment activities and there is little that research in finance can say about investment choices that are not investment decisions made on financial ground.

Instead, in this paper, we propose to focus on the following question: **How should we approach the relationship between ESG and the market value of infrastructure investments?** *In fine*, this is a key question that institutional investors and prudential regulators need answered in order to integrate ESG into their financial decision making process.

We discuss this question using a systematic approach grounded in financial and information theory.

1.1 The Primacy of Risk

To the extent that the role of ESG in investment decisions is driven by its impact on asset values, then it must result from considerations of risk.

Indeed, The starting point of any asset valuation approach is to postulate the existence of a trade-off between risk and returns i.e. between the risks to which investors are exposed and the price they are willing to pay for risky assets. The main challenge then is to gauge how to measure these risks. Whether investments are made by the private or public agents, investment decisions should always be evaluated in terms of their risk-adjusted expected benefits. In other words, risk considerations must determine both the expected rate of returns of private investors and the social rate of return of public investments (Freeman et al., 2018).

Still, from an ESG standpoint, a focus on risk may seem at odds with the frequent insistence on the role of the 'impact' of a business or project in the 'green investing' literature or marketing. Of course, any economic activity has an impact and, as suggested above, infrastructure companies can have very significant impacts, both positive and negative, on their natural and economic environments.

The first kind of impact of an infrastructure asset is its ability to make a service available to its potential users (see TICCS® (2020) for a discussion of the definition of infrastructure "as a service"). The value of this service to its current and future users is normally what

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justifies the creation of the infrastructure in the first place. For private investors, the value of their infrastructure assets and their ability to receive a positive pay-off from such investments is a direct result of how valuable an infrastructure service is to its users/clients or public-sector underwriters. As we will argue in this paper, this impact is not an ESG impact; it is consumption. The value of the goods and services consumed by a business's clients is included in its asset price. Here, from an investment standpoint non-financial reporting of this impact is unnecessary, because it is fully reflected in financial accounts. Of course, non-financial reporting may still be demanded by investors and society in relation to meeting non-financial objectives.

However, the consumption of infrastructure service also tends to create significant 'externalities' i.e. direct and indirect positive or negative impacts that are not priced, and thus do not increase or reduce the payoff of an investment. For example, a new road, even if it collects tolls from users, can have a non-priced positive impact by enabling valuable economic flows over and above the present value of its future revenues that investors accept to pay to hold this asset. Likewise, the same road can create noise and air pollution and have a negative impact of local residents, which is only partly, if at all, reflected in the present value of its future cash flows. Such effects, we argue, are genuine ESG impacts.

It is easy to see that these impacts do, in turn, create risks i.e. they increase the payoff uncertainty for the investment. The positive economic dynamic of a new road is itself uncertain; hence the number of users willing to pay tolls and both future revenues and maintenance costs is all the more uncertain, as is the likelihood that the project may have an impact beyond the pure consumption of transportation services. At the same time, if a road creates a lot of pollution, residents may convince local authorities to impose the construction of costly noise barriers or to levy an environmental tax, which would be business risks for the road company. *In fine*, these impacts contribute to the discount rate or expected return that investors require to buy the asset.

In effect, ESG impacts are often contributors to ESG risks: impacts do, directly or indirectly, create or change risks for the party causing them. The impact of one party, like a power plant burning coal and thus contributing to climate change, is a risk for others, such as people or businesses exposed to the consequences of climate change, and for the power plant itself, which may face the direct (regulatory) and indirect (physical) consequences of its contribution to climate change. A firm's impacts thus create, contribute to or mitigate regulatory, environmental or social risks.

The perception and acceptability of the impact of certain economic activities also creates business risks. For instance, frequent calls for individual action in relation to climate change may lead to lasting changes in consumption preferences, from eating habits to business and leisure travelling.

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In the end, the relationship between ESG and fair value is determined by the extent to which the ESG profile of a firm creates exposures to risks that materially (systematically) drive the discount rates of the future cash flows of financial assets. Without a framework explicitly taking into account the direct and indirect risks that the ESG characteristics of infrastructure investments create, the relationship between ESG and the market value of these investments remains obscure and unclear.

In this paper, we propose a framework to integrate the role of ESG in the fundamental relationship between risk and fair value, which necessarily takes into account the role of each infrastructure company's impacts on environmental, social and governance matters. We argue that it is important to first distinguish between *direct* risks and impacts relative to a specific entity (here, the investment made in an infrastructure company) and, in a second step, to clearly identify how the impact of such investments can be understood as indirect sources of risk.

To develop this framework, we conduct a comparative analysis of existing ESG schemes used by infrastructure investors to determine the scope of ESG issues in relation to infrastructure investments, establish a common matrix or taxonomy of the ESG risks and impacts of infrastructure companies, and determine how the question of (financial) materiality i.e. what factors can be expected to *systematically* impact value, should be approached scientifically.

1.2 Scope, measurement and aggregation of ESG reporting schemes

In what follows, we begin by analysing how ESG risks and impacts are reported and understood by investors in infrastructure today. We review 12 existing tools and standards created to report and assess ESG data and discuss briefly their recent and potential evolution, drawing on the research literature on the evolution of standards in general and voluntary accountability standards in particular. In addition to this, we review 5 guiding frameworks that serve as the starting point of many of the reviewed schemes.

Indeed, over the past decade, in response to an increased appetite for understanding and measuring the ESG characteristics of infrastructure investments, numerous tools, standards (collectively referred to as ESG schemes in this paper) have been developed to allow the reporting of ESG metrics by investors.

We argue that ESG schemes for infrastructure investors is still at the initial 'proliferation' stage of standard development and that a degree of consolidation and integration of these soft rules into more stringent and mandatory regulatory frameworks can be expected, perhaps in the near future given the key role of infrastructure in the climate change equation and the rapidly growing interest of regulators for this topic.

From the multiple schemes available, we build a parsimonious taxonomy of ESG impact and risk that, at the most general level, universally apply to any infrastructure company. The

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objective of this taxonomy is to define classes of risks and impacts that:

- Are always relevant to some extent for any infrastructure asset and service, so that at the aggregate level, different infrastructure investments may be directly compared;
- Can be described as a function of objective attributes, leaving no or little room for interpretation. As is the case with TICCS® when it comes to business risk or industrial activities, the ESG characteristics infrastructure companies can be described in terms of its well-defined classes (types) of risks and impacts;
- Is not a static list but a taxonomy of factors that potentially contribute explaining or influencing the fair value of a given infrastructure investment on *a relative basis*. In other words, it should be the relative exposure of individual infrastructure companies to ESG risk and impacts that determines the relationship between ESG and value.

We follow Berg et al. (2019) and their work on the ESG reporting of listed firms, and categorise 1,659 indicators (including 4,850 potential disclosures) provided by infrastructure ESG rating providers using our taxonomy, which includes 10 super classes, 24 classes and 67 subclasses of ESG impacts and risks. This allows us to better understand the scope, level of aggregation, measurement difference of existing ESG schemes for infrastructure investment.

We find that despite current ESG schemes being made for the purpose of infrastructure investing (among other purposes as explained in chapter 2), the centrality of the firm and the importance of asset pricing are often ignored by or lost on existing schemes, which typically do not achieve a clear distinction between impacts and risks, in particular between the *whose* impacts and risks that ESG reporting and assessment should focus on. Instead, they tend to be laundry lists of 'things that matter' and do not necessarily focus on trying to measure the risks to which investors in infrastructure companies are exposed in the context of ESG. We argue that such lists, while very useful, fail to meet the standard of an analytical framework i.e. an ontology[2] of ESG for infrastructure investors.

We follow the TICCS® classification system of infrastructure companies and put the firm at the centre of the approach. Infrastructure companies are what equity investors buy and debt investors lend to. Hence, while ESG includes a wide range of stakeholders, the point of any ESG reporting or assessment exercise should be to understand what the **impact of an infrastructure company** is in the ESG space, and **what risks this company is exposed to** in this regard as well. It follows that any ESG reporting or scoring, while it may spring from asset-level data, should be about the firm, which is the correct unit of accountability for an investment reporting scheme.

We find little agreement between schemes in terms of scope (what the ESG perimeter includes), weights (what defines or constitutes materiality) and measurement (what

2 - A list of concepts and categories that describe the relationships between them. We return to this notion in the section chapter.

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data should be used to capture ESG characteristics). From one scheme to the next, the ESG performance of infrastructure companies is currently measured and presented in different and evolving ways.

Because of their lack of focus on the firm and its value, existing schemes focus almost entirely on 'impacts', which may of course be indirect factors of risk, but also do not shed much light on the direct risks that arise from ESG. We find that, 88% of reviewed disclosures focus on impacts while only 12% aim to capture direct risks.

We conclude our review and analysis with a roadmap for a program of research, based on the creation of directly observable ESG metrics for infrastructure assets and how they may be defined for each type of infrastructure asset recognised in the TICCS® classification system by creating objective (i.e. based on physical design) materiality profiles for the impacts and risks recognised in this study.

The rest of this paper is structured thus: we first discuss the main results of the comparative analysis of ESG schemes in chapter 2. Chapter 3 presents our approach of an ontology of ESG and the mapping of ESG characteristics across existing schemes using taxonomy of ESG impacts and risks. Chapter 4 then presents a more quantitative analysis of existing ESG schemes through the lens of this taxonomy. Chapter 5 concludes the paper and suggests future developments.

2. ESG Schemes for Infrastructure Investors Today

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In this chapter, we review the recent development of ESG reporting and assessment schemes for infrastructure investors and conduct a comparative review of 12 such schemes and 5 guiding frameworks currently in use. We also examine the degree of *scope, weight, aggregation and measurement divergence* in these schemes and frameworks.

2.1 The Development of Accountability Standards

ESG schemes are quite a recent addition to the infrastructure investment sector, but comparable accountability standards have existed for decades in other sectors and their development has been the object of extensive research.

Standards are normative and prescribe what those who adopt them should (and should not) do (Brunsson et al., 2000), thus requiring or restricting behaviour (Ortmann, 2010). In other words, the point of standards is to outline requirements, specifications, guidelines, methods or terminologies that are expected to change the behaviour of individual firms and improve consistency and compatibility between firms. ESG standards thus belong to broader group of international accountability standards (IAS) defined as "voluntary predefined rules, procedures, and methods to systematically assess, measure, audit and/or communicate the social and environmental behaviour and/or performance of firms." (Gilbert and Rasche, 2008; Rasche, 2009)

The research literature documents a kind of 'arc' of the development of accountability initiatives. During a first phase, there is "standard proliferation" due to increasing demand from various stakeholders for more stringent social or environmental standards, in combination with weak or non-existent national and international regulation of these issues. To fill what is perceived as a governance gap, multiple players (international organisations, for-profit companies, governing bodies, etc.) typically emerge as the promoters of the responsible behaviour of firms and of their accountability and transparency with regard to their environmental or social performance (Göbbels and Jonker, 2003; Leipziger, 2010; Paine et al., 2005; Waddock, 2008; Gilbert et al., 2011). These developments tend to concur in the context of economic globalisation, outsourcing and other forms of transnational corporate behaviour and phenomenon.

A number of research papers document how these initiatives emerge gradually as a result of the uncoordinated actions of various actors, and often differ with regard to the scope or measurement of the emerging norms (Jamali, 2010; Rasche, 2009). In this first phase, standard proliferation can lead to duplication of efforts, perhaps even undermining the stringency of certain standards, causing investor confusion and scepticism, and exacerbating third party concerns regarding the credibility and legitimacy of (private) voluntary sustainability standards and certification schemes (Glasbergen, 2013). Thus, while competition between standard providers encourages innovation, standard

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multiplicity can be inefficient or ineffective because it hampers meaningful comparisons across investments (Derkx and Glasbergen, 2014).

At this stage, these initiatives are voluntary, considered to be 'soft' rules that are not enforced by a hierarchy of norms or the authority of national or other organisations. The decision to comply or not is left to potential adopters, resulting in differing levels of adoption of the various schemes.

The research literature also suggests that this first phase is typically followed by a second one of "consolidation and maturation " of voluntary standards, including a degree of harmonisation as certain initiatives emerge as more 'salient' than others Arnold (2012). In a study of the UNPRI, Majoch et al. (2017) shows that the *salience* of a voluntary standard and the organisation that carries it is a "critical mass" phenomenon combining at least four factors: power, legitimacy, urgency and management values.

Indeed, while voluntary initiatives do not have enforcement powers, over time they can develop a degree of normative power e.g. some initiatives become so widespread that non-compliance can carry a form of stigma for investors. Apart from standard creators, third parties (stakeholders) also have some power over adopters and may force them to comply with specific standards (Bernstein and Cashore, 2007; Büthe and Mattli, 2010). For instance, certain large corporations only contract with suppliers complying with ISO 9001 [3] (Guler et al., 2002). Some organisations also make compliance within groups of organisations mandatory once they have adopted a standard and some standards are so largely adopted that not adopting them can make it difficult to do business (Brunsson et al., 2012; King et al., 2005).

Second, existing research suggests that the legitimacy of voluntary standards is the result of the credibility of the provider, its perceived ability to lead a specific type of initiative and to generate new adopters (Majoch et al., 2017). Standard legitimacy then springs from being perceived as "desirable, proper, or appropriate" (Suchman, 1995). With the proliferation of competing standards, adoption is one of the main criteria by which the legitimacy of standards is established, especially for new adopters (Brunsson et al., 2012).

Third, the notion of urgency refers to that of the issue at stake. (Mitchell et al., 1997; Gifford, 2010). The literature also highlights the role of crises in driving the consolidation and generalisation of standards (Arnold, 2012). The urgency of climate change, and the central role of infrastructure in its possible abatement or mitigation, might mean this process of consolidation is taking place faster that would otherwise be the case.

Finally, the management values or the core principles that guide business decisions of standard setters matter to the extent that they overlap with that of potential adopters. Alignment of values can lead to faster adoption of certain initiatives.

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Another route to voluntary standard consolidation consists of having multiple schemes aggregated into one by a legitimate (or salient) third party. This is referred to as the 'regulation of self-regulation' or meta-governance in Sørensen (2006): a process "enhancing coordinated governance in a fragmented (regulatory) system based on a high degree of autonomy for a plurality of self-governing networks and institutions" (Sørensen, 2006, p 100).

Here, the actors involved remains independent, but consider their interdependencies to create a higher level 'negotiated order' (Derkx and Glasbergen, 2014). Historically, this phenomenon has been primarily the concern of governments, but more recently a number of private voluntary standards (fair labour, sustainable tourism, organic agriculture, etc.) have started to develop in the context of a joint or meta-governance. Typically, the most successful schemes and the organisations that created them aim to address the challenges, contradictions or inconsistencies of their self-regulatory systems and improve coherence.

This phenomenon is already at play in the ESG space including the infrastructure investment sector with for example the standard collaboration projects between Global Infrastructure Basel (Sure Standard), Ceequal, the Infrastructure Sustainability Council of Australia (ISCA), GRESB and the Institute for Sustainable Infrastructure (ISI) with the support of the World Bank Group. We return to this below.

Ultimately, whether standards emerge through 'salience' or 'meta-governance', essential actors in the consolidation phase of voluntary standards are the various regulatory agencies that need to recognise and integrate voluntary standards. Regulators support consolidation initiatives (including through funding) and eventually translate voluntary standards into enforceable regulations or 'hard' law, as can be seen by the requirements of the Sustainable Finance Disclosure Regulation (SFDR). At this stage, when regulators step in and formalise a given initiative, the standardisation process reaches a new, more permanent level of consolidation.

Next, we propose a comparative analysis of the current standards and tools that propose to document the ESG performance of infrastructure investments. We follow Berg et al. (2019) and review the degree of *scope, weight, aggregation and measurement divergence* of these schemes and discuss what stage they are likely to have reached today along the 'arc' that stretches from the proliferation, consolidation and legalisation of voluntary standards.

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First, we must acknowledge some of the specificities of infrastructure companies which make them different from the type of firms that led to the creation of other voluntary standards. While international accountability standards (IAS) have often emerged to fill a regulatory gap in a transnational setting, in the infrastructure sector

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only a small proportion of firms are multinationals. For instance, in the universe of investible firms tracked by EDHECinfra, only 8% are categorised as global assets (TICCS® taxonomy, third pillar on geo-economic exposure) out of USD2.1Tr of enterprise book value, and more than half are national or sub-national entities. Of course, some infrastructure assets are 'global businesses' such as large airports or ports but these are in the minority.

Furthermore, a large proportion of investible, private infrastructure companies are located in countries with strong legal and regulatory regimes covering corporate governance, accounting, labour and environmental standards. In addition, infrastructure companies in regulated industries like water supply, airports and power are also subject to sector-specific economic and operational regulation at the national and sometimes international level. Together, these features of infrastructure help to explain why firms in the sector have not felt yet the same pressure from stakeholders for additional ESG standards – there is much less of a regulatory vacuum to fill.

Next, while IAS aim to change the behaviour of firms, the scope for behavioural change in the infrastructure sector is limited: new roads, power plants or transmission lines are procured in the context of public economic development plans. Once they are built and operational, their environmental, social and economic impacts are mostly given. Compared with the range of behaviours that is available to other firms in the conduct of their business, in terms of procurement, production technologies or labour practices, infrastructure firms can only make behavioural changes at the margin since they are highly constrained in terms of capital expansion, diversification of revenues, etc. Of course, in the medium to long term, given enough new capex, infrastructure companies can also be transformed e.g. from fossil fuel burning to renewable energy providers (e.g. Drax in the UK) but this is a slow and expensive process and essentially amounts to creating new infrastructure assets to replace old ones within the same corporate structure.

Because infrastructure assets are designed to deliver a defined set of services, using a given technology that is selected at the project design stage and typically cannot be changed due to large sunk capital costs, the design and construction stages are critical for owners and managers to make choices that can meaningfully impact the ESG profile of infrastructure companies. Many aspects of infrastructure design standards are also covered by existing national regulations, such as noise pollution from new roads in urban centres or waste-water discharge standards. In the majority of cases, self-imposed ESG standards are unlikely to be more stringent and, crucially for investors, there cannot be much variation of outcome within one jurisdiction.[4]

In some cases, there may be scope for companies to go beyond regulatory minimum requirements to reduce negative social or environmental impacts. Still, in contrast with the purpose of accountability standards which aim mostly to change the firm's

4 - We acknowledge that this depends partly in the heterogeneity and stringency of construction rules and regulation within each jurisdiction, e.g. in different US States.

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behaviour, ESG considerations for infrastructure companies are less about corporate behaviour and more about the services that infrastructure companies provide, their location and the nature of their assets.

Thus, a key role for ESG assessments of infrastructure companies is to allow for *asset selection or exclusion* by investors or to enable them to understand whether assets create specific ESG-related impacts or risks. For example, if a power plant is designed to burn coal, and coal-burning is at risk of being regulated or heavily taxed by the regulator to promote a low-carbon economy, this asset is at risk of becoming 'stranded' and its owners at risk of a significant loss. Short of successfully lobbying against carbon taxation, There is little that the owners of this firm can do to reduce this risk except to dispose of the asset, given that is designed to do one thing only, namely burning coal.

The fact that infrastructure investment is heavily 'relationship-specific' i.e. based on single-use assets that require a counter-party (often an contractual relationship) to make the investment valuable in the first place, is a fundamental element of the ESG profile of infrastructure companies, given the fixed nature of their assets and business. As result, numerous aspects of what matters or is 'material' in the ESG profile of a given infrastructure asset can be described directly and objectively as a function of what this infrastructure is and what it does.

Next, before looking at scope, weight and measurement of existing ESG schemes for infrastructure investors, we set a benchmark based on research done on ESG and public equities.

2.2.1 A Benchmark of ESG Scheme Divergence

The research literature that looks at ESG ratings in general points out that they are produced by different agencies and show significant divergence (Chatterji et al., 2016). Allen (2018) points out that in September 2018, FTSE placed Tesla last among the global automotive companies on ESG performance while MSCI placed it at the top, and Sustainalytics' placed it somewhere in the middle. Semenova and Hassel (2015) explored the convergent validity of the environmental ratings of MSCI, Thomson Reuters' ASSET4 and Global Engagement Services and found that while the ratings have common dimensions, on aggregate, they do not converge. Dorfleitner et al. (2015) compared individual environmental, social, governance and economic scores as well as the aggregate ESG scores of three rating products: Thomson Reuters' ASSET4, MSCI/KLD ratings and the ESG data set of Bloomberg. Using a subsample containing companies covered by all three rating providers they show that while correlations between ASSET4 and Bloomberg were as high as 0.62 for the aggregate score and varied between 0.47 and 0.60 for individual dimensions, MSCI/KLD ratings showed little resemblance to the other two (correlation varying between 0.05 and 0.39). Similarly, Chatterji et al. (2016) conclude that the six ratings they compared (i.e., MSCI/KLD, ASSET4, Calvert, FTSE4Good, DJSI,

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and Innovest) exhibited low convergence in their assessments of ESG factors.

Since ESG standards are still evolving towards consolidation, we rely on the results of a recent paper on ESG ratings as a benchmark for our own findings. Indeed, the issues found in the schemes we review are not always specific to infrastructure companies and it is helpful to provide a point of reference using data for a much broader set of ESG ratings.

Berg et al. (2019) conduct a detailed study of ESG ratings for listed investments and quantitatively assess the degree of divergence of these schemes in terms of scope (when different company attributes are used as a basis for different ratings), weight (when views on the relative importance of certain attributes differ), aggregation (when certain attributes are not taken into account by certain schemes) and measurement (when different data are used to measure the same thing). The authors build a mapping of the criteria used by each rating provider to provide a comparative analysis of their methodologies and outcomes.

Their findings use the actual ratings of five different ESG rating data providers and, using a common taxonomy to cross-reference the standards, quantify the degree of divergence of each the ESG data between providers. The authors make a number of findings that are worthy of note for our purpose:

- Individual raters use between 37 and 236 indicators per rating scheme;
- Many of the common categories (taxonomy) they build to map the data together are not covered by one or several rating provider;
- Ratings are systematically influenced by the rating provider (the authors call this the 'rater effect');
- On average differences in measurement explain 53% of differences in ratings;
- Likewise, differences in scope explain 44% of differences in ratings; and
- Differences in weight only explain 3% of differences in ratings.

They conclude that rating providers disagree quite as much on the extent of the definition of ESG as they do on how the various aspects of ESG are or should be measured. They also show that large differences in ratings can be explained by a small number of factors on which standard providers disagree.

Two other results are 'a fundamental problem of the ESG rating industry itself, namely that differences between raters are not merely differences in opinion, but differences in measurement' and that final scores are easily replicated with a greatly reduced number of indicators, suggesting that they form highly correlated subgroups and are in part redundant.

With this starting point, we examine 12 ESG schemes and 5 guiding frameworks used by infrastructure investors.

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2.2.2 Selection of Infrastructure ESG Schemes Reviewed

To conduct our analysis, we review the 17 ESG tools, standards and guiding frameworks shown in table 2 and conduct a detailed assessment of 1,659 indicators including 4,850 potential disclosures used by these to report performance on or measure different ESG topics. The analysis looks at the extent they diverge in terms of scope, measurement, weight and aggregation.

The schemes reviewed were selected based on expert opinion and desk research (Sloan et al., 2019; Hove et al., 2020). ESG schemes that do not cover the infrastructure sector in their scope at all were not included in this assessment. Our intention is to capture the range of disclosures used in ESG schemes in order to assess the different approaches used to quantitatively or qualitatively report and measure ESG for infrastructure investors. Of course not all reviewed schemes are developed specifically for infrastructure investors, but cater to multiple user types inclusive of investors.

ESG schemes for infrastructure investors can be defined as:

- ESG **standards**: which are either used as reporting guidelines or certification schemes;

- ESG **tools**: which are used to produce ESG ratings, scores or classifications.

The main scheme development steps include defining and identifying ESG indicators, short-listing the 'material' indicators for a given type of end user, collecting data documenting these indicators, and aggregating them into a score or certification that describes the ESG performance of a company or project.

In addition to schemes, guiding frameworks serve as the starting point of many of the reviewed tools and standards. They are open-ended value systems, open to interpretation, and do not offer precise guidance on specific ESG indicators or disclosures. We reviewed the documentation of five guiding frameworks in the context of this study, but they are not included in the quantitative analysis of the schemes (chapter 4) since they do not contain specific disclosures.

2.2.3 Scope

Measuring infrastructure ESG performance requires clear definitions of both infrastructure and ESG performance.

However, looking at the scopes of each scheme and framework and whether they diverge significantly, we find that, in line with Berg et al. (2019), the aim, creators, intended end-users and, crucially, the definition of 'infrastructure' used all vary sufficiently between schemes and frameworks to suggest significant scope divergence.

These schemes and frameworks define the infrastructure sector with varying granularity. As shown in table 5 and table 6, although standard setters like GRESB and an increasingly large number of investors use The Infrastructure Company Classification Standard or TICCS®, other schemes use

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Table 2: List of Reviewed ESG Schemes

Scheme	Category
SuRe (GIB, 2018a)	Standard
SASB (The SASB Foundation, 2018a,b,g,d,e,f,h)	Standard
GRI Standards (GSSB, 2016a)	Standard
GRESB Infrastructure Asset Assessment (GRESB, 2019)	Tool
MSCI ESG Ratings (MSCI, 2019)	Tool
IS Rating Scheme (Australia and NZ) (ISCA, 2019),	Tool
RepRisk Index and Ratings	Tool and database
Refinitiv ESG Scores (Refinitiv, 2020)	Tool and database
EU Taxonomy	Tool
CEEQUAL (International) (BRE Global, 2019)	Tool
Envision rating tool	Tool
Sustainability and Resilience SmartScan (GIB, 2018b)	Tool
PRI (PRI Association, 2018)	Guiding principles
Equator Principles (Equator Principles Association, 2019)	Guiding principles
IFC Environmental and Social Performance Standards (IFC, 2012)	Private regulatory framework
PPIAF	Advisory facility
SDGs	International development goals

Table 3: Aims of ESG Schemes

Scheme	Attract Financing Opportunities	Identify Material ESG Risks and Impacts	Foster Communi-cation	Improve Sustainability Performance	Enable Standardi-sation
SuRe	✓	✓	✓	✓	✓
SASB	-	✓	✓	✓	✓
GRI Standards	-	✓	✓	-	✓
GRESB Infrastructure Asset Assessment	✓	✓	✓	✓	✓
MSCI ESG Ratings	-	✓	-	-	-
IS Rating Scheme (Australia and NZ)	-	-	✓	✓	-
RepRisk Index and Ratings	-	✓	-	-	-
Refinitiv ESG Scores	-	✓	-	-	-
EU Taxonomy	✓	-	✓	-	✓
CEEQUAL (International)	-	-	-	✓	-
Envision rating tool	-	✓	✓	✓	-
Sustainability and Resilience SmartScan	-	✓	-	✓	✓
PRI	-	-	✓	✓	-
Equator principles	✓	✓	-	-	-
IFC Environmental and Social Performance Standards	✓	✓	-	-	✓
PPIAF	✓	-	-	-	-
SDG	-	-	-	✓	-

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Table 4: Developers and Primary User Types of ESG Schemes

Scheme	Developer	Developer Type	Primary User Types
SuRe	Global Infrastructure Basel Foundation	Not-for-profit foundation	Regulators, companies, financial investors
SASB	Sustainability Accounting Standards Board	Not-for-profit organisation	Financial investors
GRI Standards	Global Reporting Initiative	Not-for-profit organisation	Regulators, companies, financial investors
GRESB Infrastructure Asset Assessment	GRESB	Joint initiative of a company (GRESB BV) and a Foundation (GRESB Foundation).	Companies, financial investors
MSCI ESG Ratings	MSCI	Company	Financial investors
IS Rating Scheme (Australia and NZ),	Infrastructure Sustainability Council of Australia	Not-for-profit organisation	Regulators, companies, financial investors
RepRisk Index and Ratings	RepRisk	Company	Regulators, financial investors
Refinitiv ESG Scores	Refinitiv	Company	Financial investors
EU Taxonomy	European Commission	Governing body	Regulators, financial investors, companies
CEEQUAL (International)	BRE Global Limited	Charity	Regulators, financial investors, companies
Envision rating tool	Institute for Sustainable Infrastructure	Not-for-profit organisation	Regulators, companies, financial investors
Sustainability and Resilience SmartScan	Global Infrastructure Basel Foundation	Not-for-profit foundation	Regulators, companies, financial investors
PRI	PRI Association	Not-for-profit organisation	Financial investors
Equator Principles	Equator Principles Association	Multiple organisations	Financial investors
IFC Environmental and Social Performance Standards	International Finance Corporation	International organisation	Financial investors
PPIAF	World Bank	International organisation	Regulators, financial investors, companies
SDGs	United Nations	International organisation	Universally applicable overarching goals

in-house stand-alone definitions of infrastructure, with different degrees of overlap, including with TICCS. Other multi-sector schemes use industry filters such as GICS®, which do not isolate infrastructure companies from equipment suppliers and other types of firms active in an industry. It is important to point out that the definition of infrastructure used aligns with the aims of the schemes and their primary user types. For example, investor related schemes may benefit from aligning with TICCS, while other schemes looking to identify and assess impact and risks from an engineering standpoint may use in-house classifications.

Schemes and guiding frameworks that are designed specifically for the infrastructure sector or cover the infrastructure sector in some detail include the SuRe standard, SASB, GRESB infrastructure asset assessment, CEEQUAL, the Envision rating tool, PPIAF and the IS Rating Scheme. Others are not sector specific and include infrastructure together with other sectors and thus do not capture the infrastructure very well.

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Table 5: Infrastructure Classification System Followed by & Target Sectors of ESG schemes

Scheme	Infrastructure Classification System Followed	Target Sectors
SuRe	No classification available. It is applicable to all types of infrastructure projects	Including but not limited to: water, energy, solid waste, transport networks, nodes and fleet, communication networks, social infrastructure, food systems, mining and extractive sites
SASB	In-house classification SICS (Sustainable Industry Classification System)	Infrastructure standards include: electric utilities and power generators, gas utilities and distributors, water utilities and services, waste management, engineering and construction services, home builders, real estate, real estate services
GRI Standards	Not applicable	Not infrastructure specific
GRESB Infrastructure Asset Assessment	TICCS® (The Infrastructure Company Classification Standard)	Data infrastructure, energy and water resources, environmental services, network utilities, power generation (excluding renewables), renewable power, social infrastructure and transport
MSCI ESG Ratings	Not Applicable for ESG ratings, but their Infrastructure indices use GICS® (Global Industry Classification Standard)	Not infrastructure specific
IS Rating Scheme (Australia and NZ)	In-house classification	Including but not limited to: airports, rails, roads, social infrastructure, ports, telecommunication, utilities, waste, water
RepRisk Index and Ratings	Not Applicable	Not infrastructure specific
Refinitiv ESG Scores	In-house classification: Thomson Reuters Business Classification (TRBC)	Not infrastructure specific
EU Taxonomy	Recommendations are structured around the EU's NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) industry classification system	Not infrastructure specific
CEEQUAL (International)	No classification available. It is applicable to all types of infrastructure projects	Any infrastructure project that involves the construction of new assets or refurbishment of existing assets.

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Table 6: Infrastructure Classification System Followed by & Target Sectors of ESG schemes

Scheme	Infrastructure Classification System Followed	Target Sectors
Envision rating tool	In-house classification	Energy, water, waste, transportation, landscape, information.
Sustainability and Resilience SmartScan	No classification available. It is applicable to all types of infrastructure projects	Including but not limited to: water, energy, solid waste, transport networks, nodes and fleet, communication networks, social infrastructure, food systems, mining and extractive sites
PRI	Not applicable	Not infrastructure specific, however infrastructure specific reporting framework is avaialble which is applicable to all infrastructure investments.
Equator Principles	Not applicable	Not infrastructure specific
IFC Environmental and Social Performance Standards	In-house classification	Not infrastructure specific
PPIAF	In house classification	ICT, transport, water and sanitation, power
SDGs	Not applicable	Not infrastructure specific

Table 7: Number of Indicators of Individual ESG Schemes

Scheme	No. of Disclosures
SuRe	61
SASB	160
GRI Standards	945 (Inclusive of all GRI Standards relevant for infrastructure companies)
GRESB Infrastructure Asset Assessment	58
MSCI ESG Ratings	37
IS Rating Scheme (Australia and NZ)	45
RepRisk Index and Ratings	NA
Refinitiv ESG Scores	48
EU Taxonomy	NA
CEEQUAL (International)	241
Envision rating tool	64
Sustainability and Resilience SmartScan	NA
PRI	NA
Equator Principles	NA
IFC Environmental and Social Performance Standards	NA
PPIAF	NA
SDGs	NA

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Given that these schemes and frameworks use varying definitions of infrastructure, they are not all applicable to the same infrastructure sub-sectors. For example, when comparing applicability with TICCS, Envision is applicable only to civil infrastructure, that is, it does include social infrastructure. SuRE covers food systems, while SASB covers home builders, real estate and real estate services, none of which are defined as 'infrastructure' under TICCS.

Different classifications subdivide the infrastructure universe in different ways making the comparison of infrastructure sub sectors difficult across schemes and frameworks. Using different definitions/classifications for the infrastructure sector (or not using any and lumping all infrastructure together) leads to a varied coverage of infrastructure sub-sectors by different schemes and frameworks.

The reviewed schemes and frameworks also define ESG differently: although there is a broad consensus on what constitutes an environmental, social or governance issue, there is no agreed upon taxonomy detailing the ESG impacts and risks relevant to infrastructure companies. Likewise, there is no apparent consensus on suitable metrics or indicators that could be used to measure these. Table 7 shows that the schemes reviewed use between 37 and 945 individual indicators (refereed to as criterion by SuRe, accounting metric by SASB, reporting requirements by GRI Standards, indicator by GRESB Infrastructure Assest Assessment, issues by MSCI ESG Ratings, credits by IS Rating Scheme, themes and controversy labels by Refinitv ESG Scores, assessment criterion by CEEQUAL and credits in Envision rating tool) for reporting or assessing ESG performance.

While the common goal of ESG standards is to certify ESG performance (e.g. SuRe) or serve as a reporting guideline (e.g. SASB, GRI Standard), each standard is built using a different perspective on ESG. For example, SASB and GRI are both reporting frameworks meant for companies, but are developed for different audiences and approach ESG disclosures from two opposing perspectives: SASB requires the disclosure of sustainability information relevant to financial investors i.e. data that could affect investment decisions. On the other hand, the GRI standards take an all-encompassing approach to allow a wide variety of stakeholders to understand and communicate the sustainability impact of companies. In other words, SASB tries to capture *impacts on the company* and its financial performance i.e. risks, while GRI focuses more on the *impact of* the company.

For example, looking at water sourcing, SASB captures sourcing risk by requiring companies to report the total volume of water sourced from regions with high or extremely high baseline water stress and the percentage of water purchased from a third party (The SASB Foundation, 2018g, p 29). The GRI standard aims to capture a larger picture of water sourcing and requires the reporting of the total volume of water withdrawn from all areas including areas with water stress. This is accompanied by reporting the breakdown of this total volume by sources including : groundwater, surface water, seawater, produces water and third

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party water (GSSB, 2018, p 9). Such metrics, while both looking at water sourcing, address the issue on a different scale and answer different questions.

As well as varying definitions of infrastructure and ESG, reviewed schemes and frameworks have different aims. The purpose of ESG tools is to either rate and score (GRESB Infrastructure Asset Assessment, MSCI ESG Ratings, CEEQUAL, IS Rating Scheme, Envision Rating Tool, RePRisk Index and Ratings, Refinitiv ESG Scores) or classify (EU Taxonomy) ESG performance. Standards, meanwhile, are meant to provide a certification of ESG performance (The SuRe Standard) or serve as a reporting guideline (SASB, GRI Standard). Still, in practice they can have very different aims. A summary analysis of the aims of the various schemes is presented in table 3:

Another reason for the scope divergence of ESG schemes and frameworks is the nature of their curators and end users, as shows in table 4: ESG standards and guiding frameworks have all been developed by international, independent, not-for-profit organisations and foundations, whereas tools are largely developed by for-profit entities who are in the business of quantifying and benchmarking the ESG performance of companies. The same table shows that different ESG schemes and frameworks also tend to focus on different end-user groups, namely:

- Financial investors (e.g. fund managers, pension funds, insurance companies, institutional investors and sovereign funds)
- Infrastructure companies (e.g developers, operators, engineers, architects and managers) who use ESG schemes to identify and act on the most important ESG issues likely to impact operating and financial performance, enable clear communication by systematically reporting useful information to stakeholders, pinpoint areas of improvement and prove compliance with internal policies and international standards.
- Regulators (e.g. governments and international organisations, prudential and sector regulators)

Thus, we find significant scope divergence built into ESG schemes and frameworks for infrastructure investors simply because of the absence of a unified definition of infrastructure and of a certain lack of clarity of what performing well in ESG terms means for an infrastructure company, in particular, whether ESG risks (the impact on the company) or ESG impacts (of the company) are what is at stake.

2.2.4 Weights

Weight divergence between schemes comes from a difference of views between ESG ratings providers on what can be considered a first-order question for a given investment, and what is less important, that is, what is "material" and what is not.

The terms "material" and "materiality assessment" are extensively used in the documentation covering ESG performance. The notion of materiality determines the requirement to measure and report certain

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Table 8: Materiality Assessment Methodologies

Scheme	Materiality Assessment Methodology
SuRe	Done by users at a starting point. Revised by an independent third party (certification body) and subject to public consultation before being finalised.
SASB	Self materiality assessment guided by the SASB standards which are designed to identify a minimum set of sustainability issues most likely to impact the operating performance or financial condition of the typical company in an industry, regardless of location. The SASB materiality map is available to understand disclosure topics across industries.
GRI Standards	Self materiality assessment guided by the stakeholder Inclusiveness and the Materiality principles documentd by GRI. GRI sector disclosures also offer guidelines in assessing the material topics.
GRESB Infrastructure Asset Assessment	The GRESB Materiality and Scoring tool consists of a survey, plus answers to other reporting characteristics, that determine the materiality of ESG issues based on 15 factors. Users provide data for this assessment which assigns a materiality (no relevance, low relevance, medium relevance, high relevance)to each of the 46 ESG issues of the asset assessment. The materiality is fixed for seven of the 46 issues. The weighting derived from this assessment goes into the materiality-based scoring conducted by GRESB.
MSCI ESG Ratings	A two-level materiality assessment is performed by MSCI which looks at the industry and the specific characteristics of any given company.
IS Rating Scheme (Australia and NZ),	A weightings assessments within the IS Rating tool is undertaken by the stakeholders and/or the individual assessor. This is verified by the ISCA case manager. This assessment helps to determine the materiality score for each topic. The materiality scores range from 0 to 4 (0 being not material, 1 indicating low materiality, 2 indicating medium materiality, 3 indicating high materiality and 4 indicating very high materiality). These scores help adjust the credit weightings from their defaults.
RepRisk Index and Ratings	NA
Refinitiv ESG Scores	Materiality for Refinitiv ESG is defined in the form of category weights. Category weights are calculated to determine the relative importance of each theme to each individual industry group. Based on the themes covered in each category, data points with sufficient disclosure are used as proxies for industry magnitude. This means that the weights are automatically and dynamically adjusted as ESG corporate disclosure evolves and matures. The weights of all relevant categories together inform the ESG magnitude matrix.
EU Taxonomy	NA
CEEQUAL (International)	Materiality in CEEQUAL is used to eliminate questions or factors that are not relevant to the project. Questions classified as "NSO" cannot be scoped out of the assessment for any project. The assessor (member of the project team certified by CEEQUAL) conducts a scoping process to account for materiality and proposes a set of relevant evaluation questions to the project verifier (independent third party certified by CEEQUAL) for approval.
Envision rating tool	No direct approach to materiality. However individual credits can be omitted from consideration by desginating them as "not applicable". An explanation and supporting documentation as to why the credit is not applicable is only required for projects pursuing the verification tract.
Sustainability and Resilience SmartScan	NA
PRI	NA
Equator Principles	NA
IFC Environmental and Social Performance Standards	NA
PPIAF	NA
SDGs	NA

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data, and how much *weight* should be assigned to individual measurements calculating the ESG score of a company. Recent research suggests that firms with strong ratings on material sustainability issues may have better future performance than firms with inferior ratings on the same issues. In contrast, firms with strong ratings on immaterial issues may not outperform firms with poor ratings on these issues (Khan et al., 2016). Thus, a critical part of any ESG scoring scheme consists of determining what is material and what is not (Khan et al., 2016; SEC, 2020).

An early definition of financial materiality can be attributed to the US Supreme Court's interpretation of securities laws: that is, material information is defined as presenting a substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the total mix of information made available. [5]

5 - TSC Industries v. Northway, Inc., 426 U.S. 438, 449 (1976).

In effect, the question of materiality is dual: what is material and to whom?

In relation to an ESG scheme or framework, the second part of this question is that of the intended users already evoked above. For example, in the Supreme Court view above, materiality is interpreted as a threshold beyond which the economic decisions of investors may change, which is also a common interpretation in financial reporting. However, other stakeholders may find non-financial consequences to be more material. Hence the recurring matter of what is at stake in infrastructure ESG schemes and the lack of a clear 'centre of gravity' to establish what matters and to whom.

Table 4 shows that SuRe, GRI, GRESB, RepRisk, EU Taxonomy and CEEQUAL are schemes that cater to multiple user types. Given that different users require different *types* of information, the schemes leave it up to the users to derive the information that they need from the reported data (contingent on certain rules and guidelines). While this practice is appropriate for the purposes of the reviewed schemes, it makes it difficult to answer the second part of the above question objectively. We return to this point in the next chapter when we put forward our taxonomy of ESG Risks and Impacts with a focus on investors in infrastructure companies.

Turning to the 'what' in the notion of materiality, in the schemes we reviewed, different approaches are used to identify the set of material issues that are counted towards a final ESG score. Each scheme includes guidelines to help undertake materiality assessments and there is a degree of overlap if not full consensus in what is expected to be reported: e.g., a power plant should almost always report its carbon footprint. But the choice of method and metrics used is usually open-ended (e.g. scope 1, 2 or 3 for GHG emissions), etc. For example, several of the assessed ESG schemes give users the flexibility to omit disclosures based on their own materiality assessments and individual judgments:

- The Sure standard consists of 61 criteria. Out of these, compliance with the 22

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Safeguarding Red Criteria criterion is mandatory. Opting out from Safeguarding Red Criteria is not allowed, except in special cases where the non-materiality of specific criteria has been identified as a result of the materiality assessment and is supported by evidence which has been reviewed and approved by an accredited SuRe auditor. In addition, the SuRe standard includes two general requirements for compliance: a materiality assessment and an overarching reporting requirement. While users can opt out of the remaining 39 criteria, compliance with a certain number of them is required depending on the level of certification sought and the materiality of the criteria.

- SASB has no set compliance requirements. A company determines which standard(s) is relevant to it, which disclosure topics are financially material to its business, and which associated metrics to report, taking relevant legal requirements into account.

- GRESB does not require users to report data for their entire portfolio, giving them the choice to omit information about specific components of their portfolio when reporting. Further, even under each category, GRESB gives users certain allowable exclusions, i.e. the users can choose to not report on all sub-sections. However since 2019, GRESB requires users to report the facilities, activities, sources and scope that were excluded from performance data reporting. It is noteworthy that exclusions are not penalised within the current scoring framework.

- Within the framework of CEEQUAL, the criteria that can be scoped out are clearly listed in the documentation- if a specific criterion is excluded, the points associated with that criterion are lost.

- Envision allows credits to be omitted from consideration by allowing them to be designating as "not applicable". However, this can only be done for cases where the sustainability indicator addressed by the credit does not exist for the project being evaluated. There is no penalty for items that are not applicable. For projects pursuing ISI's third-party verification program, an explanation and supporting documentation as to why the credit is not applicable to the project is required.

We also find that in a majority of cases, these self assessments are not subject to any verification or audit. Only a small number of schemes require materiality assessments to be verified or audited, or at least conducted by an accredited professional or even directly by the standard provider.

The approach to materiality assessments found in the various ESG schemes reviewed is presented in table 8. Clearly, there is considerable divergence not only between schemes but also between reporting firms, since users can determine which factors and which data to report. Thus, while differences in weight contributed little to divergence between schemes in the Berg *et al.* study, it is likely to be a substantial source of

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divergence between ESG schemes for infrastructure investors.

There have been targeted efforts to standardise materiality assessments such as the SASB Materiality Map. However, this map is designed at the level of industries and sectors, presenting issues likely to be material for more or less than 50% of industries in any given infrastructure sector (The SASB Foundation, 2018c). This and other schemes leave a lot of room for interpretation at the user level, despite the fact that subjective and discretionary definitions of materiality are problematic for at least two reasons: First, when self-reporting materiality, companies have some control over the weights of different inputs that go into their ESG assessment and letting companies determine the materiality of their reporting creates opportunities for them to bias results and could lead to so-called 'decoupling' i.e. a gap between the reality of ESG profiles and what is reported.

Second, the fact that companies find certain ESG issues not to be material suggests that disclosures have been constructed as laundry lists containing all possible issues, rather than constructed on the basis of a relevant theoretical framework, which would provide an objective basis for the prioritisation and tailoring of ESG issues, and comparison across companies within the same category.

Instead, materiality would ideally be defined *ex ante* in objective, technical and quantifiable terms, in terms of what issues are truly of the first order - given the asset type, technology, location and corporate structure of each infrastructure company - and should not be a simple list of issues that are considered to be the most relevant for a particular user. We return to this in the next chapter: without a theoretical framework, it is impossible to create something more than just a list.

In the case of infrastructure companies, defining first-order questions in terms of their ESG risks and impacts is made more straightforward by the fact that, following the TICCS view of infrastructure, their activities are the result of sunk investments in large, immobile physical assets that can usually be used solely for only one purpose.

Hence, defining what is material and what is not should be primarily a matter of design and engineering, location and regulation. In other words, it is possible to define materiality profiles for infrastructure companies that are objective and fact-based. We return to this point in the following chapters.

2.2.5 Measurement

Measurement divergence between schemes corresponds to a situation in which the same indicator is estimated or computed using different underlying data or metrics by different rating providers.

There are two approaches to data collection in the ESG schemes we reviewed:

- Contributed or self-reported data: SuRe, GRESB infrastructure asset assessments, CEEQUAL international, the IS Rating Scheme, SASB, GRI standards, GIB Smart

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Table 9: Collection of ESG Data

Scheme	Self-Reported Data and Assessments	Derived Data
SuRe	Self reported data, self materiality assessment.	NA.
SASB	User determines which standard(s) is relevant to the company, which disclosure topics are financially material to its business, which associated metrics to report and how to report them.	NA.
GRI Standards	User determines what to report within the GRI framework.	NA.
GRESB Infrastructure Asset Assessment	User completes assessment and provides supporting documentation.	NA.
MSCI ESG Ratings	NA	The following sources are used: publicly available company disclosure documents, media publications and governmental regulatory and NGO datasets.
IS Rating Scheme (Australia and NZ)	The scheme is applied by an in-house sustainability professional who should be an Infrastructure Sustainability Accredited Professional (ISAP).	NA.
RepRisk Index and Ratings	NA	Capture and analyse information from media, stakeholders and other public sources external to the company.
Refinitiv ESG Scores	NA	The following public data sources are used: company annual reports, company websites, stock exchange filings, CSR reports, NGO websites and news sources.
EU Taxonomy	Financial market participants offering financial products in Europe must now incorporate disclosures with reference to the Taxonomy. Companies subject to disclosure requirements under the Non-Financial Reporting Directive (NFRD) must make disclosures with reference to the Taxonomy. The EU and Member States, when setting public schemes, standards or labels for green financial products or green (corporate) bonds have to comply with the taxonomy.	NA.
CEEQUAL (International)	User provided data	NA.
Envision rating tool	Self assessment	NA.
Sustainability and Resilience SmartScan	Self assessment	NA.
PRI	Signatories complete an online assessment.	NA.
Equator principles	NA.	NA.
IFC Environmental and Social Performance Standards	Client provides key information on assets and management of E and S risks and impacts.	NA.
PPIAF	NA.	NA.
SDG	NA.	NA.

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Table 10: Outcome of ESG Schemes

Scheme	Certification	Score	Rating	Other
SuRe	Bronze, Silver, Gold	-	-	-
SASB	-	-	-	A guideline on what to report
GRI Standards	-	-	-	A guideline on what to report, giving the organisation the right to claim that its sustainability report is in line with GRI standards or make a GRI-referenced claim for a sub-set of disclosures
GRESB Infrastructure Asset Assessment	-	Absolute scores ranging from 0-100, a scorecard, detailed benchmark report	Peer and overall GRESB universe ratings	-
MSCI ESG Ratings	-	-	AAA to CCC relative to industry peers	Company reports, industry reports, thematic reports, analyst calls and webinars
IS Rating Scheme (Australia and NZ)	Commended, Excellent and Leading	Absolute scores ranging from 0-100	-	-
RepRisk Index and Ratings	-	Absolute Score ranging from 0-100. Three RepRisk Indices (RPI) are provided : Peak RRI (highest RRI in last two years), Current RRI and the RRI for change or trend	Overall ratings from AAA to D	The RepRisk UN Global Compact Violator Flag: A flag (red or yellow) that identifies companies with a high risk or potential risk of violating one or more of the ten UNGC Principles
Refinitiv ESG Scores	-	Percentile and absolute (0-100) ESG Score, ESG Controversies Scores and ESG combined Scores. Industry and country benchmark scores available	A+ to D-	-
EU Taxonomy	-	-	-	A list of economic activities assessed and classified based on their contribution to EU sustainability related policy objectives
CEEQUAL (International)	-	Absolute Score ranging from 0-100	Outstanding, Excellent, Very Good, Pass, Unclassified	-

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Table 11: Outcome of ESG Schemes (continued)

Scheme	Certification	Score	Rating	Other
Envision rating tool	-	-	Verified, Silver, Gold, platinum	-
Sustainability and Resilience SmartScan	-	-	-	Spider diagram of project performance on 14 themes; Recommendations for improvement
PRI	-	-	-	Public Transparency Report, Private Transparency Report, Assessment Report
Equator principles	-	-	-	Set of guiding principles
IFC Environemtnal and Social Performance Standards	-	-	-	Credit risk assessment and subsequent financing of a project
PPIAF	-	-	-	knowledge and technical assistance grants
SDG	-	-	-	International development goals

Scan and the Envision rating tool: rely on user reported data to conduct an ESG assessment.

- Calculated or derived data: MSCI ESG Ratings, RepRisk index and ratings and Refinitiv ESG Scores use data from publicly available company disclosures and other sources external to the company such as media publications, news sources, NGO and governmental websites and data sets to conduct and ESG assessment.

An summary of the approach that the various schemes take to collect ESG data is presented in Table 9.

ESG schemes that use self-reported data have the ability to capture more granular metrics – information that is known only to the companies reporting the data. These schemes are also the ones that cater to the infrastructure sector specifically (see table 5, and table 6), tend to cover a range of more relevant topics and can thus most of them can meet the requirements of all user types (Regulators, companies and financial investors).

However, relying only on self-reported data (verified or otherwise) can be problematic since it opens the potential for selective reporting by companies (the so-called 'decoupling'). For instance, the UK utility Southern Waters was fined GBP126m by its regulator (Ofwat) in June 2019 for failing to prevent sewage spills over seven years and subsequently manipulating disclosures to avoid penalties Plimmer and Provan (2019). Nevertheless, it received a five-star rating from GRESB, one of the tools that provides a rating based on validated self-reported data.

Conversely, schemes that do not require users to report data are the ones that are not infrastructure specific: granular ESG data is generally not available in the public domain and they have to use a lowest common denominator in their data standard. Mainly catering to financial investors, these schemes typically capture generic metrics and offer

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macro perspectives on the ESG performance of companies with operations in (one or) multiple sectors beyond infrastructure.

Beyond the matter of self-reported vs observed data, two more issues drive measurement divergence between schemes: first, even if an indicator is consistent, the way it is measured and reported is not. For example, in assessing the greenhouse gas emissions, SASB, GRESB infrastructure asset assessment, GRI standards, Refinitiv ESG Scores and the SuRe standard all ask for the reporting of greenhouse gas emissions in metric tons of carbon-dioxide equivalents (i.e. output indicators). However, even though the metric captured is the same, the level of detail and associated reporting requirements vary between the schemes. For example, GRESB infrastructure (GRESB, 2020b, p 140) asks users to report greenhouse gas emissions but allows choosing the methodologies that can be used to calculate them. They do require disclosure of whether this assessment has been reviewed by external parties and/or if the methodology is aligned with the Science-Based Targets Initiative (GRESB, 2020b, p 141). It also allows users to exclude reporting emissions from specific facilities, activities and sources within their portfolio, that they do not wish to disclose. Even though exclusions have to be accompanied with a declaration, they do not impact the final score (GRESB, 2020b, p 142). In fact, the reporting of scope 2 emissions methodology, external data review, science-based targets and exceptions were not scored in 2020 (GRESB, 2020b, p 70). On the other hand, the SuRe standard (GIB, 2018a, p 11) offers a comprehensive guideline on the emissions calculation methodology to be followed by different users and projects seeking a higher compliance rating within SuRe have to report scope 3 emissions at least for the first tier of suppliers and contractors.

Second, for a number of metrics, a consistent view on what should be reported or measured often does not exist. For example, when it comes to assessing the anti-corruption practices and policies of a company, the GRI standards call for the reporting of operations assessed for risks related to corruption (i.e. a process indicators) (GSSB, 2016b, p 7), of the communication and training about anti-corruption policies and procedures (i.e. process indicators) (GSSB, 2016b, p 8), and of the confirmed incidents of corruption and actions taken (i.e. output indicators) (GSSB, 2016b, p 9). The SuRe standard, however, approaches this indicator differently and requires the project owners to develop an anti-bribery and corruption management system (GIB, 2018a, p 48) aligned with Good International Industry Practice and Standards, and which is at least as stringent as that articulated in the Transparency International Business Principles for Countering Bribery and International Organization for Standardization (ISO) 37001 – Anti-Bribery Management Systems (this could be viewed as a process, outcome or output indicator). Finally, Refinitiv does not rely on reported data, but uses the number of controversies (i.e. output indicator) published in the media linked to anti-competitive behaviour (e.g., anti-trust and monopoly), price-fixing or

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kickbacks to proxy an (anti) corruption metric (Refinitiv, 2020, p 17).

A critical aspect of undertaking an ESG assessment is collating data. Even though the assessed measures look to capture similar metrics, they rely on an array of data sources and data collection methodologies to do so. Accounting for any given metric may require the reporting of a precise calculated number, simply involve completing a qualitative checklist that only requires indicating if the relevant ESG measure is in place or require no reporting as the measure uses only external data sources to assess the reputation of the company in regard to the metric in consideration. These differences do not make any scheme better than the other, they only indicate that schemes have a measurement divergence as they capture data in a manner most suited to their purpose and methodology, which does not overlap.

Thus, as was the case in the Berg *et al.* study, measurement divergence is significant amongst ESG schemes for infrastructure investors.

2.2.6 Aggregation

ESG ratings are also the result of aggregation rules applied to the underlying data. Here too, significant divergence is possible. Most of the schemes we review produce ratings or scores. These measures are typically not directly additive. Yet, most of the schemes reviewed in this study produce a single compound score or rating that aggregates all aspects of the ESG characteristics of infrastructure companies and assets. In some cases this is supplemented with other addition reports, scores and ratings.

It is worth mentioning that while schemes produces a range of outputs, users are free to use these outputs in addition to underlying data as a basis for their decisions.

A summary of the output of the various schemes is presented in table 10 and 11: tools lead to a score or rating. Several schemes provide scores out of 100, but the same score from two different schemes does not indicate the same level of ESG performance. Rating of ESG performance use different scales that are not related: MSCI ESG ratings range from AAA to CCC and are awarded relative to industry peers; RepRisk follows a rating system that ranges from AAA to D, while Refinitiv ESG ratings are presented from A+ to D-. CEEQUAL and the Envision rating tool follow their own rating tiers: "outstanding, excellent, very good, pass and unclassified" for the former and " bronze, silver, gold and platinum" for the latter.

The assessment methodologies followed by the various schemes are presented in table 12 and 13, which confirm that direct comparisons between schemes are not possible. The incoherence of adding ESG scores has been noted before: a company's activities could result in environmental or other negative impacts that are not mitigated by transparent governance or high safety standards for its own workforce. This practice may also be a source of decoupling since many ESG issues, however 'material' in the absolute (e.g. gender equality), are not direct substitutes

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for what should be considered first-order issues in certain infrastructure sectors (e.g. burning coal in the electric power sector). Combining metrics and aggregating empirically and conceptually distinct ESG constructs can thus mask important differences between companies in terms of their impact and risk characteristics. (Mattingly and Berman, 2006)

Jay Clayton, the former chairman of the SEC said as much in May 2020 when he warned about the risks of relying on simplistic ratings when considering environmental, social or governance issues as part of an investment decision. The Financial Times reported Mr. Clayton as saying: "I have not seen circumstances where combining an analysis of E, S and G together, across a broad range of companies, for example with a 'rating' or 'score', particularly a single rating or score, would facilitate meaningful investment analysis that was not significantly over-inclusive and imprecise." (Financial Times May 28, 2020)

Instead of taking the arithmetic mean of social, environmental and governance scores, final ESG scores could be conditional on, for example, meeting minimum thresholds in each ESG aspect, that could be used to exclude assets from portfolios. The SuRe standard aims to do this by using their Red Criterion (GIB, 2018a, p 11), The CEEQUAL uses minimum standards of performance (BRE Global, 2019, p) while the EU Taxonomy follows the same principles by means of the Do No Significant Harm (DNSH) requirements (TEG, 2020).

Thus, we conclude that aggregation divergence between ESG schemes for infrastructure investors is thus just as significant as it is for other types of investments.

2.3 Divergence, Overlap and Consolidation of ESG Schemes

Prima facie, the ESG schemes and frameworks we reviewed have some broad common objectives, in particular:

- Better ESG identification and management: these schemes and frameworks all aim to enable individual infrastructure companies to manage ESG by helping them identify, assess, avoid, mitigate and monitor material ESG issues likely to impact their operating performance or financial conditions. They can help companies and their owners understand resilience and risks and inform their sustainability strategies.

- Better ESG reporting and regulation: standards all aim to support public policy and the regulation of the negative ESG impacts of infrastructure companies by helping create better compliance with regulations and international commitments through improved standardisation of reporting and evaluation.

In practice, as discussed above, the schemes and frameworks reviewed diverge substantially in scope, weighting and aggregation rules and measurement. This divergence is characteristic of the earlier phase of development of voluntary standards and norms.

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Table 12: Assessment Methodology of ESG Schemes

Scheme	Assessment Methodology
SuRe	• Prelimnary self materiality assessment based on SuRe materiality assessment methodology. • Appointment of a SuRe accredited certification body to carry out the full assessment, including auditing. • The certification body revises the materiality assessment and submits the results for public consultation. This is revisited after the consultation process of 30 days. • Independent third party audit based on desk review leading to certification. • Annual reporting and surveillance audits. • Re-certification in five years.
SASB	• Self materiality assessment. • Self selection of disclosure topics. • Reporting based on SASB guidelines.
GRI Standards	• The organisation can follow one of two routes: using the GRI Standards as a set to prepare a sustainability report in accordance with the GRI Standards or using selected or partial GRI Standards to report specific information • In the first the organisation can either report on the minimum required standards (core) or build on this by adding additional disclosures (comprehensive). • Notify GRI of the use of the GRI standards and the claims made in the report or published material.
GRESB Infrastructure Asset Assessment	• Self assessment. • Three step validation process by the GRESB/GBCI validation team. • Objective materiality based scoring, peer benchmarking. • Annual reassessment.
MSCI ESG Ratings	• Data is collected solely by MSCI. • Standardised proprietary methodology to assess company risk exposure and risk management relative to industry peers. • The data is verified by user companies. • Industry-specific key issues are scored using a proprietary rules-based methodology. • Key ESG Issue scores and weights combine to create an ESG rating. • Ratings are subject to industry and market-led checks and formal committee review. • Ratings are updated weekly while in-depth company review occurs annually.
IS Rating Scheme (Australia and NZ),	• Self assessment by an in-house assessor who is recommended to be a Infrastructure Sustainability Accredited Professional. • Undertake a weightings assessment to identify material issues by stakeholders and/or the assessor. • Verification by ISCA case manager and independent verifier(s). • Credit weighted based scoring and certification. • Re-certification per phase of the project.
RepRisk Index and Ratings	• Capture information from various sources. • Companies are invited to participate in a formal data verification process. • A score and rating (updated daily) is assigned to the company based on proprietary system.
Refinitiv ESG Scores	• Capture information from various sources. • Calculate category weights using the Refinitiv ESG materiality matrix and develop the magnitude matrix. • Category weighted-based scoring is used to produce pillar scores and ESG scores. • ESG controversies score is calculated based on recent controversies in the latest assessment period. • ESG combined scores are calculated. • Annual re-assessment.

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Table 13: Assessment Methodology of ESG Schemes (continued)

Scheme	Assessment Methodology
EU Taxonomy	• Companies subject to disclosure requirements under the Non-Financial Reporting Directive (NFRD) must make disclosures with reference to the Taxonomy. • Financial market participants offering financial products in the EU, including occupational pension providers, are required to make Taxonomy disclosures. • Disclosures are mandatory for certain types of products or offerings, and on a comply-or-explain basis for all others. • The EU and Member States, when setting public schemes, standards or labels for green financial products or green (corporate) bonds, have to comply with the taxonomy.
CEEQUAL (International)	• Five different assessments can be undertaken: whole project, strategy and design, design only, design and construction and construction only. • A member of the project team that has completed a certification by CEEQUAL (assessor) undertakes a scoping process to account for materiality which is approved by an independent certified third party (verifier). • Self assessment completed by the assessor. • Subsequent external validation and scoring by the verifier. • Re-certification per phase of the project.
Envision rating tool	• Self assessment. • Scores are generates using a publicly available scoring system. • Optional third party verification is conducted. • Re-certification per phase of the project.
Sustainability and Resilience SmartScan	• Self assessment. • Optional evaluation by GIB.
PRI	• Self assessment. • Independent evaluation by PRI.
Equator Principles	• Adoption of Equator Principles by users.
IFC Environmental and Social Performance Standards	• Client provides key information on assets and management of environmental and social risks and impacts. • IFC team generates an environmental and social review summary and an environmental and social action plan. • Plans are reviewed and approved by the client. • Plans are publicly disclosed and consultations with the local community are held. • The investment agreement that reflects the terms of the environmental and social action plan and other commitments is drawn out. • Funds are disbursed to the client. • Ongoing monitoring and disclosure activities continue.
PPIAF	• PPIAF promotes knowledge transfer by capturing lessons and funding research and tools.
SDGs	• Users aim to meet the international development goals set by the United Nations.

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It should also be noted that, in the absence of coherent regulation and consolidated standards, ESG reporting divergence is also driven by cost considerations. Clearly, the quality and granularity of any given scheme is proportional to the resources required to complete and maintain the resulting ESG score or rating. Indeed, the costs of using these different schemes we reviewed varies considerably:

- The SuRe certification, depending on the CapEx and project stage, takes two to six month to complete, costs USD30K- 60K (GIB, 2018c, p 12)) and has to be repeated every five years.

- The GRESB reporting portal is open for reporting for four months each year, but the time required to complete the reporting is typically 1 to 4 weeks. An Assessment participation fee of EUR 4,000 applies for every submission. This fee remains the same as the fee for a single entity in 2020 and will be fixed for the next three years. For participants with a large number of participating portfolios, the total Assessment participation fee will be capped at EUR 36,000.

- The IS Rating scheme for Australia and New-Zealand (version 2.0) is similar, taking three months for completion and following different fee structures for members and non-members. This analysis is done per phase of the project with fees ranging from AUD17.9K to AUD76.4K (ISCA (2020)) in 2020.

- An Envision rating is received within three months and is subject to a verification cost that ranges from USD9k to USD56K depending on the project size and verification pathway chosen (ISI (2020)). The verification is done post construction or post design and construction phase.

- MSCI ESG Ratings or Refinitiv ESG scores do not cost anything to the firms being rated and are updated regularly.

Despite this divergence, ESG schemes for infrastructure investors are on a path to consolidation. They started appearing after 2003 and have proliferated since 2015. This stage of their development is still happening. But given the international nature of infrastructure investors, competing standards are inconvenient and some consolidation will be necessary. As investors also buy and sell infrastructure companies from one another, they will benefit from a common standard of ESG assessment and reporting.

The work done by a number of organisations to develop and roll out such standards in a relatively short period of time has in fact created a very positive dynamic for ESG reporting and measurement in the infrastructure sector. These schemes have identified numerous aspects that are relevant to ESG in infrastructure and proposed a range of ways to report information about them. Investors are currently faced with a wide choice of alternative schemes, but lack clarity on their relative strengths to guide them on the selection of a suitable standard for their needs.

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Like other accountability standards, ESG schemes will eventually move from the initial phase of innovation and experimentation towards consolidation and maturity. Within ESG schemes, there is already momentum towards enabling consolidation. Initiative such as the "Aligned Set of Sustainability Indicators" (ASSI) (GIB, 2021) that enable meta-governance of ESG schemes have now started to emerge to aggregate standards including between GIB (SuRE), ISCA, ENVISION, CEEQUAL and GRESB with the support of PPIAF (Public-Private Infrastructure Advisory Facility of the World Bank Group). Another example is The " Common Set of Aligned Sustainable Infrastructure Indicators" (SII) (Inter-American Development Bank , 2020) by the MDB Infrastructure Cooperation Platform (Inter-American Development Bank) that consolidates the Green, Resilient, Inclusive and Sustainable (GRIS) Indicators by the Asian Development Bank (ADB), The Infrastructure Indicators within the Compendium of Indicators developed by the European Bank for Reconstruction and Development (EBRD), the Sustainable Infrastructure Framework (SIF) developed by the Inter-American Development Bank (IDB), The Quality Infrastructure Indicators Framework (QII), by the International Finance Corporation (IFC) and the afore mentioned Aligned Set of Sustainability Indicators (ASSI) developed by the Public-Private Infrastructure Advisory Facility.

In addition, regulatory pressures are also increasing as policy-making bodies attempt to impose ESG taxonomies and to promote climate change impact measurement, which will require certain metrics to be recognised and reported to regulatory entities. Central banks and prudential regulators are also increasingly interested in 'green finance' which often means infrastructure investment and will be requiring standardised definitions and qualifications of these investments under various financing schemes and mechanisms.

While it remains to be seen how infrastructure ESG standards will evolve and consolidate, the following developments can support the harmonisation of existing ESG schemes:

1. **Infrastructure Definition**: The adoption of clear and consistent definition of what infrastructure investment refers to. This is possible since the development of TICCS, which at least one ESG rating organisation (GRESB) already uses;

2. **Infrastructure ESG Taxonomy**: a scientific taxonomy (a classification system) that is part of an ontology of ESG impacts and risks from the point of view of infrastructure owners and managers. This is essential to clarify the role of ESG in infrastructure investment and move beyond the 'laundry list' approach to structuring ESG reporting standards. In particular, as we discussed above, a 'centre of gravity' is needed to untangle the myriad of causes and consequences that are included in ESG considerations. In the next chapter, we propose to focus the development of ESG data on the 'infrastructure company' as the primary unit of account for infrastructure investors and to develop a taxonomy of risks and impact from that perspective;

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3. **Objective Materiality Profiles**: For each class of ESG risk and impact thus identified, it becomes possible to develop evidence- and science-based, objective 'materiality profiles' for different types of infrastructure asset, themselves well-defined as per point 1. In other words, for each type of infrastructure investment as defined by TICCS, and within each class of ESG risks and impacts, a list of relevant attributes can be drawn that is also designed to be observable and measurable and leaves little or no room for interpretation.

In the rest of this paper, we address these points and, building on the TICCS taxonomy, develop a new taxonomy of the ESG Risk and Impacts of infrastructure companies and their assets, and discuss the development of a scientific standard for materiality assessments and its measurement. We also use the proposed taxonomy to conduct a quantitative analysis of existing ESG schemes and assess quantitatively the extent of their divergence.

3. A Taxonomy of Infrastructure ESG Risks and Impacts

3. A Taxonomy of Infrastructure ESG Risks and Impacts

In this chapter, we discuss an approach to developing ESG metrics in a scientific manner and introduce a taxonomy of ESG risks and impacts for infrastructure investors that will serve as the basis for the rest of our analysis of existing ESG schemes.

This taxonomy also aims to create an analytical framework of the ESG issues found in the infrastructure sector: an *ontology* of ESG for infrastructure investment, including a taxonomy which is objective, parsimonious of ESG risk and impact classes that are, by design, applicable to any infrastructure companies, ensuring comparability and consistency in subsequent measurements.

In what follows, we first return briefly to the role of ESG in infrastructure investment decisions. We then discuss the design of an ontology of ESG i.e. a system of ESG investment knowledge. Next, we introduce our taxonomy of ESG impacts and risks for investors in infrastructure. Finally, we discuss how from the point of view of investors, ESG impacts and risks are in effect related to each and emphasise the role of impacts as factors of risk.

3.1 ESG Reporting and the Investment Process

The intended users of ESG investment knowledge are investors in infrastructure and their regulators. We want to focus on the development of ESG metrics that are relevant to the investment decisions made by the buyers and sellers of infrastructure companies (equity investors) or their creditors (debt investors). The many other stakeholders that may have an interest in the ESG characteristics of infrastructure are out of scope.

As stated in the introduction, investors may decide to take ESG into consideration in their infrastructure investment decisions for three reasons:

- Motive 1: because ESG explains asset prices directly today;
- Motive 2: because ESG explains asset prices conditionally on future and uncertain events like regulatory or climate change; and lastly,
- Motive 3: as a matter of principle, because certain activities or behaviours are considered undesirable by some investors, irrespective of their relationship with asset prices.

In practice, institutional investors and their members or beneficiaries have long-term investment and consumption goals (in real terms) and their primary mission and objective is to achieve these goals to serve the function for which they exist e.g. provide retirement income or life insurance. When ESG considerations amount to implementing rule- or principle-based constraints on the investment process (Motive 3), while this can be perfectly laudable, it does not *per se* help these investors achieving their financial goals, which is the primary reason why collective investment schemes exist. In effect, the choice of these constraints is unrelated to these long-

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term investment objectives, which must now be achieved *in spite of* these constraints.

Of course, this choice of non-financial objectives can be perfectly legitimate and be explicitly part of the mandate of investors. It remains that such constraints pre-exist the investment and risk management process, which, once these constraints have been determined, still needs to be implemented and to integrate ESG from a financial perpsective.

Thus, to the extent that ESG considerations also relate to asset prices (Motives 1 and 2), ESG can also become a part of the investment process itself i.e. risk management. Thus, a **central question is that of the relation between ESG and asset prices i.e. ESG risks**.

Indeed, the most fundamental proposition of modern finance is that financial asset prices are formed as a result of the risks they create for their owners and their expectation to be compensated for taking risks. Infrastructure investments are financial assets i.e. their present value (or fair market price) corresponds to a risky (uncertain) stream of future payments to be made to their owners. At a fundamental level, the relationship between ESG and asset prices thus hinges around the question of what risks the ESG characteristics of an infrastructure company create for its owners. A cursory look at the issues at stake reveals that ESG considerations are very much related to the risks taken by infrastructure investors, whether we consider the debate on climate change, social acceptability or reputation risks.

Of course, ESG also matters to investors because of the significant social, environmental and economic *impacts* of infrastructure companies and the services they provide. In effect, various impacts of the activity of the firm are likely to contribute to or mitigate these risks. Understanding how ESG impacts relate to the formation of asset prices thus requires mapping their contribution to the risk profile of infrastructure companies.

Next, we discuss how creating an ontology of ESG for infrastructure investment can be the foundation of investment knowledge documenting the relations between classes of impacts and risk.

3.2 From ESG Ontology to Infrastructure Investment Knowledge

In the previous chapter, we established that existing ESG schemes about infrastructure investment are divergent in terms of scope, weights, measurement and aggregation. This is not surprising since the definition of infrastructure, the intended users and the objectives of these schemes all vary.

These ESG schemes have developed in response to an increasing *demand for monitoring* from investors, requiring more information than what is observable in the market price of assets to make investment decisions. Indeed, if all the information about the role of ESG in the financial performance of assets was already included in asset prices, new ESG reporting schemes of the type

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that have proliferated recently would be superfluous, except to exclude investments.

Since ESG schemes are still at an early stage in their development and consolidation, they have emerged in response to investors' demand for monitoring but as a series of lists and topics of more or less obvious interest, and without being a part of a broader framework that created knowledge. Instead, a scientific approach to the consolidation of ESG standards requires an *ontology* of ESG for infrastructure investment.

Ontologies (the study of 'what is') aim to represent entities, ideas and events, with all their interdependent properties and relations, according to a system of categories or taxonomy. A good example of ontology is Mendeleev's periodic table of elements: it does not only describe data on particles, but shows how matter is structured and how different particles interact. Famously, its theory-based design is such that it could integrate elements that had not yet been discovered at the time of its first publication.

Most fields of knowledge use ontological assumptions underpinning theories, research and applications. Objects and the relationships that can be described and measured through a formalised vocabulary and metrics represent the *knowledge* created through ontologies: ontologies create knowledge (here, infrastructure investment knowledge), which must be distinguished from mere data or information (clean data).

As with the periodic table, investment knowledge is created by processing data and information in the context of a theoretical *world view*, whether agents are aware of this view or not. For example, when investors use a listed equity beta to proxy the risk premia of unlisted infrastructure companies, they make several assumptions about the equivalence of listed and unlisted infrastructure and the validity of the capital asset pricing model (CAPM).[6] In practice, investor knowledge is not homogeneous and can be very variable. It can be limited or deep, flawed or based on robust hypotheses. Ultimately, investors have to use whatever knowledge of ESG and infrastructure investment they have to make investment decisions.

An ontology is simply a way of formalising a world view to be able to create the most useful knowledge, but also retrieve and manipulate it. In an investment context, what 'is' is simply *the market value of infrastructure companies and their determinants*. The main theoretical framework is modern asset pricing and portfolio theory. Related theoretical and technical frameworks include aspects of physics, geography, engineering or economics to represent the relations between the activities of infrastructure companies, society and the environment.

Existing ESG standards focus on describing various aspects of these activities, but they lack explicit theoretical foundations that would give meaning to these lists and data, and create knowledge for investors. A lot of ESG data may be collected today, but not a

6 - Both of which have been shown not to be robust.

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lot of ESG investment knowledge necessarily results from these efforts.

How should an ontology be designed? In an oft-quoted paper, "Toward Principles for the Design of Ontologies Used for Knowledge Sharing", Grüber (1993) highlights that ontologies are not limited to introducing terminology, but instead create new knowledge through axioms that constrain the interpretation and use of the terms employed, for example by creating 'integrity constraints' on the data. As an example, the distinction between ESG impacts and ESG risks should be consistent and explicit.

Moreover, the lists of metrics developed in existing ESG reporting schemes are typically not proper classification systems built using *classes*, class definitions, and subsumption relations (class inheritance) principles. Without a well-designed classification, these schemes cannot create a coherent *domain* of knowledge.

Grüber also argues that ontologies in information science are always the result of design choices, intentional or not, and emphasises the importance of *clarity* in this design: definitions should be objective, complete and when possible axiomised i.e. stated as logical relations or postulates, for example: "the social acceptability of infrastructure companies by its customers is a combination of the quality, affordability and accessibility of its service." Or: "if a company pollutes water resources, it has a negative impact on the environment beyond a threshold pollutant concentration or pollutant load ."

Well-designed ontologies also avoid specifying a level of precision that may not always be available in the data (so-called encoding bias) but instead focuses on defining the most relevant domain of knowledge.

The notion of relevant knowledge echoes that of 'materiality': if knowledge is defined in terms that are designed to answer fundamental questions in a given theoretical context, the information collected and used can only be relevant to the question at hand i.e. material. Whether it is based on high-level asset pricing mechanisms (e.g. there is a trade-off between risk and returns) or detailed physical or engineering specifications (e.g. low-lying airports are exposed to business disruption because of flood risk), a clear and objective terminology can incorporate these mechanisms and create knowledge.

In the end, ontologies are used to "define conceptual entities described by the data, rather than just specifying the data" (Grüber, 1993, p 15). This is precisely the issue with much of the ESG data collected today: it is not defined in relation to the conceptual entities that matter in the investment process, especially risks. Instead it tends to borrow from multiple world views, including those of investors but also customers, society and governments.

For example, whether an infrastructure company received an "ESG award" (not defined) which is sometimes requested in existing ESG schemes does not help document a key mechanism or answer any fundamental

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question about the asset. It is data but not knowledge.

Finally, Grüber highlights the notion of 'ontological commitment', which is the information theory equivalent of the reporting standard convergence described in the previous chapter: agents can commit ontologically to using a common vocabulary in a consistent manner. They do not need to share the knowledge itself (the knowledge base) nor to systematically address all aspects of the shared vocabulary, but only to report within the same framework. Ontological commitment is desirable and should be encouraged. To promote this, ontology design can minimise the required ontological commitment of agents "by specifying the weakest theory (allowing the most models) and defining only those terms that are essential to the communication of knowledge consistent with that theory" (Grüber, 1993, p 3).

Real-world ESG standard convergence thus requires an increasing ontological commitments by scheme users, which can only be facilitated by the creation of an explicit ontology.

3.3 Preliminaries

For a given knowledge *domain*, the minimal building blocks of ontologies are *instances*, *classes* (a taxonomy), *attributes* and *relations*. We return to each in turn to propose an ontology of ESG and infrastructure investment.

3.3.1 Domain

While there are numerous impacts and risks associated with infrastructure, creating an ontology of ESG for infrastructure investment requires bounding the notion of ESG to a well-defined domain of knowledge (or universe of discourse).

As we saw in the previous chapter, the various schemes reviewed do not agree on the scope of ESG reporting. Here, we propose to define the scope *heuristically*: first, we argued earlier that the recent development of non-financial reporting like ESG schemes *by investors* springs from the demand for monitoring by the same investors (Holmström *et al.*, 1993), implying that not all relevant information is currently available to them through asset prices.

As a result, assuming weakly efficient financial markets, the ESG domain of knowledge need *not* include the most direct impact of a business: the 'priced consumption' of its output; nor should it include risks that are already fully priced in markets, especially business and financial risks.

For example, the paid consumption of electricity by economic agents as a result of the activities of power generation, transmission and distribution companies is not an ESG impact. This is the case even if this consumption is only partly paid for by its direct users due to various subsidies across consumers, tax payers and generations. The direct consumption of the service, in this case receiving kilowatt-hours of power to operate various electrical equipment, is not an

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economic externality but direct consumption by households and businesses. This 'impact' is reflected in the asset prices of power companies (through their revenues). Likewise, if the future price of a kilowatt-hour of power or the demand for power are uncertain, this business risk of power companies is also reflected in asset prices.

Conversely, there are unpriced aspects of the activities of companies (externalities). For instance, The availability of power can have positive impacts beyond the operation of electric equipment by households and businesses e.g. there is a documented relationship between electrification and education outcomes (Sovacool and Vera, 2014). Power generation also has negative impacts (hidden costs), often characterised as market failures that could justify regulatory interventions (see for example Lee et al., 2010).

These aspects of the firm's activities are the reason for the demand in ESG reporting today: how much does infrastructure contribute or help mitigate climate change? Do infrastructure projects create local jobs? What is the risk of business disruption from extreme weather events? etc. If the answer to these questions was already fully integrated in asset prices there would be no need for additional ESG reporting, at least from the standpoint of managing the portoflio after excluding assets out of principle.

Instead, investors anticipate that *externalities, while unpriced, can have consequences* for the market value of infrastructure companies. Over time, a better educated population tends to be more affluent and have a higher demand for power. This impact on human development contributes to the business risk of power companies (the discount rate of future cash flows). Again, the negative environmental impact of power companies also creates regulatory risks.

To the extent that systematic non-financial reporting can be developed, implemented and trusted, this information can become integrated in the pricing of financial assets, to the extent that it helps better document the risks to which investors are already exposed or reveals new risks for which investors systematically require a premium. As non-financial reporting becomes as standardised and mandatory as its financial equivalent, this should increasingly be the case.

In the end, creating ESG investment knowledge does not change or remove economic externalities, it only makes them and their potential consequences for businesses more apparent and better documented. **It is the knowledge of the uncertain consequences of externalities, including on future regulation or cash flows, that can influence asset prices.**

In effect, the current demand for ESG reporting conflates two issues: 1/ a lack of knowledge about the impacts and risks of infrastructure companies and 2/ the more fundamental uncertainty that characterises these aspects of their activity. Addressing the first issue amounts to documenting the exposure (or beta) of a company to certain

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risks, while the consequences of ESG impacts and risks themselves for the firm remain uncertain, but can inform decision making and become a driver of the cost of capital.

Defining this domain of knowledge heuristically leaves it open to future revisions as ESG investment knowledge develops and becomes standard and integrated in valuations. This ontology is designed so that new and better information can be transformed into investment knowledge. As Infrastructure ESG knowledge develops, its definition can evolve from a heuristic ("What we do *not* know about ESG through asset prices today") to a more normative one, which can also serve as the basis for embedding non-financial reporting in mandatory rules.

Today, even the possibility of measuring certain aspects of the ESG profile of companies is not set in stone, as methods of data collection evolve and rely less on self-reporting (which creates a number of agency issues) and more on the direct observation of data and information, especially with the development of machine learning techniques.

Hence, we take a pragmatic approach and define the relevant domain knowledge for an infrastructure investment ESG scheme as those *ESG risks and impacts of investments in infrastructure companies* that can be expected not to be fully captured in current asset prices, and from which investors would therefore gain additional investment knowledge.

3.3.2 Instances

Individuals or instances are the most basic components of an ontology. In the knowledge domain defined above, we identify two type of instances: the *ESG risks and impacts of infrastructure companies*.

To identify infrastructure companies, we rely on The Infrastructure Company Classification Standard or TICCS®, a classification system used by investors and organised along four pillars for business risk, industrial activity, geo-economic exposure and corporate structure. These pillars define a several types of classes that any infrastructure companies must fall under: companies must qualify under at least one class in all four pillars, short of which the firm in question cannot be considered an infrastructure company. As required by Grüber's guidelines, TICCS provides a clear classification of infrastructure companies: classes all correspond to objective, observable aspects of individual firms. Incidentally, TICCS is also an ontology.

Next, an infrastructure company's ESG impacts and risk are the result of its activities, processes, operations and policies, all of which can have an *impact on* the environment, society and its governance, but also create *risks* stemming *from* the environment, society and its own governance.

This definition of ESG impacts and risks keep the firm (the investment) at the centre of the approach and creates a clear demarcation between which impacts and risks relate to ESG, and which ones do not. For example, the

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oft-mentioned 'transition risks' (risk inherent to the regulatory consequences of climate change for GHG-intensive businesses) are *not* ESG risks. Transition risks are business risks created by the *impact* of firms' activities on the climate (see for example Deloitte (2020)).

The relevance of transition risks for infrastructure businesses notwithstanding, instances of the transition risks of infrastructure firms can be measured by looking at their environmental impact (contribution to GHG emissions). In keeping with our world view ("ESG matters to investors because there is a trade-off between risks and returns"), the impacts of a firm can be treated as risk contributors or mitigants. Likewise, valid instances of the ESG risks of infrastructure companies must be directly created by environmental, social and governance factors and, following our heuristic approach to defining the relevant domain of knowledge, unlikely to be public knowledge already included in asset prices.

Next, creating knowledge about *instances of the risks and impacts of infrastructure companies* requires a classification system of these risks and impacts.

3.3.3 Classes

Classes are essential to creating knowledge because they allow both organising information about objects in accordance with a world view, but also to retrieve, compile and analyse accumulated knowledge (controlled vocabulary).

As discussed above, classes must be clearly defined. For example the class of impacts "natural resources" includes properties such as "natural resources stocks", "land" and "ecosystems," amongst others (see Appendix). We say that classes are defined *intensionally*. A collection of all such intensions makes up the *comprehension* of that class. Classes can have necessary conditions as well as sufficient conditions for inclusion, the combination of which makes that class fully defined.

Importantly, a class can subsume or be subsumed by other classes: a class subsumed by another is called a sub-class (or sub-type) of the subsuming class (or super-class). For example, Hydrological Event subsumes Flood Risk, since anything that is a member of the latter class is necessarily a member of the former. Subsumption relations thus create *hierarchies* of classes.

The role of subsumption is to allow *inheritance* of properties between classes: from the parent (subsuming) class to the child (subsumed) class. Anything that is necessarily true of a parent class is also true of all of its subsumed child classes. When objects can be classified in either one class or another but not in both, it creates a *partition* in the taxonomy.

All of the classes together must then contain all of the objects of the domain of knowledge i.e. all the ESG risks and impacts of infrastructure companies, to ensure a comprehensive, non-overlapping coverage. Such a classification system is both exhaustive and parsimonious.

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For the purpose of designing an ESG taxonomy, the definitions of the risks and impacts of infrastructure companies must specify whether they are environmental, social or governance risks and impacts. In the EDHECinfra ESG taxonomy, shown in table 14 to table 19, for example, Geophysical Events are a sub-class of the Physical Risk super-class, which is defined as a class of environmental risks: 'risks that infrastructure assets face from physical events or natural disasters' (see Appendix:ER1). What is true for the super-class is inherited by the child class, which is also an environmental risk class: 'Events originating from solid earth' (Below et al. (2009) and Appendix:ER1.1).

The EDHECinfra ESG taxonomy includes four super-classes of impacts and six super-classes of risk (detailed description of these are available in Appendix A):

- Impacts of the firm's activities on:
    1. Natural resources (EI1:environment)
    2. Human wellbeing (SI1:social)
    3. Economic development (SI2:social)
    4. Organisational quality (GI1:governance)
- Risks to the value of the firm arising from:
    1. Physical damage (ER1:environment)
    2. Access to resources (ER2:environment)
    3. Social acceptability (SR1:social)
    4. Workforce availability (SR2:social)
    5. Organisational Failure (GR1:governance)
    6. Staff Failure (GR2:governance)

Within each super-class of impacts or risks, classes and sub-classes create a more granular specification. Classes and subclasses are built to represent the fundamental partitions or mechanisms that the taxonomy aims to capture and be used to document. For instance, the Natural Resources impact super-class includes four classes of environmental impacts, based on the OECD definition of Natural Capital (see Appendix):

1. Biodiversity
2. Water Resources
3. Land
4. Atmosphere

These classes partition the domain into distinct types of impacts, and their union includes all possible impact types inherited from the Natural Resources impact super-class.

Note that in order to avoid encoding bias, which is frequent on existing ESG schemes, we create classes of risk and impacts, and *not classes of measures of risks or impacts*. For example, the quantity of solid waste that a company generates does not reveal its impact, which depends on how this waste interacts with the environment e.g. pollutes the soil, contaminates water resources, etc. Limited quantities of waste in a given environment may also have no impact.

Thus, while measuring waste is part of assessing the environmental impact of a firm, it does not define it. A quantitative waste or pollution indicator is instead considered to be an *attribute* of this sub-class of environmental impacts.

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3.3.4 Attributes

The objects of an ontology can be described as relating to other things, typically aspects or parts of these objects. Related aspects are called *attributes* and express a *fact* that is specific to the object to which it is related. In other words, all information and data about the ESG aspects of an infrastructure company can be stored as attributes of instances of impacts or risks.

For example, if company A has an activity in the land pollution sub-class, this instance of land pollution impact (sub-class EI1.3.1) can be given the following attributes:

- has-an-activity-name: *solid waste discharge*
- has-an-activity-unit: *ton per year*
- has-an-activity-value: *3 million*
- has-an-activity-date: ... etc.

The attributes of each instance of risk or impact may also be organised in classes (e.g. type of energy production units, types of energy production technologies, types of water pollution, types of services provided, etc.). Such classes of attributes are sometimes known as *gazetteers* or entity dictionaries. Gazetteers store structured information about the features of named entities i.e. list of the relevant information for a given type or class of impact or risk.

Looking at the ESG standards reviewed in the previous chapter, most of these schemes really are gazetteers: they compile lists of indicators used to collect data, that is, to document *attributes*. Without a classification system designed to reflect and develop a specific domain of knowledge and a clear understanding of the questions that an ontology aims to address, these schemes create information but little investment knowledge.

We also see that attributes will play a key role in the measurement of materiality. By design, the taxonomy of ESG risk and impacts presented in table table 14 to table 19 is relevant to any infrastructure company: for any qualifying infrastructure company under the TICCS standard, there is a relationship of the type <creates-by-definition> between this entity and each class of risk and impacts present in the taxonomy. For example:

- Power Plant Company B creates-by-definition: climate change impact (EI1.4.2)
- Power Plant Company B creates-by-definition: social acceptability risks (SR1)
- Motorway Company C creates-by-definition: social acceptability risks (SR1)
- etc.

Since types of risks and impacts are designed to always be relevant to any infrastructure company, differences between companies are a matter of their attributes: individual instances of risks and impacts for a given company are described by collections (or sets) of attributes that together determine the materiality of this instance.

For example, if company B is an Airport, the instance of Flood Risk created (by definition) is described by a set of attributes:

- is-a-factor-of: *distance from the sea*
- is-a-factor-of: *elevation*

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- ...

In other words, the *materiality profile* of a given infrastructure company or type of company is a *collection of risk and impact attributes*, which can be used in combination to create a *measure of materiality* for each instance of risk or impact. The definition of the relevant attribute set should then be based on a clear theoretical and technical understanding of the key activities of the company, including what type of physical assets it includes and how they operate.

For instance, issues of water pollution are essentially a matter of concentration and proximity with other resources. Risks of flooding from sea level surges are primarily a matter of elevation, terrain, distance from the sea and type of structure, etc. Social acceptability risks are a combination of public and political perceptions of privatised infrastructure and of the regulatory ideology and history of the sector, etc.

It follows that, contrary to the approach taken by most existing schemes to leave the definition of materiality to the users of the scheme, the set of attributes that measures the materiality of a impacts and risk can often be defined clearly, and rely on objective and observable measures related to the physical, economic and financial characteristics of the firms.

3.3.5 Relations

We have already shown examples of relations between entities above. A set of relations is used to describe the semantics of the domain of knowledge created by an ontology. A relation specifies in what sense an object is related to the another object in the ontology. A fundamental type of relation is the subsumption relation (<is-a-superclass-of> and it converse <is-a-subclass-of>), which defines which objects are classified by which class. Thus, a taxonomy really is a set of <is-a-subclass-of> relationships.

Ontologies also include additional types of relations that further refine the semantics they model, such as relations between classes. This allows the formalising of links between impacts and risks, but also between impacts and between risks. For example, the impact on Public Health and Safely of an infrastructure company can be related to the Company Reputation class of social risks by a relation of type <is-a-significant-factor-of>. This fact is expressed as:

The Public Health and Safely impact of Company A <is-a-significant-factor-of>: (Company A's) Company Reputation risk

These relations between classes of ESG risks and impacts of infrastructure companies then describe the theoretical and technical knowledge embedded in the ontology.

Next, having introduced the domain, instances, classes and relations of an ESG ontology for infrastructure investment, we describe the three pillars of the taxonomy.

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3.4 Three Pillars of ESG Classes

3.4.1 Definition of ESG for Infrastructure Investors

A definition of ESG flows naturally from the domain of knowledge defined above: for infrastructure investors, the perimeter of ESG includes 1/ the direct risks created by aspects of an infrastructure company that are potentially material to its revenues and profits and therefore drive expected returns/discount rates, and 2/ the direct environmental, social and governance impacts of the firm's activities that create, increase or mitigate risks that are also potentially material.

This perimeter is purposefully restrictive and can exclude considerations that are often associated with ESG, in particular, regulatory changes. For instance in this setting, so-called transitions risks, which include a number of potential regulatory developments that would strongly incentivise the de-carbonisation of the economy, are not ESG risks. They are regulatory risks (e.g. a carbon tax) that are likely to be correlated with the carbon footprint of a company, and therefore result from its environmental impact profile (which is included in the perimeter of ESG impacts and risks). Hence, the ESG profile of a company can contribute to taxation risk exposure, which remains a form of business risk and is not within the scope of ESG.

To this restrictive perimeter of ESG impacts and risk, we add the heuristic layer discussed above: we should focus on those aspects of the characteristics of firms that are at least partly not captured by asset prices today and can thus respond to investors demand for monitoring of infrastructure investment beyond what they already know via the market.

Thus, the following topics are excluded from a taxonomy of ESG risks and impacts:

1. Financial risks
2. Regulatory risks including changes in laws, regulations, subsidies etc. which may be linked to ESG considerations but are not ESG risks by themselves
3. Economic risks
4. Other risks such as wars, pandemics, cyber-attacks, terrorism etc.

While the aim is to be as exhaustive as possible, some impacts or risks may not be accounted for in this version of the taxonomy. Like The Infrastructure Company Classification Standards (TICCS), this taxonomy will undergo periodic reviews and updates. Also like TICCS, the taxonomy of ESG risks and impacts of infrastructure companies can be organised by pillars along the lines of environmental, social and governance themes, which are embedded in the definitions of the super-classes described above (and inherited by their child classes). We return to each pillar in turn below.

3.4.2 Environment Pillar

Following the TICCS approach, infrastructure companies invest in large, irreversible, immobile capital assets that have little to no alternative use. Given their significant physical footprint, they typically impact important areas of land and require substantial amounts of materials and natural

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resources to build, operate and maintain, refurbish and decommission. Throughout their life-cycle, infrastructure assets thus impact all aspects of stock of natural capital, from biodiversity (EI1.1), to water (EI1.2), land (EI1.3) and the atmosphere (EI1.4), including the climate (EI1.4.2).

Indeed, as the backbone of modern economic activity, the ultimate role of infrastructure is often to support the consumption of energy by economic agents engaged in activities that require considerable amounts of energy, the vast majority of which is currently sourced from fossil fuel (IEA 2020). Hence, most infrastructure contributes to a degree to green house gas emissions. The definitions of each class and the relevant references are provided in the Appendix.

Infrastructure assets are also exposed to multiple environmental risks: their rigid and static nature implies that extreme weather events can damage physical assets or make them unusable if they become isolated from the the network within which they are designed to function. Earthquakes, landslides, etc. are good examples of physical risks that infrastructure asset can be exposed to (See Below et al. (2009) and the Appendix:ER1 for a complete list of risk classes). One of the consequences of climate change is indeed to increase the frequency and severity extreme weather events (Hoegh-Guldberg et al., 2018), making the likelihood and impact of such events sufficiently dynamic and difficult to predict today to challenge the technical and physical assumptions used when existing infrastructure assets were built. Likewise, the long term consequences of climate change such as permanent shifts in temperature or sea levels create physical risks for infrastructure assets.

Environmental degradation may also lead to limiting or preventing an infrastructure from functioning normally if certain natural resources became unavailable (e.g. water used as coolant in a power station, ER2.2.2).

Thus, Physical Risk and Access to Resources are the super-classes of environmental risk to which infrastructure companies are exposed. Depending on their location, design and activities, i.e. their attributes, infrastructure companies are more or less exposed to these risks.

Taken together, classes of environmental impacts and risks make up the environmental pillar of the taxonomy and tables 14 and 15 list the risk and impact classes of the Environmental pillar.

3.4.3 Social Pillar

Still following TICCS, infrastructure is created to provide specific services to end users, most of whom tend to be the general public as well as public and private sector organisations. Services such as access to electricity, transport or telecommunication provide direct benefits to end-users and the utility directly derived from consuming infrastructure services is private and does not constitute a form of social impact. For instance, roads provide a service for individuals and firms to move people and goods from one point in space to another.

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Table 14: Environmental Pillar Impact Classes

Identifier	Class Name	Class Definition
EI 1	**Natural resources**	The world's stock of naturally occurring assets (including geology, soil, air, water and all living things) that can be used for economic production or consumption.
EI 1.1	*Biodiversity*	The variety and variability of life on Earth at the genetic, species, and ecosystem level.
EI 1.1.1	Loss	The decline in number, genetic variability, variety of species, and the biological communities in a given area.
EI 1.1.2	Disturbance	A temporary and localised change in environmental conditions that causes a pronounced change in an ecosystem.
EI 1.1.3	Restoration	The process of assisting in the recovery of habitats and establishing the ecological processes necessary to make terrestrial and aquatic ecosystems sustainable, resilient, and healthy under current and future conditions.
EI 1.1.4	Conservation	The practice of protecting and preserving the wealth and variety of the biodiversity and maintaining the function of the natural ecosystems of a given region.
EI 1.1.5	Enhancement	The process of improving the organisms and habitats of a given region.
EI 1.2	*Water resources*	Natural sources of water that that are useful for human activities.
EI 1.2.1	Pollution	Discharge of harmful substances or contaminants that cause degradation of the water quality of a given resource.
EI 1.2.2	Depletion	The consumption of a water resource faster than it can be replenished.
EI 1.2.3	Diversion	Mass movement of water of water temporarily or permanently.
EI 1.2.4	Preservation and protection	Protecting the quality, quantity and integrity of water resources.
EI 1.2.5	Restoration	The process of restoring the quality, quantity and integrity of the water bodies that have been subject to pollution or depletion.
EI 1.3	*Land*	Land resources refers to the soil geographic land (soil) and all the naturally occurring resources such as rocks, minerals and ores present under the surface of the land.
EI 1.3.1	Pollution	The deposition of waste materials on land or underground in a manner that can contaminate the soil.
EI 1.3.2	Change in land use	Human induced transforming of the landscape of a piece of land.
EI 1.3.3	Degradation	Decrease in the quality or integrity of soil that causes the economic or biological productivity of a given piece of land to fall.
EI 1.3.4	Preservation and protection	Protect the quality, quantity and integrity of land resources.
EI 1.3.5	Restoration	The process of restoring the quality, quantity and integrity of land resources that have been subject to pollution or degradation.
EI 1.4	*Atmosphere*	The blanket of gases that surrounds the earth.
EI 1.4.1	Air pollution	Release of gaseous and particulate contaminants into the air.
EI 1.4.2	Climate change	The abnormal variations and the significant long-term change in the expected patterns of the average weather of the Earth's local, regional and global climates.
EI 1.4.3	Air quality improvement	Reducing the concentration of contaminants present in the air.

3. A Taxonomy of Infrastructure ESG Risks and Impacts

Table 15: Environmental Pillar Risk Classes

Identifier	Class Name	Class Definition
ER 1	**Physical risk**	The risks that infrastructure assets face from physical events or natural disasters.
ER 1.1	*Geophysical events*	Events originating from solid earth.
ER 1.1.1	Earthquake risk	The physical risk stemming from the shaking and displacement of the ground due to seismic waves.
ER 1.1.2	Volcanic risk	The physical risk stemming from volcanic activity such as rock falls, ash falls, lava streams, gases etc.
ER 1.1.3	Mass movement (dry) risk	The physical risk stemming from the displacement caused by the physical movement of the earth.
ER 1.2	*Hydrological events*	Events associated with water occurrence, movement and distribution.
ER 1.2.1	Flood risk	The physical risk stemming from a significant rise in water levels.
ER 1.2.2	Mass movement (wet) risk	The physical risk stemming from the displacement caused by the physical movement of the earth caused by a change in hydrological conditions.
ER 1.3	*Climatological events*	Events caused by long-lived/meso to macro scale processes (in the spectrum of intra-seasonal or multi-decadal climatic variability).
ER 1.3.1	Extreme temperature risk	The physical risk stemming from a variation in temperature above or below normal conditions.
ER 1.3.2	Drought risk	The physical risk stemming from a long-term event triggered by a lack of precipitation.
ER 1.3.3	Wildfire risk	The physical risk stemming from an uncontrolled burning fire, usually in wild lands.
ER 1.4	*Meteorological Events*	Events caused by long-lived/meso to macro scale atmospheric processes (in the spectrum of minutes or days)
ER 1.4.1	Storm risk	The physical risk stemming from the disturbance of the atmosphere marked by wind and one or more of rain, snow, hail, sleet or thunder and lightning.
ER 2	**Access to natural resources**	Access to natural resources can be understood as the opportunity and the ability to make use of the natural resources required for the activities of the infrastructure company.
ER 2.1	*Resource loss risk*	The risks associated with the reduction in the quantity or deterioration of quality of natural resources in a given geographic region.
ER 2.1.1	Quality risk	The deterioration of quality of natural resources in a given geographic region, associated with the human activities.
ER 2.1.2	Availability risk	The depletion in the stock of a natural resource in a given geographic region, associated with the human activities.

Electricity companies provide households and firms with power to operate electrical devices. Such strictly private consumption does not qualify as social impact.

However, because they often provide essential services, the activities of infrastructure companies also have significant social impacts on individuals, households, the economy and society. As argued above, the role of infrastructure in promoting socio-economic development is well-documented, from reducing child-mortality through better sanitation, to improving education outcomes, enabling the flow of goods and services to markets and protecting populations from natural hazards (see amongst others Günther and Fink, 2011; Barrett et al., 2019; Ismail and Mahyideen, 2015; Garschagen et al., 2016; Donaldson, 2018; Banerjee et al., 2012; Duflo et al., 2015). These are examples of the social impact of infrastructure companies: indirect benefits or externalities that have social value.

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The taxonomy distinguishes between two super-classes of social impacts of infrastructure companies: Economic Development and Human Wellbeing. The former refers to the social (indirect) impact of infrastructure services on *individuals*, while the later refers to social impacts on the *collective*.

Types of Economic Development impacts (SI2) created by infrastructure companies and services include impacts on Human Development (SI2.1) and on capital (asset) values (SI2.1). The former is well defined by the three categories of human development proposed by UNDP (see Appendix), while the later relates to the impact on the value of adjacent land, real estate, businesses and other infrastructures on the provision of a given infrastructure service. For example, beyond the strict consumption of transport services, mobility creates valuable real options for individuals who can work (Standard of living SI2.1.1), study (Human Capital SI2.1.2) or receive medical treatment (Healthy Life, SI2.1.3) as a result. Together, Human Development (which includes Human Capital) and Asset Values constitute the Economic Development impact of infrastructure.

Likewise, classes of impacts on Human Wellbeing (SI1) are divided between impacts on Collective Welfare outside the firm, in both the public space and the polity, and impacts on the wellbeing of the firm's Workforce. In the public space, infrastructure companies can have a range of impacts spanning Human Rights infringements or protection (SI1.1.1), changing health conditions in the public space (SI1.1.2), disturbing or improving the quality of life in the public space (e.g. by creating or avoiding congestion, SI1.1.3), and the preservation, promotion or degradation of heritage and culture (SI1.1.4).

Next, infrastructure companies are also exposed to Social risks of two types: Social Acceptability Risks and Workforce Availability.

Social acceptability is a central issue when investing in private infrastructure companies. As indicated above, infrastructure assets have a significant environmental footprint and can lead to significant disruption for surrounding populations that may nor always be the direct beneficiaries of the construction of these assets (e.g. dams, high-voltage power transmission, etc.). The for-profit private operation of infrastructure companies is also highly controversial in a number of countries. There is a documented regulatory pendulum effect by which different countries go from periods of supporting private infrastructure ownership to opposite periods of widespread nationalisations, followed by new waves of privatisations (See Blanc-Brude, 2013, for a discussion and literature review).

The Social acceptability risk of infrastructure companies (SR1) is split between the perception of its customers (SR1.1), including in terms of service quality, affordability and accessibility, that of the general public (SR1.2) especially the reputation of the sector and of the firm, as well as sentiments surrounding privatisation. Finally, social acceptability risks are reflected in the ideology and practices of the sector regulators (SR1.3).

3. A Taxonomy of Infrastructure ESG Risks and Impacts

For example, certain regulators are built to implement the notion of yardstick competition (ideology) and proceed to regular reviews and determinations of the allowed cost of capital of infrastructure firms. Others take a more transactional approach and negotiate with private infrastructure companies as needed, on a more *ad hoc* basis.

Workforce availability (SR2) is another class of social risk for infrastructure companies. While operating infrastructure assets is usually not a labour intensive activity, their construction and maintenance phases can be. Some infrastructure companies such as ports or utilities can also employ numerous staff. Industrial action (SR2.1) as well as issues with access to skilled labour (SR2.2).

Tables 16 and 17 list the risk and impact classes of the Social pillar.

3.4.4 Governance Pillar

Corporate governance refers to systems of rules, practices, processes and strategies by which a firm is managed and controlled.

Instances of governance impact fall into a single class of Organisational Impacts (GI1) and denote to the way in which the firm governs itself (G1.1) and its relationship with other parties (G1.2), including shareholders, the management, customers, suppliers, financiers, the government and society.

The management of Firms can be more or less effective at reaching their objectives (GI1.1.1). A necessary condition for an infrastructure company or any organisation to succeed is appropriate strategic planning, clear visions and strategies and their subsequent successful implementation-which comes from a competent team with a clear management approach and strong management systems. Instances of management effectiveness and quality would consider attributes such as the structure of the board of the company using the indicators of board independence, board diversity and board tenure.

The same firms can be more or less focused on *managing* their social and environmental impacts and risks (GI1.1.2). For instance, one of the issues faced by large infrastructure project is that of corruption allegations. The extent of public officials' discretion on the investment decision, the size of the projects and the multiplicity of stages and stakeholders involved make them more prone to corruption (OECD, 2015). Infrastructure companies need strong policies for managing bribery and corruption within their organisation.

Instance of governance impacts in relation to third parties (GI1.2) include transparency, corporate accountability, stakeholder engagement and supplier management.

Transparency (GI1.2.1) refers to the manner in which an infrastructure company manages its operational, financial, legal, regulatory, environmental and social disclosures. Timely disclosures about the activities, policies, strategies and performance of the company ensures that all stakeholders of the company have access to clear, factual information which accurately reflects the financial, social

3. A Taxonomy of Infrastructure ESG Risks and Impacts

Table 16: Social Pillar Impact Classes

Identifier	Class Name	Class Definition
SI 1	**Human wellbeing**	The state of health, happiness and/or prosperity.
SI 1.1	*Collective wellbeing*	The positive and impacts of infrastructure companies on the wellbeing of a given community.
SI 1.1.1	Human rights	Rights inherent to all human beings, regardless of race, sex, nationality, ethnicity, language, religion, or any other status.
SI 1.1.2	Public health and safety	The anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and wellbeing of the public.
SI 1.1.3	Public disturbance	The state in which the comfort or peace of members of the public is disrupted.
SI 1.1.4	Heritage and culture	The legacy of physical artifacts and intangible attributes of the community.
SI 1.2	*Workforce wellbeing*	Employee wellbeing refers to the state of employees' health, happiness and/or prosperity.
SI 1.2.1	Workforce health and safety	The anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and wellbeing of the workforce.
SI 1.2.2	Working conditions	Working conditions to encompass a broad range of topics and issues, from working time to physical conditions and mental demands that exist in the workplace.
SI 1.2.3	Benefits	Benefits are any perks offered to employees in addition to salary.
SI 2	**Economic development**	The process by which the economic wellbeing and quality of life of a nation, region, or local community are improved.
SI 2.1	*Human development*	Enabling people to lead a long and healthy life, to be educated, to enjoy a decent standard of living, as well as political freedom, other guaranteed human rights and various ingredients of self-respect.
SI 2.1.1	Standard of living	The level of wealth, comfort, material goods, and necessities available to a certain socioeconomic class or geographic area.
SI 2.1.2	Human capital	The stock of habits, knowledge, social and personality attributes (including creativity) embodied in the ability to perform labor so as to produce economic value.
SI 2.1.3	Healthy life	A long life, free from diseases and acute and chronic health conditions
SI 2.2	*Assets Values*	The market value of all assets that can be impacted by infrastructure.
SI 2.2.1	Related land value	The value of a piece of property including both the value of the land itself as well as any improvements that have been made to it.
SI 2.2.2	Related real estate value	The worth of a piece of real estate.
SI 2.2.3	Related business value	The entire value of the business; the total sum of all tangible and intangible elements.
SI 2.2.4	Related infrastructure asset value	The market value of any given infrastructure asset as a function of the availability of infrastructure networks connected physically or digitally.

3. A Taxonomy of Infrastructure ESG Risks and Impacts

Table 17: Social Pillar Risk Classes

Identifier	Class Name	Class Definition
SR 1	**Social Acceptability**	The outcome of a collective judgment or collective opinion of a project or company.
SR 1.1	*Customer*	The group of individuals that use the service provided by the infrastructure company.
SR 1.1.1	Quality of service	The description or measurement of the overall performance of a service as seen by users.
SR 1.1.2	Affordability of service	The ability of a large proportion of society (at least the top of the bottom quartile) to pay for a service.
SR 1.1.3	Accessibility of service	The degree to which a service is available and physically accessible to as many users as possible.
SR 1.2	*General Public*	The individuals in a given population.
SR 1.2.1	Sector reputation	The social acceptance of a whole infrastructure sector by the general public.
SR 1.2.2	Privatisation perception	The social acceptance of privately owned infrastructure by the general public.
SR 1.2.3	Company reputation	The overall estimation in which an organisation is held by its internal and external stakeholders.
SR 1.3	*Regulators*	Bodies that are tasked with regulation of infrastructure.
SR 1.3.1	Ideology	A set of opinions or beliefs of a group or an individual, the regulators in this case.
SR 1.3.2	Politics	The acceptability, or lack of it, of an infrastructure company or an infrastructure sector by the general public can lead to the government promoting or barring specific companies or types of infrastructure.
SR 2	**Workforce Availability**	The availability of a sufficient workforce to carry out all the activities of an infrastructure company.
SR 2.1	*Industrial action*	Action by workers as a protest and means of forcing compliance with demands.
SR 2.1.1	Strikes and slowdowns	The mass refusal of employees to work.
SR 2.2	*Labor Market*	Refers to the supply of and demand for labor, in which employees provide the supply and employers provide the demand.
SR 2.2.1	Skill drought	The unavailability of trained, educated, or experienced segments of the workforce.

and environmental position and performance of the organisation.

Accountability of the firm (GI1.2.2) refers to the degree to which a company accepts responsibility for the impact of their actions on society and the environment either voluntarily or by coercion. Ensuring strong corporate accountability has multiple benefits ranging from improving the social acceptability of the company, maintaining the brand value of the company, alignment with investor values, customer satisfaction and employee engagement. Not doing so has the converse. For example, dam developers are often understood to face little accountability for the damage they cause.

One of the biggest challenges to good governance for infrastructure companies is the multiplicity of stakeholders. Involving stakeholders such as users, civil society organisations and the private sector, can improve the quality of planning efforts and ultimately the effectiveness of the asset. Instances of Stakeholder Engagement (GI1.2.3) refers to identifying, consulting and communicating with stakeholders, including grievance mechanisms processes.

3. A Taxonomy of Infrastructure ESG Risks and Impacts

The governance of the firm can have an impact through the management of its contractors and suppliers. Contractors and suppliers with poor /unethical environmental and social practices can cause reputation damage and reflect poorly on the governance of the infrastructure company. The impact of the firm's governance is a matter of its ability to select contractors and suppliers based on their social and environmental performance.

Finally, the governance of the firm can create hidden risks. Instances of governance risk amount to the company putting itself at risk due to failings in its own processes and staff. Thus, two types of governance risks can be found in infrastructure firms: Organisational Failures (GR1) and Staff Failures (GR2). Instances of organisational failure risk include the failure of existing processes (GR1.1) in particular reporting (GR1.1.1) and compliance failures (GR 1.1.2) with regulatory bodies. An example of this is the case wherein Thames Water failed to comply with the terms of the permits issued by the Environmental Agency to Maidenhead STW in 2014 which resulted in a fine of over GBP700,000. This compliance failure was a result of poorly performing equipment or monitoring processes that let to a discharge of raw and partially treated sewage instead of treated sewage into Berkshire waterways (UK Environmental Agency, 2019).

Instances of failing to create processes, including mandatory ones (GR1.2.1) is another class of organisational risk. For instance, the Californian utility PG&E, in 2018 was found not to have put in place processes for regularly inspecting and maintaining a power line that cut through a heavily forested area which led to a deadly wildfire killing 85 people and destroying the town of Paradise. The company had to ultimately file for bankruptcy in response to the associated financial challenges (Penn and Eavis, 2019).

Staff quality and behaviour (GR2) are other instances of governance risks: a firm can fail to hire competent staff or fail to detect and prevent negligent or even criminal activities by members of its staff. In this case, the firm is at risk because of its lack of or limited governance. For example, most ports in Europe are part of well-documented drug-trafficking routes, ensuring the distribution of cocaine across the continent (see Europol, 2013).

Tables 18 and 19 list the risk and impact classes of the Governance pillar.

As we argued above, types of Environmental, Social and Governance impacts of infrastructure companies are linked to certain risks for the firm, primarily business and regulatory risks, whether these impacts create, increase or mitigate these risks. ESG risks can also be linked to ESG impacts.

3.5 Relations Between Risks and Impacts

Finally, we consider how the impacts and risks classes defined in the taxonomy above are related. As discussed above this ontology includes relations between types and subtypes of risk and impacts. Based on desk research and expert opinion, a relation of the

3. A Taxonomy of Infrastructure ESG Risks and Impacts

Table 18: Governance Pillar Impact Classes

Identifier	Class Name	Class Definition
GI 1	**Organization quality**	The ability of an infrastructure company to govern itself.
GI 1.1	*Company management*	The organisation and coordination of a company's activities in order to achieve company goals.
GI 1.1.1	Effectiveness	The capability of management to achieve the company's desired targets in a specified time.
GI 1.1.2	Impact and risk management	The ability of an infrastructure company to manage all impacts and risks resulting from its activities and external actors.
GI 1.2	*External relationships*	The process of maintaining healthy relationships with the internal and external stakeholders of the company.
GI 1.2.1	Transparency	The extent to which a corporation's actions are observable by outsiders.
GI 1.2.2	Corporate accountability and responsibility	The degree to which a company accepts responsibility for the impact of its actions on society and the environment.
GI 1.2.3	Stakeholder engagement	The process of involving all parties who may be affected by the company's decisions or can influence the company's business.
GI 1.2.4	Contractor and supplier engagement	The identification, selection, and management of relevant contractors and suppliers.

Table 19: Governance Pillar Risk Classes

Identifier	Class Name	Class Definition
GR 1	**Organisation Failure**	The failure of a company to govern itself.
GR 1.1	*Process failure*	A failure of organisation processes, either due to the process being difficult to use, poorly designed or poorly implemented, can pose a risk to the governance of the company.
GR 1.1.1	Reporting failure	The inability to partially or completely report mandatory and/or voluntary disclosures as a result of a process failure.
GR 1.1.2	Compliance failure	The failure of internal management systems designed to prevent and detect violations of applicable law, regulations, rules, international guideline and ethical standards by the company.
GR 1.2	*Absence of processes*	The absence of core and other organisation processes.
GR 1.2.1	Mandatory processes	The process required to ensure that companies comply with all applicable rules and regulations and adhere to all mandatory standards.
GR 1.2.2	Other processes	The processes that enable smooth running of the company but are not mandated by law or industrial standards.
GR 2	**Staff failure**	The inability of the team as a whole to successfully or efficiently complete company activities.
GR 2.1	*Competency*	The specific demonstrable or measurable skills required to complete a specific company activity.
GR 2.1.1	Core competency	The specific skills required to complete the core business activities of a company.
GR 2.1.2	Non-core competency	The specific skills required to complete the non-core business activities of a company.
GR 2.2	*Integrity*	The quality of the company workforce having strong ethical and moral principles.
GR 2.2.1	Criminal activity	Dishonest behaviour on part of its employees and can cause a company to be part of criminal activities.
GR 2.2.2	Non-criminal activity	Dishonest behaviour which is not criminal in nature, but can hamper internal processes, thus creating issues for company management.

3. A Taxonomy of Infrastructure ESG Risks and Impacts

Figure 1: Network plot of the <is-a-significant-factor-of> relation for impact classes

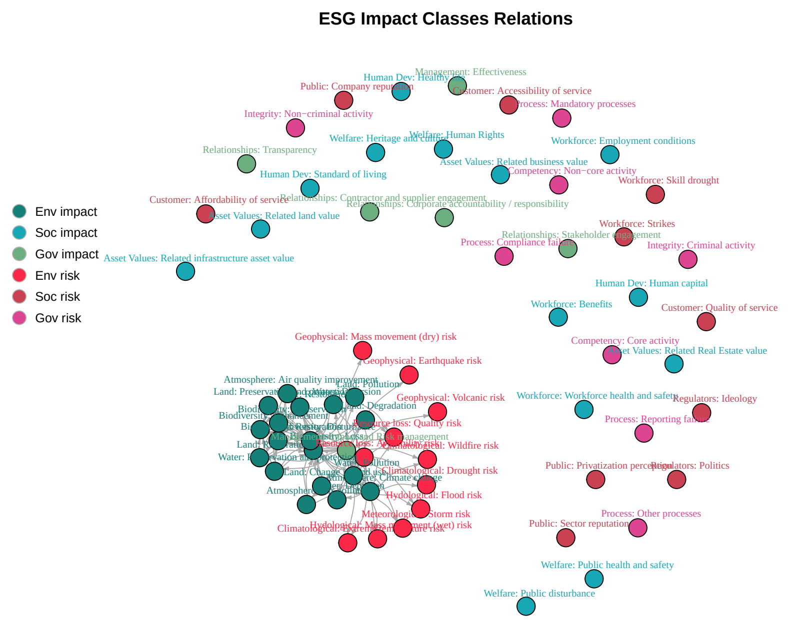
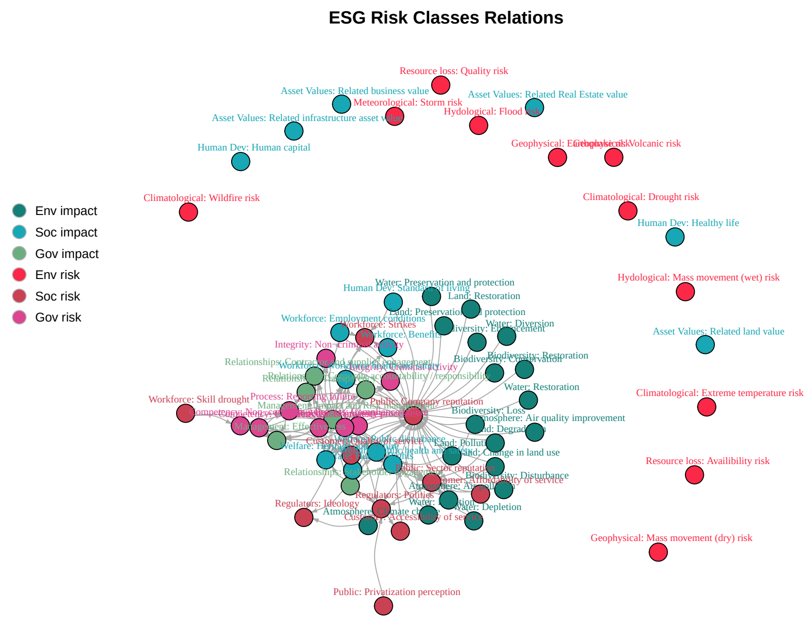


Figure 2: Network plot of the <is-a-significant-factor-of> relation for risk classes



3. A Taxonomy of Infrastructure ESG Risks and Impacts

type <is-a-significant-factor-of> was established between subclasses of impacts and/or risk.

Looking at the concentration of links between types of impacts and risks, we find that risk types are more often driven by types of impacts and identified almost three times more links between impacts and risks than between risks types. We also find that:

- Environmental risk types are dependent the most on types of environmental impacts, followed by governance impact types. They are independent of all types of risks.

- Social risks are driven by all types of impacts, as well as types of Social and Governance risks. Social risks are seemingly independent from the environmental risks faced by the firm.

- Governance risks are driven more by types of Governance impacts and to a lesser extent by types governance risks and some social risks.

Impacts on the other hand tend to be related to other impact types but less often to types of risks.

The classes that are the most frequently related to other types are: governance impact types (GR1.1.2: Impact and Risk management and GI1.2.3: Stakeholder Engagement), an environmental impact type (EI1.4.2: Climate Change) and governance risk types (organisational failure risks of GR 1.2.2: absence of mandatory processed GR1.2.1: other processes and GR1.1.2 compliance failure).

Figures 1 and 2 provide an illustration of the links between classes. Figure 1 shows that impacts are mostly related with other impacts. Conversely, ESG impacts are also important drivers of ESG risks as shown on figure 2.

Next, we revisit the ESG schemes reviewed in the previous chapter through the prism of this taxonomy of impacts and risks designed as part of an ontology of ESG for infrastructure investors.

4. Do Existing ESG Schemes Create Investment Knowledge?

4. Do Existing ESG Schemes Create Investment Knowledge?

This chapters continues our analysis of the existing ESG schemes currently used for infrastructure investments and examines their content through the prism of the taxonomy of ESG impacts and risks presented in the previous chapter. The aim is to understand what kind of ESG investment knowledge is created by existing schemes.

We focus on the list of 'disclosures' used by each scheme i.e. the information that ESG tools and standards require their users to report, at the data level.

The documentation for individual ESG aspects tend to consist of multiple possible disclosures grouped together under one ESG indicator or criterion.

The nature of these disclosures varies greatly. Under each one of their topics, the schemes either ask users to report an exact indicator in specific units, gives them a choice to report one from a list of specific indicators, ask for a qualitative explanation about a specific topic or give users complete discretion to provide the suitable indicators in the form on quantitative metrics or qualitative explanations, discussions or analysis.

In ontological terms, the indicators (GRESB), categories (CEEQUAL) or criteria (SuRe) and the disclosures of ESG schemes are forms of classification and attribution of the data being reported. However, because they are not structured to address an ontological question (not designed to create specific knowledge), they consists of long lists of data or information that *may* be reported. As argued earlier, these lists of disclosures are equivalent to 'entity dictionaries' or gazetteers, but do not form a system of knowledge.

Again, we follow Berg *et al.* and map the disclosures used by individual ESG schemes together using the taxonomy discussed in the previous chapter as a common, parsimonious matrix of ESG risks and impacts classes.

Seven of the 12 ESG schemes reviewed above have detailed public documentation of the disclosures they use. The schemes included in this analysis are: CEEQUAL, ENVISION, GRESB, GRI, ISCA, SASB and SuRe. Most of these schemes do not restrict disclosures by users to an exhaustive list. Still, we analyse all the disclosures presented in official documentations.

For these seven schemes, we identify a cumulative total of 1,659 ESG topics and 4,850 individual disclosures. These disclosures are then mapped at the sub-class level of the ESG risks and impacts taxonomy. We also classify these disclosures as qualitative or quantitative, and as indicators of either inputs, processes, outputs, short-term or long-term effects. We also identify a number of disclosures that are too vague or not relevant ESG indicators.

In what follows, we first describe the rules used to classify ESG scheme disclosures before describing our findings about what existing ESG schemes effectively cover.

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4.1 Classification Rules

4.1.1 Rule 1: Disclosures relate to all relevant classes (one-to-many)

Although the ESG schemes reviewed group disclosures into specific ESG topics, these topics are not consistent across schemes and are typically broad. Individual disclosures can thus be mapped to multiple classes and sub-classes of risks and impacts the taxonomy.

For example, SuRe disclosures for the 'Direct Employment and Training' criterion (SuRe code: S5.1) include considerations about 'hiring workers in the local community' and disclosures about gender equality, nationality of employees etc., as well as the training provided to employees. These disclosures and the related performance indicator can thus be mapped to four classes of ESG risks and impacts: 1/ SI1.1.1-Human Rights, 2/ SI1.2.2-Employment Conditions, 3/ SI2.1.1-Standard of Living, and 4/ SI2.1.2-Human Capital.

When this is the case, disclosures from the same topic are mapped to multiple risk and impact classes based on the definition provided for each disclosure in the scheme documentation.

4.1.2 Rule 2: Qualitative vs. qualitative disclosures

Disclosures that are numerical in nature are classified as quantitative. Conversely, qualitative indicators include:

- Policies, strategies, commitments, etc.;
- Indicators that require the user to provide descriptive answers; and
- Evidence requirement that is not numeric, but qualitative and specific (such as photographs and drawings).

Two types of disclosures require specific classification rules. These are:

- The content of "reports and analyses" reported by schemes users may vary from one user to another. By default, we categorise such disclosures as qualitative unless it is explicitly mentioned that the report/analysis should contain numerical output, in which case it is classified as both quantitative and qualitative.
- Likewise "Impact and Risk Assessments" are classified as both qualitative and quantitative by default.

4.1.3 Rule 3: Indicator types

The majority of individual disclosures used in ESG schemes are, in effect, indicators. Following an established UN typology of indicators (Hales, 2010), we classify disclosures as one or more of the following indicator types to classify:

- **Input Indicators:** These indicators refer to the resources needed for the implementation of an activity or intervention or required to maintain the operations of the company. This is inclusive of requirements of material, resources, skilled personnel and broad organisation level objectives policies, strategies, rules, guidelines, commitments, plans, goals, proposals.
- **Activity Indicators:** Indicators that help assess if a specific activity is undertaken by a company and its expected outputs-are knows as activity indicators. There are

4. Do Existing ESG Schemes Create Investment Knowledge?

two types of activity indicators: process indicators and output indicators (World Health Organization, 2014).

- **Process Indicators:** simply indicate if you have a process in place or used to identify the number and types of activities carried out. This is inclusive of the development of systems to enable an activity, carrying out studies, training employees, ensuring compliance with required standards/regulations and actions carried out to further company process such as hiring of staff, purchase of equipment etc. These are indirect indicators of merit, and as such do not guarantee the achievement of outcomes.
- **Output indicators** add more details in relation to the product ("output") of the activity/processes. They may monitor the quality of the activities conducted based on a number of established quality criteria or standards. These indicators are useful management tools to monitor implementation and its quality/quantity. However, they do not provide information on the results and impact of the activity.

- **Effect indicators:** Indicators that are used to assess the short-, intermediate- and long-term effects of the activities, processes, plans, policies, procedures and actions of a company. They are of two types: Outcome Indicators and Impacts Indicators. For semantics, we refer to them as short-term effect indicators and long-term effect indicators.
  - **Short-term effect Indicators:** Also known as outcome indicators, these refer more specifically to the short-term/intermediate changes that an intervention brings about that is it's 'results', or its 'outcome'. These indicators, therefore, allow us to know whether the desired outcome has been generated.
  - **Long-term effect Indicators :** Also known as impact indicators, these refer to results over longer periods of time. Thus, they refer to the cumulative results (positive or negative) of an intervention.

Classifying ESG disclosures according to this typology of indicators is typically straightforward. When disclosures could be understood as multiple type of indicators, they were categorised under each possible indicator type. For instance, when a given scheme asks for an impact assessment report - this could be understood as a process indicator (assessing if this report is compiled by the company, or not), an output indicator (assessing what type of information is present in the report), an effect indicator (wherein the result of the report are assessed that contain the short term and long term effects of the company's activities).

4.2 Findings

Starting from the 4,850 disclosures identified in the seven ESG reporting schemes, 850 of these disclosures could not be mapped to a class of ESG risk or impact either because they were not strictly speaking related to ESG risks or impacts (218 disclosures), they were too vague to be classified (330 disclosures), or were not indicators (302 disclosures).

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Disclosure may be classified as not related to ESG risks and impacts for two reasons: they either do not fit the perimeter of ESG risks and impacts defined earlier, or the information required refers to attributes of risks and impacts which is neither in itself e.g. geographic location.

Amongst the 218 disclosures we exclude from the analysis as not relevant to classifying ESG risks and impacts, a third are attributes (e.g. address, size, industrial classifications, etc.), a third refer to financial and economic data (e.g. business plan, financing, residual value, etc.), another 10% refer to the nature of the reporting (e.g. report scheduling, data standards, etc.) and the rest includes a few sustainability issues that are not directly related to ESG impacts and risks and other non ESG aspects surrounding the cybersecurity practices and lobbying activities of the company.

The following results are based on the assessment of the remaining 4,000 disclosures.

4.2.1 Distribution of indicators across ESG pillars

As shown on figure 3, in aggregate current ESG schemes for infrastructure investors cover ESG pillars fairly evenly by number of disclosure, the environmental pillar (42% of disclosures), the social pillar (27%) and the governance pillar (31%).

The relatively greater focus on environmental data is the reflection of the fact that most schemes include extensive and detailed environmental considerations, while not all approach a social or governance assessment in comparable detail. Moreover environmental impacts are more varied across different types of infrastructures, resulting in a larger number of associated disclosures. Conversely the disclosures of social and governance indicators tends to be similar for all sectors.

However, this coverage is very different across the schemes, as shown on figure 4. This is further evidence of scope divergence, as discussed in a previous chapter: a reflection of the lack of consensus on the definition of the ESG domain, the range of aims and types of users documented earlier. Some schemes like SASB are clearly more focused on governance disclosures, while others are more focused on social (SuRe) or environmental ones (GRI, ENVISION).

Turning to the coverage of each pillar by individual schemes described in figures 5, 6 and 7.[7]

We find that impacts on natural resources (biodiversity, water, land and atmosphere) are addressed by all schemes, but none of them covers all the environmental risks defined in the taxonomy. In terms of physical risk stemming from environmental events, risks from hydrological events are most commonly addressed across schemes. GRESB is the only scheme that touches upon all potential physical risks outlined in the taxonomy. SuRE and GRI do not have disclosures that capture how physical risk can manifest and pose a threat to infrastructure (They do consider

7 - Note that these tables only map the presence of ESG impact or risk in the different scheme, not the quality or appropriateness of the associated disclosures.

4. Do Existing ESG Schemes Create Investment Knowledge?

Figure 3: *Combined Weights of the E, S and G Pillars - All Schemes*

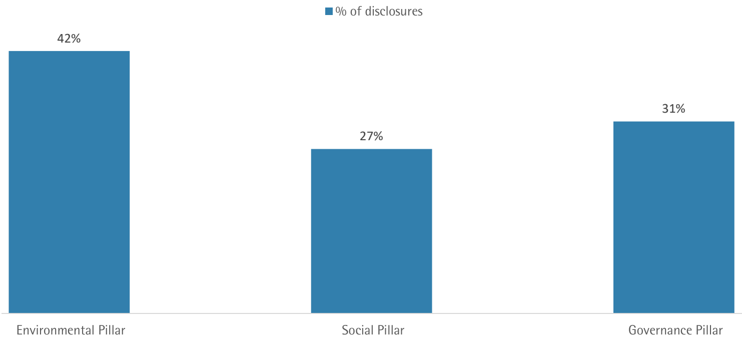


Figure 4: *Distribution of disclosures across E, S and G Pillars by ESG Schemes*

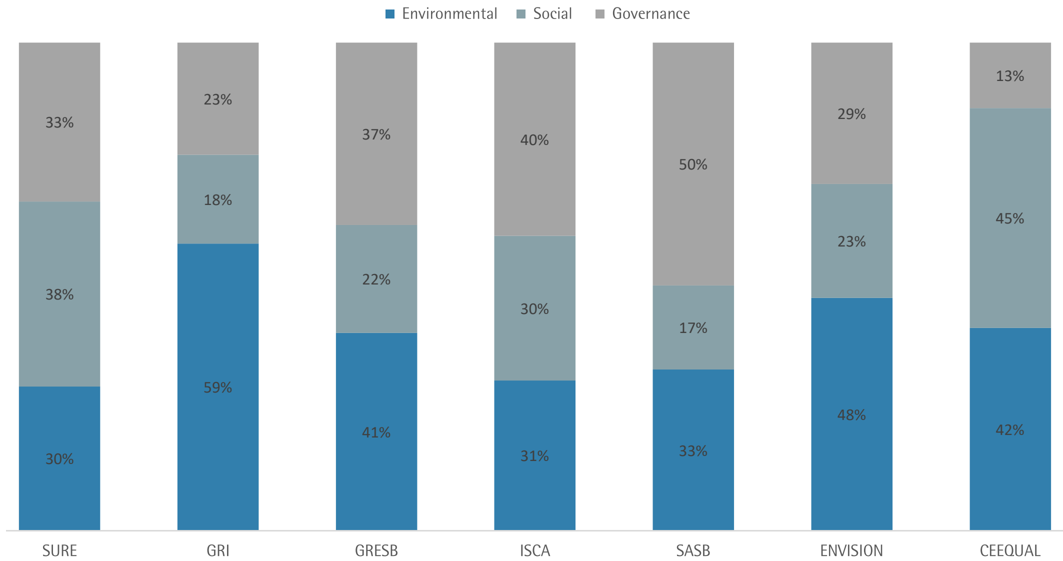


Figure 5: *Environmental Pillar Coverage of Taxonomy of ESG Impacts and Risks, by ESG Schemes*

	Environmental Pillar								
	Impacts				Risks				
	Natural Resources				Physical Risk				Access to natural resources
	Biodiversity	Water resources	Land	Atmosphere	Geophysical Events	Hydrological Events	Climatological Events	Meteorological Events	Resource loss risk
SURE	✓	✓	✓	✓					
CEEQUAL	✓	✓	✓	✓		✓			
GRESB	✓	✓	✓	✓	✓	✓	✓	✓	
GRI	✓	✓	✓	✓					
ISCA	✓	✓	✓	✓		✓			
ENVISION	✓	✓	✓	✓		✓			
SASB	✓	✓	✓	✓		✓			✓

4. Do Existing ESG Schemes Create Investment Knowledge?

Figure 6: Social Pillar Coverage of Taxonomy of ESG Impacts and Risks, by ESG Schemes

	Social Pillar								
	Impacts				Risks				
	Human well-being		Economic development		Social acceptability			Workforce	
	Collective welfare	Workforce well-being	Human development	Assets Value	Customer	General public	Regulators	Industrial Action	Labour market
SURE	✓	✓	✓	✓	✓	✓		✓	
CEEQUAL	✓			✓					
GRESB	✓	✓	✓		✓	✓		✓	
GRI	✓	✓	✓	✓		✓	✓	✓	
ISCA	✓								
ENVISION	✓	✓	✓	✓		✓	✓		
SASB	✓	✓			✓	✓		✓	

Figure 7: Governance Pillar Coverage of Taxonomy of ESG Impacts and Risks, by ESG Schemes

	Governance Pillar					
	Impacts		Risks			
	Organization quality		Organization failure		Staff failure	
	Company management	External Relationships	Process failure	Absence of processes	Competency	Integrity
SURE	✓	✓	✓	✓		✓
CEEQUAL	✓	✓	✓	✓	✓	
GRESB	✓	✓	✓	✓		✓
GRI	✓	✓	✓	✓	✓	✓
ISCA	✓	✓		✓	✓	✓
ENVISION	✓	✓	✓	✓	✓	
SASB	✓		✓			

physical risk from the perspective of risk management, which is classified under governance impacts). The risk of loss of access to natural resources is only addressed by SASB.

None of the schemes cover all classes of social impacts and risks identified. With regards to social impact classes, collective welfare has the highest coverage followed by workforce wellbeing. Within social risks, social acceptability by the general public has the highest coverage followed by industrial action. Risks stemming from the labour market are not covered by any scheme.

When it comes to governance, again there is no universal coverage of the classes of impacts and risks identified. Nor is there a scheme that covers at least all impacts or all risk classes. Company management is the class with the highest coverage within social impacts (it is covered by all the schemes). Within the risk section, process failure and absence of processes are the classes most focused on by the reviewed schemes.

These findings provide further evidence of scope divergence between ESG schemes and also match findings by Berg *et al.* about the ESG coverage of public equity schemes.

4.2.2 Coverage of Impacts and Risks

Next, we use the taxonomy to assess the degree to which the schemes focus on risks or impacts. Again, the taxonomy defines risks relative to the firm (ESG risks it is exposed to) as well as impacts (the impact of the firm on other things). Thus, while some schemes may

4. Do Existing ESG Schemes Create Investment Knowledge?

Figure 8: Disclosures Types of ESG Schemes: Impact vs. Risk (proportion - left, number - right)

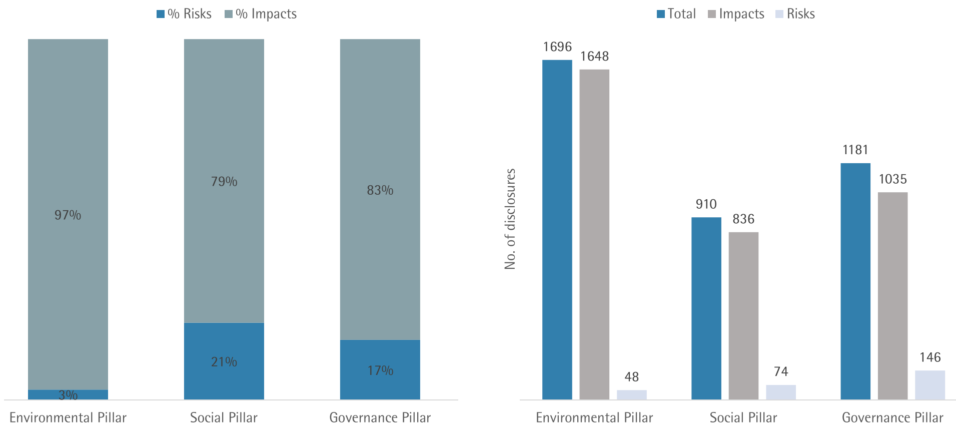


Figure 9: Disclosures Types of ESG Schemes: Impact vs. Risk - by Scheme

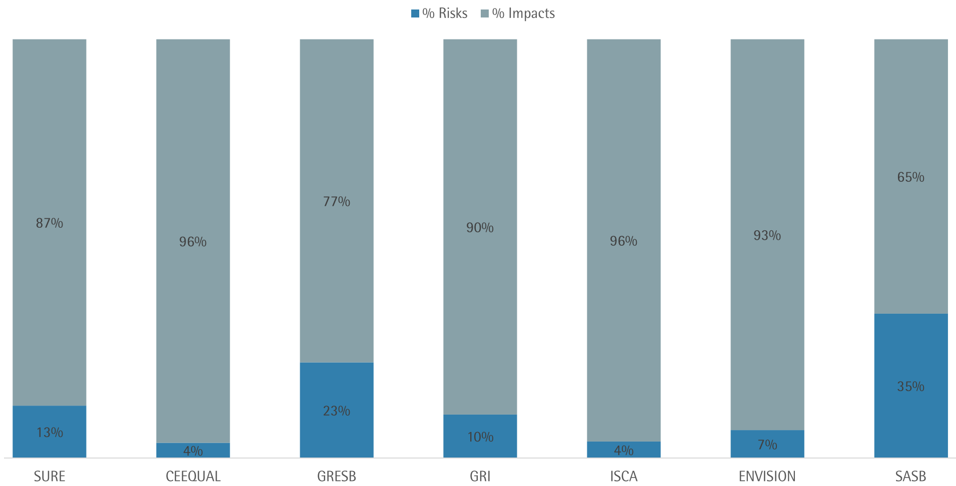


Figure 10: Coverage of Class SR1.2, "General Public" by the Individual Schemes

	SR 1.2 General public		
	SR1.2.1 Sector Reputation	SR 1.2.2 Privatisation perception	SR1.2.3 Company reputation
SURE			✓
CEEQUAL			
GRESB			✓
GRI			✓
ISCA			
ENVISION		✓	
SASB			✓

4. Do Existing ESG Schemes Create Investment Knowledge?

be describing some of their disclosures as risk data, they are often referring to other risks, either non-ESG risks like regulatory changes or risks for other parties than the firm, like the population living near an infrastructure.

Taken together, 88% indicators refer to types of impacts and 12% refer to types of risks.

Within the environmental pillar 97% of disclosures refer to impacts and 3% to risks. The disclosures in the social pillar are types of impacts in 79% of cases and types risks in 21% of cases. Finally, disclosures in the governance pillar include 83% of impacts and 17% of risks. These results are shown in figure 8.

When the reviewed schemes cover risks, it is most often from the perspective of whether firms have risk assessments and management processes and reports. Here such disclosures are classified in the governance impact sections (GI1.1.2, impact and risk management). Indeed, while risk management is an important determinant of the risks ultimately faced by a firm, as a report/disclosure it is really a type of corporate activity which is expected to lead to risk reduction and mitigation i.e. a type of impact. However, the effectiveness of risk management is seldom measured or let alone reported. More importantly, the presence of risk management processes does not reveal the actual existence or the exposure to certain types of risks, which is the purpose of having a classification of risks. Furthermore, the disclosures classified under section GI 1.1.2 are generic in nature i.e. the level of documentation details is not granular enough to map these disclosures to specific classes of risk or impact identified in the taxonomy.

At the scheme level, as shown on figure 9, we find the same bias towards reporting types of impact and little focus on capturing risk exposures. GRESB, SASB and to some extent SuRE are the only schemes that include meaningful reporting of risk exposures, albeit still overwhelmingly focusing on the types of impacts of the firm.

Again the reason for this bias is the lack of ontology: *what* are these schemes aiming to measure? If they are focused on investors as their primary users, they should also be focusing on what drives asset values i.e. risks and impacts that cause or influence other risks.

An illustration of this is the role of social acceptability by the general public, a key risk for private infrastructure investors that must rely on the oft-mentioned 'social licence to operate' to protect their investment from expropriation by various public and state-owned entities. Figure 10 shows the coverage by each scheme of the individual risk sub-classes of the "General public" risk class (in the Social Acceptability Risk Super-class). Clearly, this coverage of social acceptability risk is far from comprehensive. In particular the schemes do not look at the acceptability of a given infrastructure sector (e.g. water companies) which is likely to determine public opinion and, in turn, policy decisions that can have an important impact on the value of infrastructure companies.

4. Do Existing ESG Schemes Create Investment Knowledge?

Figure 11: Disclosure Types of ESG Schemes: Quantitative vs. Qualitative (proportion - left, number - right)

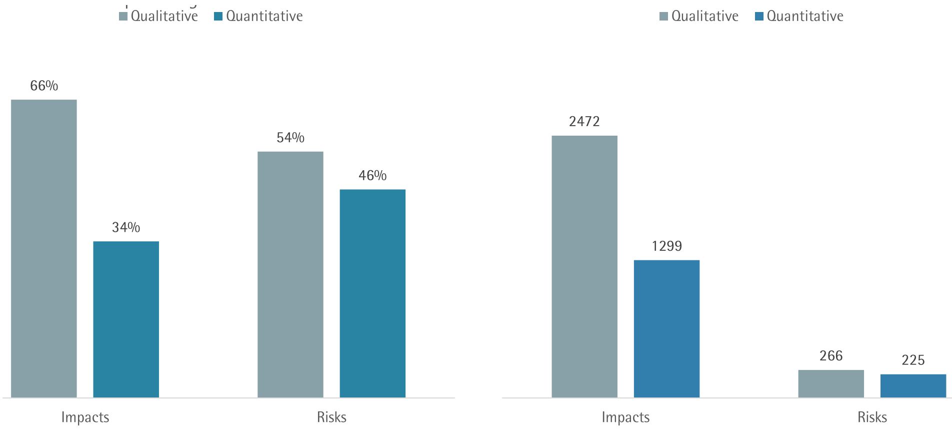


Figure 12: Disclosure Types of ESG Schemes: Quantitative vs. Qualitative by ESG Pillar

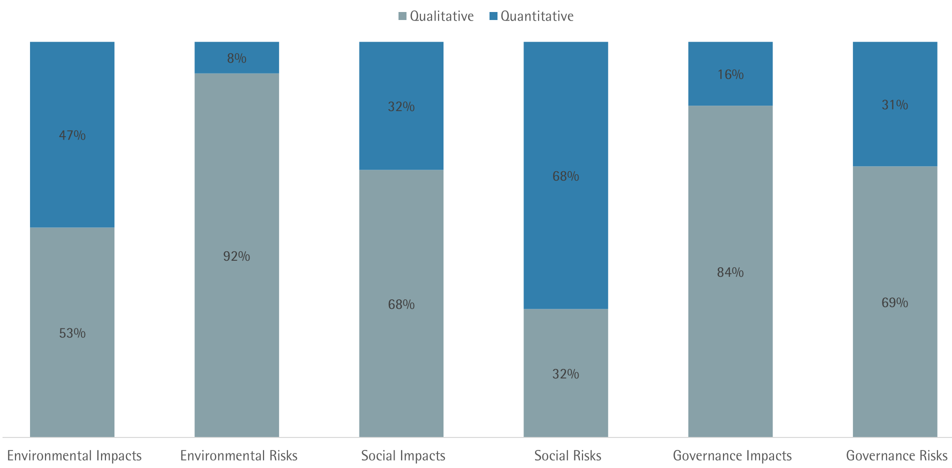
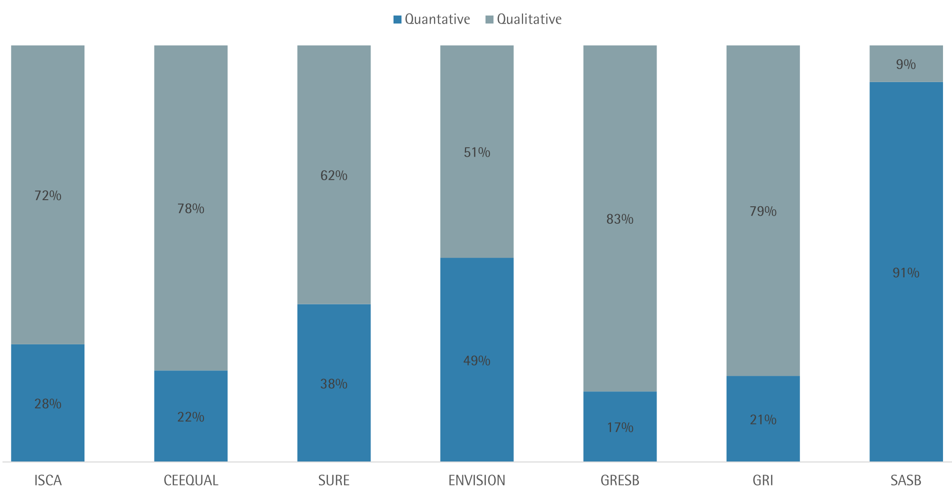
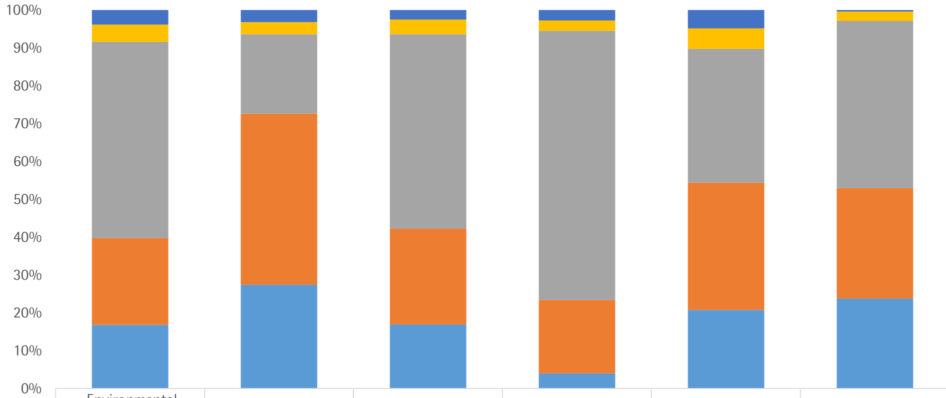


Figure 13: Disclosure Types of ESG Schemes: Quantitative vs. Qualitative by ESG Scheme



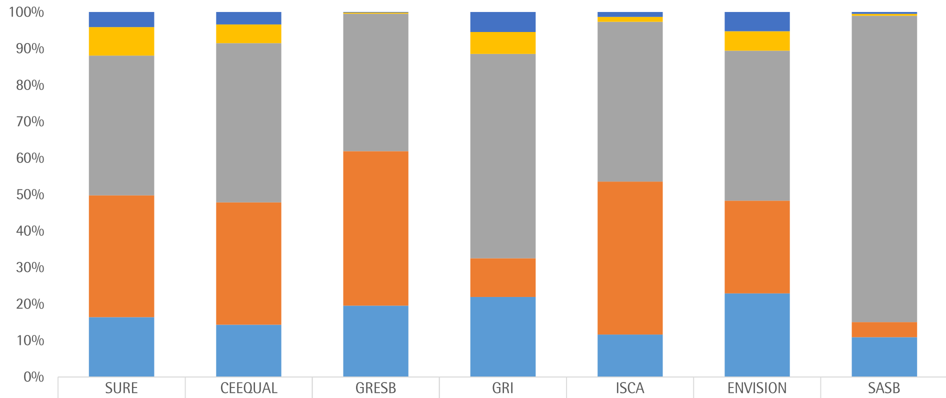
4. Do Existing ESG Schemes Create Investment Knowledge?

Figure 14: Disclosure Types of ESG Schemes: Indicator Types by Pillar



	Environmental Impacts	Environmental Risks	Social Impacts	Social Risks	Governance Impacts	Governance Risks
LONG-TERM EFFECT	4%	3%	3%	3%	5%	0%
SHORT-TERM EFFECT	5%	3%	4%	3%	5%	3%
OUTPUT	52%	21%	51%	71%	35%	44%
PROCESS	23%	45%	25%	19%	34%	29%
INPUT	17%	27%	17%	4%	21%	24%

Figure 15: Disclosure Types of ESG Schemes: Indicator Types by ESG Scheme



	SURE	CEEQUAL	GRESB	GRI	ISCA	ENVISION	SASB
LONG-TERM EFFECT	4%	3%	0%	6%	1%	5%	1%
SHORT-TERM EFFECT	8%	5%	0%	6%	1%	5%	1%
OUTPUT	38%	44%	38%	56%	44%	41%	84%
PROCESS	33%	34%	42%	11%	42%	25%	4%
INPUT	16%	14%	19%	22%	12%	23%	11%

4. Do Existing ESG Schemes Create Investment Knowledge?

4.2.3 Types of disclosures

We also find that in aggregate, 64% of all disclosures are qualitative, while 36% are quantitative. Figure 11 shows that only 34% of disclosures mapped to the impact section of the taxonomy are quantitative while 46% of the disclosures mapped to the risk section of the taxonomy are quantitative. Overall, the information reported is overwhelmingly qualitative.

Moreover, as shown on figure 12, while environmental impacts are equally distributed between quantitative and qualitative disclosures, environmental risks are mainly qualitative in nature. This confirms our earlier finding that certain types of risks are not covered in terms of exposures but more notionally (yes/no answers). In the social pillar, types of risks are largely documented using quantitative disclosures while impacts are mainly captured qualitatively. Both governance impacts and governance risks are mainly captured in a qualitative manner.

Figure 13 shows the type of data (Quantitative or Qualitative) required by reviewed schemes. The differences between schemes is the result of their using different data sources and data metrics at varying levels of granularity.

Finally, as shown on figure 14 we find that ESG schemes mainly capture activity indicators i.e. process or output indicators. This is in part determined by the type of disclosures allowed by the various schemes which consist largely of asking companies to report 'what they do' (activities). In other words, ESG performance is proxied through information on the resources used by a company and its activities (typically captured as output and process indicators). Likewise, figure 15 shows the type of indicators used in different schemes, confirming that a majority of indicators corresponds to output indicators, followed by process and finally input indicators.

Given that there are no "direct measures" of ESG impacts, it is understandable that the current schemes rely on the information about the *input* resources used, the *processes* used to carry out operations and the *outputs* of a companies activities. Such data is typically captured as output and process indicators.

The consequences of their activities however (their actual impact) are seldom included in the reporting of the ESG schemes.

4.3 Conclusion

Using our taxonomy of risks and impacts to map seven ESG schemes together, we report the following stylised facts:

- Scope divergence is significant between ESG schemes for infrastructure investment as evidenced by the different biases, incomplete coverage and lack of overlap between schemes in terms of risk and impact classes, which is also a sign of measurement divergence. These findings are in line with what Berg *et al.* report for equities;
- Measurement bias in the reporting of ESG information with the dominance of

4. Do Existing ESG Schemes Create Investment Knowledge?

qualitative measures reported;

- Impact bias in the reporting of ESG information, and little attention to measuring risk exposures, especially not through quantitative risk reporting;

- Process and input indicator bias in the reporting of ESG information, highlighting the role of proxies in the various scoring and ratings methodologies used since actual impacts are not directly measured or reported.

This quantitative review of the content of existing schemes confirms the findings of our initial review and highlights divergence of these schemes in relation to a taxonomy of ESG impacts and risks that is created for the purpose of creating ESG investment knowledge.

An important finding is that documenting actual risk exposures created by environmental or social issues is not a focus of these schemes. Instead, they focus on reporting impacts, mostly proxied by aspects of the activities of infrastructure companies often self-reporting data.

As we argued before, it is not clear how much investment knowledge can be created for investors on the basis of this data and the scores or ratings they lead to. While individual asset certifications like the SuRe provide a detailed framework for investment due diligence at the asset level, it is defined in absolute terms and not available for most assets, leaving a portfolio investor with limited understanding of the relative position and role of this investment amongst others in the same portfolio.

Schemes that are created to produce relative scores could support the creation of investment knowledge more easily but their lack of focus on asset pricing mechanisms and determinants makes it difficult to relate the resulting scores to well-defined risk exposures (either direct ESG risks or resulting from ESG impacts).

In the end, these schemes are trying to document how ESG and investment decisions might cross.

In effect, existing ESG schemes do provide investors with information related to what we called the third motive to integrate ESG in the investment process: in-principle exclusions from the portfolio i.e. a non-financial decision based on factual criteria about the activities and operations of a given company. Excluding coal-fired power plants being the most typical example. In this case (portfolio exclusions), the ratings and scoring schemes we reviewed document how ESG and investment in infrastructure do not cross.

We know however that two other motives for demanding ESG investment knowledge are to manage known exposures to ESG risks and impacts, as well as conditional ones, in a portfolio of financial assets. In the next and final chapter, we summarise our findings and describe a way forward for the development of ESG investment knowledge.

5. The Way Ahead

5. The Way Ahead

In this paper, we started with the question: How should we approach the relationship between ESG and the market value of infrastructure investments? We argued that the clearly stated desire by investors to integrate ESG into their investment process is the reflection of several non-exclusive motives, one of which is to respect a number of non-financial constraints set *ex ante* and as a matter of principle e.g. excluding investments related to fossil fuels such as oil pipelines. This motive is non-financial and simply leads to the introduction of new constraints in the investment process. Investors must then continue to try to meet their investment objectives in spite of these constraints.

The other two motives are to understand the *known* consequences of the ESG characteristics on the value of infrastructure assets, as well as their *potential* consequences on asset prices, conditional on certain future developments that are related to the ESG profile of the firm. In other words, these are financial motives. For example, the ESG characteristics of an oil pipeline may be such that it is politically controversial, creating a direct reputational cost for its owners. The same ESG profile may also lead to higher future costs if a carbon tax is introduced due to the pipeline company's contribution to fossil fuel consumption.

We argued that these two later motives are the reflection of an increased 'demand for monitoring' of investors, which is characteristic of conditions in which, despite weakly efficient financial markets, not all information is available to investors through market prices. This can be because not enough useful information is available about such investments, in which case markets cannot process information that they do not have, or because some aspects of the activities of these companies are currently unpriced (they are externalities) but would be asset price drivers if the sufficient knowledge about the risk exposure they create existed, creating a demand for new information, in particular non-financial reporting.

Investors recognise that 'externalities have consequences' and, with rapid social and environmental changes over the past decades and the expectation of even more uncertain evolutions in the coming decades, they also anticipate these consequences by demanding better knowledge about their investment choices.

The consequences of the externalities of infrastructure investments could take various forms for investors, including new regulations, changing consumer patterns, higher operating costs due to extreme weather, etc. In a nutshell, ESG considerations point to new or heightened sources of risk, which can be expected to influence asset values.

Thus, what we called investors' 'demand for monitoring' following Holmström *et al.* (1993) can also be described as a demand for **ESG investment knowledge**: a combination of standardised vocabulary, classifications and theory-based relations that allows its users to understand the relationship between ESG characteristics and asset prices, and act on new information.

5. The Way Ahead

The development of a body of ESG investment knowledge is necessary to address the two financial motives described above.

In this paper, we proceeded to examine how ESG reporting and rating schemes currently in use in the infrastructure sector approach the creation of knowledge for investors.

We highlight a common but unavoidable process of standard proliferation and innovation in the development of voluntary standards, which is often followed by the emergence of salient actors and meta-governance, before 'soft' rules eventually becoming integrated in 'hard' regulations and norms. In the case of ESG schemes for infrastructure investors, we find that they are quite new and still proliferating but that some initiatives have started to appear to organise convergence that may also lead to the salience of certain organisations and standards.

We then review the design and content of 17 schemes including 12 standards and tools and five guiding frameworks that are used for infrastructure investments and follow a recent study by Berg *at al.* of ESG rating providers in the public equities sector to determine the extent to which these schemes diverge in terms of scope, weights, measurements and aggregation of ESG data.

We find that ESG schemes diverge considerably, in particular in terms of basic definitions, aims and intended users. Crucially they tend not to focus only on investments but often combine the perspective of multiple stakeholders, making the identification of the risks and impacts for infrastructure investors more difficult.

In the end, the information currently collected and aggregated by ESG schemes for infrastructure investment does not create a body of ESG investment knowledge because it is not designed to do so. These schemes only allow documenting different combinations of the ESG characteristics of infrastructure companies with a significant degree of scope and measurement divergence. We also document that these schemes focus largely on measuring impacts and very little on risks, and do so using so-called process or output indicators i.e. proxies of impacts rather than direct measures.

In effect, the information created by ESG schemes today can be used by investors to address the motive to create exclusions or add constraints on the selection of assets as a matter of principle (what we called 'Motive 3').

In order to address the more fundamental question of how ESG relates to the value of financial assets, we conclude that a robust framework is still needed to develop the kind of ESG investment knowledge that investors in infrastructure need. Existing schemes collectively create the basis for a language to develop this knowledge, but an ontological foundation is missing.

We then lay the foundations of an ontology of ESG for infrastructure investment. We define the relevant domain of knowledge as strictly limited to the environmental, social

5. The Way Ahead

and governance impacts and risks of the infrastructure companies that investors buy, which are themselves well-defined using the TICCS® system.

We put forward a parsimonious taxonomy distinguishing between direct classes and sub-classes of the impacts and risks of infrastructure companies. This taxonomy includes 10 super-classes, 24 classes and 67 sub-classes of the ESG impacts and risks of infrastructure companies and is used to map together more than 4,800 ESG disclosures found in the ESG standards and tools we reviewed.

This ontology is designed to capture the different determinants of the value of infrastructure assets in the E, S and G perimeter and also to relate them to other such determinants. For instance, a significant environmental impact creates sources of risk for a firm, whether it is with the ESG domain (e.g. social acceptability) or outside (e.g. regulation or fines).

In the paper, we also discussed how an ontological approach allows the question of materiality to be addressed. Materiality is a weak point in existing ESG schemes because while they provide long lists of potential material information to report or collect, they do not anchor materiality in objective measures that would relate to the activities of infrastructure companies. Developing science-based materiality profiles for different types of infrastructure assets is the next step in the development of a body of ESG investment knowledge for infrastructure investment. We return to this point below.

5.1 The Evolution of ESG Schemes for Infrastructure Investors

Our findings point to several likely developments in the area of ESG ratings and certification provision:

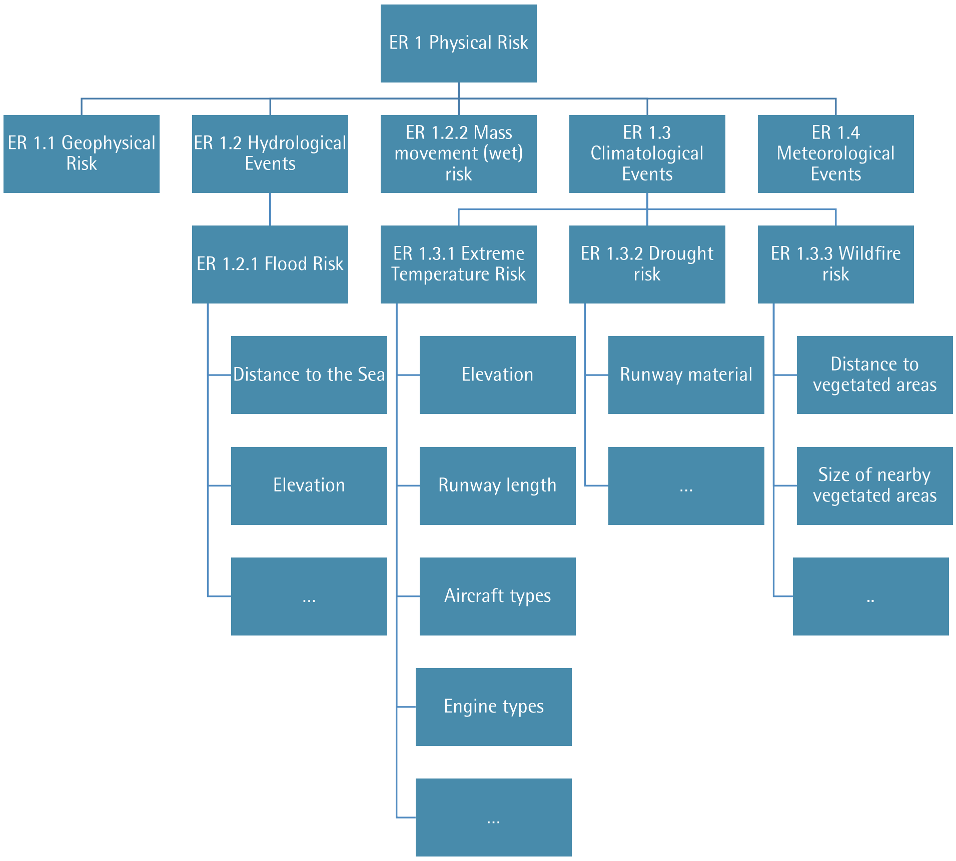
1. Infrastructure investment ESG standards will continue to change: the current absence of consistent definitions or approaches means that individual standards will continue to evolve and redefine their scope and methodologies as they attempt to dominate a winner-takes-it-all 'market' characterised by strong barriers to entry once consolidation has taken place;

2. This consolidation will be driven by an implicit ontological commitment by end-users: the degree of clarity and consensus around the objectives and the definitions used by ESG schemes, as well as the embedded assumptions that underpin these choices are likely to contribute to standard adoption, credibility and, eventually, dominance;

3. ESG Schemes that also address the most pressing questions of policy makers and regulators are more likely to attract users. In the case of infrastructure investment, this is particularly the case with regards to climate change.

5. The Way Ahead

Figure 16: Subset of attributes for sector IC-601010, Airports, to measure physical risk (ER 1)



5.2 A Roadmap for the Scientific Development of ESG for Infrastructure Investors

The scientific development of a body of ESG investment knowledge or ontology requires a number of key building blocks:

1. The clearly stated aim to create knowledge that relates the ESG characteristics of infrastructure companies to the investment decisions made on financial grounds i.e. considerations of risk and reward;

2. A well-defined domain of knowledge underpinned by financial theory. The required knowledge is concerned with instances of ESG risks and impacts, to the extent that impacts can create risks;

3. A classification system of the various objects of interest, including of course infrastructure companies and their ESG risks and impacts, but also standard classes of attributes and relations that allow the ESG characteristics of infrastructure companies to be described and create this knowledge. Any definition of the attributes and relations that create this knowledge must be science- and theory-based using the most conistent assumptions or models in order to create a broad user base and maximise ontological commitment by potential users.

5. The Way Ahead

Equipped with an ontological foundation and a taxonomy of the ESG impacts and risks of infrastructure companies, the way ahead consists of the development of science-based materiality profiles for each of the 95 types of infrastructure assets captured in the industrial activity pillar of the TICCS® classification.

These materiality profiles will consist of two key components:

1. A set of attributes that defines the relevant characteristics of each instance of risk or impact related to that type of infrastructure asset. These can be physical attributes (elevation, location, etc.) and also design ones.

   For instance, Figure 16 shows an example of a attributes that for the Airport (TICCS®-IC601010) sector, for the instance of exposure to Flood Risk (ER1.2.1), Extreme Temperature Risk (ER 1.3.1), Drought Risk (ER 1.3.2) and Wildfire Risk (ER1.3.3) in the Physical Risk super-class (ER 1). Specifically, the relative risk from extreme temperatures (ER 1.3.1) can be estimated as a function of the elevation of an airport (given that a combination of high altitude and heat can adversely impact aircraft operations (Perkins, 2017; Coffel et al., 2017), the main types of air crafts that use the airport (given that all commercial aircraft have a maximum and minimum temperature between which operations are permissible (SKYbrary, 2020), the engine types of aircraft's (given that operable temperature limits vary with engine type and phase of the flight (SKYbrary, 2020)) and at the the runway length of the airport (higher temperatures requrie longer runways for planes to reach take of speed without compromising maximum load (Coffel et al., 2017). [8]

2. Entity dictionaries listing all the relevant ways in which these attributes may be identified, collated and aggregated. For instance, all the ways in which elevation data can be captured and stored. This step requires the standardisation of possible data sources and of the available methods to process this data and document the attributes of the ESG risks and impacts of infrastructure companies.

8 - Note that this profile is only illustrative in nature and consists only of a subset of factors that contribute to the measurement of any given risk.

5.3 SFDR Alignement

The approach proposed in this paper is aligned with the work of the European Union's SFDR expected to come fully into force in 2022 (European Partliament, 12 9) expected to come fully into force in 2022.

SFDR requires "financial market participants and financial advisers (...) to disclose specific information regarding their approaches to the integration of sustainability risks and the consideration of adverse sustainability impacts." (SFDR, L317/2)

While it is concerned with minimising adverse impacts on the environment and society as a primary public policy objective, as mentioned above SFDR is also about the risks to asset values since it requires the disclosure of so-called sustainability risks, that is "an environmental, social or governance event

5. The Way Ahead

or condition that, if it occurs, could cause an actual or a potential material negative impact on the value of the investment" (SFDR, L317/9).

This, building a taxonomy of the ESG impacts and risks of infrastructure companies is an essential step to address the concerns of SFDR.

Moreover, one of the foundations of SFDR, is another taxonomy: the EU Taxonomy for Sustainable Activities describes the sustainability characteristics of various forms of industrial activities, including that of infrastructure companies. In other words, the EU Taxonomy is a first attempt at building objective materiality profiles that can be used to assess the ESG characteristics of an infrastructure company objectively.

Finally, this description of what matters from an ESG standpoint is to be documented using Technical Regulatory Standards (RTS) establishing a framework of reporting on principal adverse impacts and risks. A first draft describing ESG data that will be required by the RTS was published in the Final Report on draft Regulatory Technical Standards, of the Joint committee of the European Supervisory Authorities in February 2021, and describes detailed indicators for environmental and social impacts.

To ensure compatibility with the SFDR, the EDHECinfra ESG taxonomy allows mapping of the required disclosures to respective impact and risk classes. Given that the EDHECinfra taxonomy is an exhaustive list of ESG impacts and risks for the infrastructure sector, 100% of the mandatory disclosures can be mapped to the subclasses of the developed taxonomy. To enable measurement, each impact and risk will be measured as indicators, which in turn will be informed by data collected according to the materiality profiles of the asset.

In the RTS, these indicators are divided into a core set (18) of universal mandatory indicators that will always lead to principal adverse impacts of investment decisions on sustainability factors, irrespective of the result of the assessment by the financial market participant, and additional opt-in indicators (46) for environmental and social factors, to be used to identify, assess and prioritise additional principal adverse impacts.

Future work by EDHEC*infra* focuses on supporting the implementation of the roadmap described in this paper, including documenting the ESG characteristics of infrastructure companies.

A. Definitions of Risks and Impacts Classes

A. Definitions of Risks and Impacts Classes

The ESG taxonomy defines what ESG means from the perspective of infrastructure companies, and it consists of two dimensions- impacts and risks. An infrastructure company - as a result of its activities, processes, operations and policies - can have an impact on the environment, society or the governance of the company. In addition to this, an infrastructure company faces ESG risks stemming from external actors within the boundaries of the environment, society and governance, such as climate change, customers, communities, regulators etc.

There is an obvious circularity in this dichotomy between risk and impact: certain impacts can, directly or indirectly, create or increase risks for the party causing them. The impact of one party, like a power plant burning coal and thus contributing to climate change, is also a risk for others, such as people or businesses exposed to the consequences of climate change, and even for the power plant itself, which will face the direct and indirect consequences of its contribution to climate change (and that of every other power plant).

Without a framework that explicitly takes into account the direct and indirect risks that the ESG characteristics of infrastructure investments create, and their driving impacts, the relationship between ESG and the market value of these investments remains obscure and unclear.

The ESG taxonomy is an exhaustive list of all types of ESG impacts and risks that are relevant for all infrastructure companies. **It has three pillars- Environmental, Social and Governance and two dimensions- Impacts and Risks.**

The ESG taxonomy is built following **classification theory**, over three levels of a super-class, a class and a sub-class. The logic of classification theory requires that organising a domain of objects into classes must leave no two classes with any object in common; in addition, all of the classes together must contain all of the objects of the domain. Further, the principles or objectives used to classify a domain of objects depend upon the nature of the objects themselves.

This logic was strictly followed when building the taxonomy. Within each dimension of each pillar, the superclasses collectively provide a complete understanding of all the potential E, S or G impacts or risks from the perspective of infrastructure companies. Similarly, the classes of any given superclass were defined to be unique with the objective of providing a comprehensive overview of the pertaining ESG impacts of risks, as were their nested subclasses. For example, the environmental risks that an infrastructure company faces can either stem from physical events that can cause damage or disruption to an infrastructure asset or from reduced or no access to natural resources required for the operations of a company.

The classification was (where available) based on well-established theoretical frameworks and fundamental concepts or mechanisms. For instance, under environmental risks, the superclass of physical risk was classified into geophysical events, hydrological events,

A. Definitions of Risks and Impacts Classes

climatological events and meteorological events – a classification based on the Disaster category classification by the Centre of Research on the Epidemiology of Disasters (CRED) Below et al. (2009). Classifying the physical risks in this manner ensures that they are unique and cover all possible types of events that can pose an environmental risk to infrastructure companies. Further classifying each class into sub-classes adheres to the same rules – hydrological events can be of two types, floods and (wet) mass movements.

The data collection exercise will focus on measuring the impacts or risk identified in the subclasses as a function of their observable design, geographic and economic characteristics- described by indicators and sub indicators. For example, flood risk for a given airport can be measured as a function of its distance from the sea and its elevation. To facilitate the measurement of material impacts and risks, the observable characteristics that enable the measurement of an indicator are outlined in materiality profile which will identify the relevant indicators and sub-indicators for each type of physical infrastructure asset as defined under the TICCS® classification (pillar 2).

The ESG taxonomy, by identifying all possible ESG impacts and risks relevant for infrastructure companies, thus serves as a tool that facilitates measuring and understanding ESG risks and their driving impacts in comparable terms.

A.1 ENVIRONMENTAL PILLAR

A.1.1 ENVIRONMENTAL IMPACTS

EI 1 Natural Resources:

The OECD describes natural resources as natural assets (raw materials) occurring in nature that can be used for economic production or consumption (OECD, 2001). The World forum on Natural Capital describes natural capital as the world's stocks of natural assets which include geology, soil, air, water and all living things (The World Forum on Natural Capital, 2020). The natural capital thus consists of the natural resources of biodiversity, water, land and the atmosphere.

All infrastructure assets require construction, conduct specific activities and operations throughout their design life, require regular maintenance and finally undergo refurbishment or decommissioning. The super-class of natural resources considers the potential positive and negative impacts that the infrastructure company can have on the natural resources of an affected region by means of consuming, depleting, disturbing, polluting, conserving, restoring and protecting natural resources.

EI 1.1 Biodiversity: UNEP defines biodiversity to include plants, animals and other organisms and is defined in the Convention on Biological Diversity (CBD) as the variability among organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; it includes diversity within species, between species and of ecosystems (UNEP Finance Initiative, 2008).

A. Definitions of Risks and Impacts Classes

EI1.1.1 Loss: Biodiversity loss describes the decline in the number, genetic variability, variety of species, and the biological communities in a given area. It is inclusive of extinction of species. This loss in the variety of life can lead to a breakdown in the functioning of the ecosystem where decline has happened. Drivers of biodiversity loss are pollution, invasive species, habitat destruction, overexploitation and climate change etc.

EI1.1.2 Disturbance: In ecology, a disturbance is a temporary and localised change in environmental conditions that causes a pronounced change in an ecosystem. A disturbance can also occur over a long period of time and can impact the biodiversity within an ecosystem. Ecological disturbance can, thus, be defined as an event that causes temporary and localised shifts in demographic rates of the associated biodiversity (Dornelas, 2010).

EI1.1.3 Restoration: Degraded ecosystems are often missing species, groups of species, or even whole functional groups, such as top-level predators. Biodiversity restoration is the process of assisting in the recovery of habitats that have been degraded, damaged, or destroyed and focuses on establishing the ecological processes necessary to make terrestrial and aquatic ecosystems sustainable, resilient, and healthy under current and future conditions.

EI1.1.4 Conservation: Biodiversity conservation, the practice of protecting and preserving the wealth and variety of the biodiversity and maintaining the function of the natural ecosystems of a given region.

EI1.1.5 Enhancement: Biodiversity enhancement is the process of improving the organisms and habitats of a given region. This is done through better management, best practices and active measures.

EI1.2 Water Resources: Water resources are natural sources of water that that are useful for human activities. These include surface water, ground water and frozen water. In this case, the water resources referred to are those that the infrastructure company withdraws water from, discharges water to or those that are in the vicinity of the asset

EI1.2.1 Pollution: Water pollution occurs when harmful substances or contaminants (above a given concentration or pollutant load) are discharged or leached into water resources causing the degradation of the water quality of the given resource. In addition to making the water unsuitable for human activities, water pollution can have adverse impacts on marine and aquatic life.

EI1.2.2 Depletion: Resource depletion is the consumption of a resource faster than it can be replenished. In this case it refers to depletion of water resources linked with water consumption and extraction.

EI1.2.3 Diversion: Diversion refers to the mass movement of water temporarily or permanently to enable construction and operation of infrastructure which can cause a significant changes in the flow and water levels in a given water body.

A. Definitions of Risks and Impacts Classes

EI1.2.4 Preservation and protection: Preservation of water resources includes all policies, strategies and activities to protect the quality, quantity and integrity of water resources.

EI1.2.5 Restoration: The process of restoring the quality, quantity and integrity of the water bodies that have been subject to pollution or depletion.

EI1.3 Land: Land resources refers to the soil geographic land (soil) and all the naturally occurring resources such as rocks, minerals and ores present under the surface of the land.

EI1.3.1 Pollution: Land pollution, the deposition of solid or liquid waste materials on land or underground in a manner that can contaminate the soil.

EI1.3.2 Change in land use: Land use change involves human induced transforming of the landscape of a piece of land so it can be used for another purpose.

EI1.3.3 Depletion: Resource depletion is the consumption of a resource faster than it can be replenished. In this case it refers to depletion of land resources of soil, rocks, minerals, ores etc. used by the infrastructure company.

EI1.3.4 Preservation and protection: Preservation of land resources includes all policies, strategies and activities to protect the quality, quantity and integrity of the soil and the resources such as rocks, minerals and ores present under the surface of the land.

EI1.3.5 Restoration: The process of restoring the quality, quantity and integrity of the soil and the resources such as rocks, minerals and ores present under the surface of the land that have been subject to pollution or degradation.

EI1.4 Atmosphere: The atmosphere is a blanket of gases that surround the earth. It contains the air we breathe, protects the planet form harmful radiation, maintains the global water cycle and regulates global temperatures and the global climate.

EI1.4.1 Air pollution: Air pollution occurs in many forms but can generally be defined as gaseous and particulate contaminants that are present in the earth's atmosphere. Sources of air pollution include the emission of pollutants into the air enabled by infrastructure.

EI1.4.2 Climate change: Climate change can be understood as the abnormal variations and the significant long-term change in the expected patterns of the average weather of the Earth's local, regional and global climates. It is caused by an increasing concentration of greenhouse gases in the Earth's atmosphere. In the taxonomy, we refer to climate change induced by anthropogenic activities such as the use of non-renewable energy sources.

While air pollution and climate change are closely linked, they are different issues. Rising levels of C02 and other air-polluting gases increase the greenhouse effect, which in turn raises temperatures and affects global

A. Definitions of Risks and Impacts Classes

weather patterns, thus one of the drivers of climate change is air pollution.

EI1.4.3 Air quality improvement: Reducing the concentration of contaminants present in the air so as to maintain air quality at a level considered safe for life.

A.1.2 ENVIRONMENTAL RISKS

ER1 Physical risk:

The superclass of physical risks looks at the risks that infrastructure assets face from physical events or natural disasters.

Physical events can render the infrastructure asset inoperable (flooded roads as a result of a severe precipitation event), cause physical damage to the asset (road damaged as a result of a landslide) or to the supporting infrastructure (damaged pipeline that supplies water to a coal power plant). In addition to this, physical events can alter the availability and quality of natural resources required as inputs for the activities of infrastructure companies.

The below classification and definitions of natural disasters is based on the Disaster category classification by the Centre of Research on the Epidemiology of Disasters (Below et al., 2009).

ER1.1 Geophysical events: Events originating from solid earth.

ER1.1.1 Earthquake risk: The physical risk stemming from the shaking and displacement of the ground due to seismic waves.

ER1.1.2 Volcanic risk: The physical risk stemming from volcanic activity such as rock falls, ash fall, lava streams, gases etc.

ER1.2.3 Mass movement (dry) risk: The physical risk stemming from the displacement of the physical movement of the earth.

ER1.2 Hydrological events: Events associated with water occurrence, movement and distribution.

ER1.2.1 Flood risk: The physical risk stemming from the significant rise of the water level in a stream, lake, reservoir or coastal region usually as a result of rainfall or snowmelt.

ER1.2.2 Mass movement (wet) risk: The physical risk stemming from the displacement of the physical movement of the earth caused by a change of hydrological conditions.

ER1.3 Climatological events: Events caused by long-lived/meso to macro scale processes (in the spectrum of intra-seasonal or multi-decadal climatic variability).

ER1.3.1 Extreme temperature risk: The physical risk stemming from the variation in temperature above (extreme heat) or below (extreme cold) normal conditions.

ER1.3.2 Drought risk: The physical risk stemming from a long-term event triggered by a lack of precipitation.

A. Definitions of Risks and Impacts Classes

ER1.3.3 Wildfire risk: The physical risk stemming from an uncontrolled burning fire, usually in wild lands.

ER1.4 Meteorological Events: Events caused by long-lived/meso to macro scale atmospheric processes (in the spectrum of minutes or days).

ER1.4.1 Storm risk: The physical risk stemming from the disturbance of the atmosphere marked by wind and one or more of rain, snow, hail, sleet or thunder and lightning.

ER2 Access to natural resources:
Access to natural resources can be understood as the opportunity and the ability to make use of the natural resources required for the activities of the infrastructure company.

The degradation (loss of quality) or depletion (loss of quantity) of natural resources can occur due to various activities of the infrastructure company posing a risk to the operations of the company.

ER2.1 Resource loss risk: The risks associated with the reduction in the quantity or deterioration of quality of natural resources in a given geographic region.

ER2.1.1 Quality risk: The deterioration of quality of natural resources in a given geographic region, associated with human activities such as pollution.

ER2.1.2 Availability risk: The depletion in the stock of a natural resource in a given geographic region, associated with human activities such as over-consumption.

A.2 SOCIAL PILLAR

A.2.1 SOCIAL IMPACTS

SI1 Human wellbeing:
Wellbeing can be understood as a state of health, happiness and/or prosperity.

SI1.1 Collective wellbeing: The class of collective wellbeing refers to the positive and impacts of infrastructure companies on the wellbeing of a given community.

SI1.1.1 Human rights: As per the universal declaration of human rights (UN, 1948), human rights are rights inherent to all human beings, regardless of race, sex, nationality, ethnicity, language, religion, or any other status. Human rights include the right to life and liberty, freedom from slavery and torture, freedom of opinion and expression, the right to work and education, and many more. Everyone is entitled to these rights, without discrimination.

SI1.1.2 Public health and safety: Public Health and Safety is generally defined as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and wellbeing of public, taking into account the possible impact on the surrounding communities and the general environment (Alli, 2008).

A. Definitions of Risks and Impacts Classes

SI1.1.3 Public disturbance: A public disturbance is a state in which the comfort or peace of members of the public is disrupted.

SI1.1.4 Heritage and culture: The heritage and culture of a community/society is the legacy of physical artefacts and intangible attributes of the community including but not limited to historic and cultural resources and archaeological remains (UNESCO, 2017).

SI1.2 Workforce wellbeing: Employee wellbeing refers to the state of employees' health, happiness and/or prosperity.

SI1.2.1 Workforce health and safety: Workforce Health and Safety is generally defined as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and wellbeing of the workforce (Alli, 2008).

SI 1.2.2 Working conditions: The International Labor Organization (ILO) describes working conditions to encompass a broad range of topics and issues, from working time (hours of work, rest periods, and work schedules) as well as the physical conditions and mental demands that exist in the workplace (ILO, 2020).

SI 1.2.3 Benefits: Non-wage compensation provided to employees. The most common benefits are medical, disability, and life insurance; retirement benefits; paid time off; and fringe benefits (U.S. Bureau of Labor Statistics Division of Information Services, 2020).

SI2 Economic development:
Economic development is the process by which the economic wellbeing and quality of life of a nation, region, or local community are improved according to pre-specified goals and objectives. Thus economic development implies economic growth plus progressive changes in certain important variables which determine wellbeing of the collective society.

SI2.1 Human development: The United Nations Development Programme defines human development as the process of enlarging people's choices, wherein the said choices allow them to lead a long and healthy life, to be educated, to enjoy a decent standard of living, as well as political freedom, other guaranteed human rights and various ingredients of self-respect (UNDP in Ghana, 1997, p 15)

SI2.1.1 Standard of living: Standard of living refers to the level of wealth, comfort, material goods, and necessities available to a certain socio-economic class or geographic area.

SI2.1.2 Human Capital: Human capital is the stock of habits, knowledge, social and personality attributes (including creativity) embodied in the ability to perform labour so as to produce economic value (Goldin, 2016).

SI2.1.3 Healthy life: A healthy life refers to a long life, free from diseases and acute and chronic health conditions. It stems from the environment and from the practices of population groups that are consistent with

A. Definitions of Risks and Impacts Classes

supporting, improving, maintaining and/or enhancing health.

SI2.2 Assets Values: Asset value can be understood as the market value of all assets that can be impacted by infrastructure.

SI2.2.1 Related land value: Land value is the market value of a piece of property including both the market value of the land itself as well as any improvements that have been made to it. Land market values are highly sensitive to infrastructure investment and urban economic growth. Public works projects such as road construction, water supply, and mass transit investment produce benefits that are immediately capitalised into surrounding land values (Peterson, 2008).

SI2.2.2 Related real estate value: Property value refers to the market value of a piece of real estate based on the price that a buyer and seller agree upon. Just as with land market value, the availability of infrastructure assets and economic growth leads to a rise in real estate market value given the increased levels of accessibility and connectivity associated with the piece of real estate.

SI 2.2.3 Related business value: Business value is defined as the entire market value of the business; the total sum of all tangible and intangible elements. Examples of tangible elements include monetary assets, stockholder equity, fixtures, and utility. Examples of intangible elements include brand, recognition, good will, public benefit, and trademarks. This sub-class refers to the value of a business excluding the market value of the real estate associated with the company. Infrastructure services enable business processes thereby having a positive impact on related business market value.

SI2.2.4 Related infrastructure asset value: The market value of any given infrastructure asset is dependent on multiple factors, one of which is the availability of infrastructure networks connected physically or digitally. This network effect, increases the market value or utility a user derives from a good or service (infrastructure in this case) and leads to an increase in related infrastructure market value.

A.2.2 SOCIAL RISKS

SR1 Social Acceptability:

Social acceptability is the outcome of a collective judgment or collective opinion of a project or company. The collective judgment may be positive or negative and is never set in time. It is made up of what people feel about a company, based on their experience, what they have heard/read about the company, or available facts about the company.

A poor social acceptability, or the lack of a social license to operate can lead to reputational risks and ultimately lead to regulatory constraints which undermine the usefulness of the infrastructure asset and/or the profitability of the company.

SR1.1 Customer: Customers are defined as the group of individuals that use the service provided by the infrastructure company. Customer dissatisfaction with the services offered by the infrastructure company can

A. Definitions of Risks and Impacts Classes

undermine the usefulness and usability of the asset in the long run and even lead to regulatory interventions in extreme cases.

SR1.1.1 Quality of service: Quality of service is the description or measurement of the overall performance of a service particularly the performance as perceived by users.

SR1.1.2 Affordability of service: Affordability can be understood as the ability of a large proportion of society (at least the top of the bottom quartile) to pay for a service.

SR1.1.3 Accessibility of service: Accessibility is the degree to which a service is available and physically accessible to as many users as possible.

SR1.2 General Public: General public refers to the individuals in a given population. Negative perceptions of an infrastructure company by the general public can manifest in the form of political risk, ultimately leading to the imposition of regulatory constraints which undermine the usefulness and usability of the infrastructure assets.

SR1.2.1 Sector reputation: Sector reputation refers to the social acceptance of a whole infrastructure sector by the general public and is not related to a specific infrastructure asset or the actions of a particular infrastructure company.

SR1.2.2 Privatisation perception: Privatisation occurs when a government-owned business, operation, or property (in this case, it refers to infrastructure companies) becomes owned by a private, non-government party. The social acceptance of privately owned infrastructure by the general public is referred to as privatisation perception.

SR1.2.3 Company reputation: Reputation is the overall estimation in which an organisation is held by its internal and external stakeholders. Reputational risk stems from negative publicity, negative public perception or specific events or actions which in turn can adversely impact a company's revenue. Adverse events typically associated with reputation risk include ethics violations, safety issues, security issues, a lack of sustainability, poor quality, and lack of or unethical innovation.

SR1.3 Regulators: Bodies that are tasked with regulation of infrastructure include the government, independent regulators such as OFWAT or prudential regulators. Regulatory processes generally comprise three stages: the enactment of enabling legislation, the creation of regulatory administrations and rules, and bringing to bear of those rules on organisations whose behavior is to be influenced or controlled. Thus, poor performance on part of infrastructure companies can pose the risk of intervention from government and regulators which can manifest in the form of fines, nationalisation (where applicable) and business closure.

SR1.3.1 Ideology: An ideology is a set of opinions or beliefs held by a group or individual. The failure of infrastructure companies or infrastructure sectors to align

A. Definitions of Risks and Impacts Classes

with the ideologies of regulators can pose a risk to the infrastructure company.

SR1.3.2 Politics: The acceptability, or lack of it, of an infrastructure company or an infrastructure sector to the general public can lead to the government promoting or barring specific companies or types of infrastructure.

SR2 Workforce Availability:
Workforce availability is defined as the availability of enough personnel to carry out all the activities of an infrastructure company.

SR2.1 Industrial action: Industrial action or job action is a temporary action by workers as a protest and means of forcing compliance with demands.

SR2.1.1 Strikes and slowdowns: Labor strikes, simply called strikes, are the mass refusal of employees to work, usually in response to employee grievances, and they can disrupt the daily operations of a company. A slowdown is an industrial action in which employees perform their duties but seek to reduce productivity or efficiency in their performance of these duties.

SR2.2 Labor Market: The labour market, also known as the job market, refers to the supply of and demand for labour, in which employees provide the supply and employers provide the demand.

SR2.2.1 Skill drought: The unavailability of trained, educated, or experienced segments of the workforce that are suitable and competent to carry out the tasks and activities of the infrastructure company.

A.3 GOVERNANCE PILLAR

A.3.1 GOVERNANCE IMPACT

GI1 Organisation quality:
The superclass of organisation quality refers to how well an infrastructure company governs itself.

GI1.1. Company management: Management is defined as the organisation and coordination of a company's activities in order to achieve company goals and consists of designing corporate policies, strategies and plans to achieve the established objectives.

GI1.1.1 Effectiveness: Effectiveness in management refers to the capability of the management to achieve the desired targets in the specified time. It is inclusive of the management systems, plans, policies, strategies, commitments and approaches used by the company to ensure the smooth running of the company.

GI1.1.2 Impact and risk management: Risk management is the identification and analysis of potential risks and the implementation of strategies and plans to minimise, monitor and control the effect of those risks on the company. This section is inclusive of all ESG risks.

Impact assessment is a means of measuring the effectiveness of the activities, policies, strategies and practices of a company and judging the significance of changes brought about by those activities. This section is inclusive of all ESG impacts.

A. Definitions of Risks and Impacts Classes

GI1.2 External relationships: The class of external relationships focuses on the impact (on the organisation) of maintaining healthy relationships with the external stakeholders of the company.

The four principles of corporate governance (Pearse Trust, 2014) can be used to understand the manner in which a company can maintain external relationships.

GI1.2.1 Transparency: Corporate transparency describes the extent to which a corporation's actions are observable by outsiders. This is a consequence of regulation, local norms, and the set of information, privacy, and business policies of a company, concerning corporate decision-making and operations openness to stakeholders, shareholders and the general public. From the perspective of outsiders, transparency can be defined simply as the perceived quality of intentionally shared information from a corporation (Schnackenberg and Tomlinson, 2016).

GI1.2.2 Corporate accountability and responsibility: Corporate accountability refers to the degree to which a company accepts responsibility for the impact of its actions on society and the environment, either voluntarily or as a result of pressures exerted by social and political actors.

GI1.2.3 Stakeholder engagement: Stakeholder engagement is the process by which an infrastructure company involves all parties who may be affected by its decisions or can influence its business.

GI1.2.4 Contractor and supplier engagement: Contractor and supplier management refers to all the business processes and activities that deal with the entire life-cycle of a supplier for an organisation. This includes, but is not limited to, identification, selection, and management of relevant contractors and suppliers.

A.3.2 GOVERNANCE RISKS

GR1 Organisation Failure:

The failure of a company to govern itself.

GR1.1 Process failure: A business process is a collection of related, structured activities or tasks carried out by people or equipment in which a specific sequence produces a service or product (serves a particular business goal) for a particular customer or customers. All organisation activities rely on specific processes as well-developed and well-implemented processes aid in the good governance of a company.

A failure of organisation processes either due to the process being difficult to use, poorly designed or poorly implemented can pose a risk to the governance of the company.

GR1.1.1 Reporting failure: The inability to partially or completely report both mandatory and voluntary disclosures as a result of a process failure.

GR1.1.2 Compliance failure: The failure of internal management systems designed to prevent and detect violations of applicable law, regulations, rules, interna-

A. Definitions of Risks and Impacts Classes

tional guidelines and ethical standards by the company.

GR1.2 Absence of processes: The absence of organisation processes (core and other) to perform company activities can pose a risk to the governance of the company.

GR1.2.1 Mandatory processes: The process required to ensure that companies comply with all applicable rules and regulations and adhere to all mandatory standards including those of quality control, safety etc.

GR1.2.2 Other processes: The processes that are aimed at facilitating the smooth running of a company and improving its efficiency that contribute to effective management but are not mandated by law or industrial standards.

GR2 Staff failure:
Staff failure can be understood as the inability of the team as a whole to successfully or efficiently carry out company activities.

GR2.1 Competency: Employee competencies are a list of specific demonstrable or measurable skills required to complete a specific company activity.

GR2.2.1 Core activity: The specific skills required to complete the core business activities of a company.

GR2.2.2 Non-core activity: The specific skills required to complete the non-core business activities of a company.

GR2.2 Integrity: Integrity is the quality of having strong ethical and moral principles that are followed at all times, in this case referring to the workforce.

GR2.2.1 Criminal activity: A lack of integrity can lead to dishonest behaviour on part of the employees and can cause a company to be part of criminal activities such as fraud, bribery and corruption.

GR2.2.2 Non-Criminal activity: Lack of integrity can also lead staff to indulge in dishonest behaviour which, while not criminal in nature, can hamper internal process creating issues for company management.

B. Impact-Risk Relationships

B. Impact-Risk Relationships

The links made here are made from the perspective of the company. Natural processes that drive ESG impacts are not considered in the mapping since they cannot be attributed directly to the infrastructure company.

B.1 ENVIRONMENTAL PILLAR

B.1.1 ENVIRONMENTAL IMPACTS

EI 1 Natural Resources

All infrastructure assets requires construction, conduct-specific activities and operations throughout their design life. They then require regular maintenance and finally undergo refurbishment or decommissioning. Thus throughout their life-cycle, infrastructure assets interact with various aspects of the natural capital such as land, consume resources such as water and materials, generate waste and pollution and interact with and disturb ecosystems. In addition to this, the activities of infrastructure companies require energy and generate greenhouse gases that can have an impact on climate change.

EI 1.1 Biodiversity Given that infrastructure generally has a large land footprint, its construction is typically associated with significant land use changes (Giuliano, 2004) (Yeo, 2019, p 24) which can adversely impact the biodiversity of the surrounding areas (WEGA, 2013). Construction of infrastructure may even require the complete destruction of a habitat (submerging forests or other ecosystems to build dams, diversion of rivers to make way for highway construction, diversion of rivers etc.) or cause habitat fragmentation (building roads through forested areas), both of which are associated with the loss of local biodiversity and a decline in ecosystems of which they are a part (Laurance et al., 2006; Benchimol and Peres, 2015; Rosenberg et al., 2000).

Infrastructure activities also generate waste and pollution which, if not managed in an appropriate manner, can cause biodiversity loss and disturbance. Waste (organic and inorganic) discharge is also known to be associated with the contamination and degradation of aquatic and terrestrial ecosystems, which reduces the carrying capacity of these and surrounding habitats. Pollution, in the form of light, heat, noise, vibrations or discharge of contaminants into the air, can disturb ecosystems causing shifts in demographic rates of the associated biodiversity. For example, a power station may increase the temperature of a local water body as a result of discharging cooling water into it. This in turn may alter the metabolism, feeding habits, reproduction rates of certain species (WEGA, 2013). Finally, by contributing to climate change, the infrastructure sector can indirectly contribute to long lasting negative impacts on biodiversity.

These impacts can however be managed by the company, either though design, implementation of management systems and process that monitor and track impact or other ad-hoc activities. Companies can actively engage in conserving, restoring or enhancing the biodiversity with which they interact. They can also support efforts elsewhere to offset their impacts. These

B. Impact-Risk Relationships

activities can focus on conserving, preserving and protecting aquatic and terrestrial habitats, managing and reducing their waste and pollution and ensuing that ecological balances are not upset. For example, they can create overpasses, tunnels, or other wildlife corridors so as to not hinder the movement and migration of animals, or take appropriate steps to ensure that no invasive species (predators, pests, weeds) are accidentally introduced into a given ecosystem.

EI 1.2 Water Resources Water resources are natural sources of water that that are useful for human activities. These include surface water, ground water and frozen water. The infrastructure sector consumes water for construction and operations as well as using embodied water in the materials used to build and maintain the asset throughout its lifecycle. Consuming water from local resources in an unsustainable manner can cause depletion of these bodies, driving certain social impacts and risks (to be discussed in respective sections). In addition to this, construction of certain infrastructure may require the diversion of water resources (for example, re-routing of a river for highway construction (Flatley et al., 2018)). Discharging waste into local water bodies can cause water pollution which drives other impacts such as those on biodiversity discussed earlier and on public health and safety.

The contribution of the infrastructure sector to climate change is well documented. Climate change is projected to have adverse impacts on both the quality and quantity of fresh water resources globally (Field et al., 2014), driving the pollution and depletion of water resources among other things.

The manner in which a company manages its interactions with its water resources can change the magnitude of its impact on them. This ranges from selecting sustainable water sources (rain water harvesting), using water efficiently (for example, recycling and reusing water where possible) and ensuring that the rate of extraction of water from a resource is not higher than the rate at which it can be replenished. It also includes ensuring that waste is treated appropriately before it is discharged so as to not pollute water resources and implementing process and management systems to preserve, protect and, where necessary, restore water resources.

EI 1.3 Land The siting of the project can drive environmental impacts (impacts on biodiversity as discussed above) or social impacts (when the land site holds significance to the local community as discussed in the section of collective welfare). Construction and operation activaties can degrade the soil quality as well generate pollution and waste that contaminate the land, which can have negative impacts on biodiversity and public health. Building infrastructure typically involves land use changes, which are well-documented factors in driving climate change, especially in the case of deforestation (Shukla et al., 2019).

By proactively undertaking land use management, infrastructure companies can have positive impacts on the land they interact with. The development of infras-

B. Impact-Risk Relationships

tructure can be used as an opportunity to restore previously contaminated, polluted or degraded land. Best practices can be employed to ensure that the land is preserved and protected as much as possible against degradation (establishing heavy vehicle routes to as to minimise soil compaction) and pollution (ensuring appropriate waste management).

EI 1.4 Atmosphere The transport sector is the largest contributor to anthropogenic pollutant emissions in urban environments (Luo et al., 2017). Transportation is associated with the emissions of carbon dioxide, carbon monoxide, nitrous oxides (NOx), sulphur oxides (SOx), dust, polyaromatic hydrocarbons (PAHs) and particulate matter (PM) into the air, which can have detrimental impacts on public health as well as that of plants and animals. In addition, other infrastructure sectors also emit air pollutants and greenhouse gases. The World Bank estimates that approximately 70% of global greenhouse gas emissions - the primary driver of climate change - come from infrastructure construction and operations such as power plants, buildings and transport (Saha, 2018). Climate change is also exacerbated by land-use change brought about by infrastructure (Shukla et al., 2019).

Infrastructure companies can manage their impacts on both air quality and climate change. For example, they can switching to green energy or implement process and systems that increase energy efficiency such as maintaining and refurbishing energy infrastructure, pursuing synergies between heat and power systems and optimising scope 3 emissions associated with the services offered by infrastructure and the transport of staff and raw materials to enable company activities. Specific energy saving features can be implemented in the design of infrastructure assets to make them more efficient.

B.1.2 ENVIRONMENTAL RISKS

ER 1 Physical Risk

Infrastructure assets are rigid structures with a long lifespan. Thus, once built they are susceptible to risks stemming from natural disasters and climate change that affect their geographic location. Of course infrastructure assets do have, by virtue of engineering design, a certain degree of resilience or adaptive capacity. Nevertheless, they are exposed to physical risks which can affect the performance of the infrastructure asset. This could be by means of service disruptions of varying magnitude that temporarily render the asset inoperable (flooded roads as a result of a severe precipitation event), physical damage to the asset (road damaged as a result of a landslide), or damage to the supporting infrastructure (damaged pipeline that supplies water to a coal power plant).

Given that natural disasters and climate change pose a risk to the asset performance and the usability of the asset, and that carrying out business as usual in the face of climatic stress often requires high adaptation, operation and maintenance costs, this type of risk is especially relevant to investors.

B. Impact-Risk Relationships

ER 1.1 Geophysical Events Geophysical events such as earthquakes, volcanoes or the mass movement of the earth (avalanches, landslides, subsidence etc.) can pose a significant risk to the physical integrity of infrastructure assets. For example, land subsidence can lead to infrastructure collapsing (Shukla et al., 2019).

Proactive risk management and the implementation of strong emergency response measure can enable the infrastructure company deal with these type of events.

ER 1.2 Hydrological Events Hydrological events such as river floods, flash floods, storm surges or coastal floods are a very serious threat to infrastructure assets globally. THese also include events such as subsidence, landslides, avalanches etc. where the mass movement of earth is caused by a change of hydrological conditions for example, landslides cause by heavy precipitation.

These risks can manifest as extreme precipitation that causes river floods or storm surges that lead to damage to roads, railways, airports, ports, bridges and cause interruption to water and power supplies. In general, all coastal infrastructure faces the threat of rising sea levels (Handmer et al., 2012).

Proactive risk management and the implementation of strong emergency response measures can help an infrastructure company to deal with these type of events. While they are natural, research shows that such events can be exacerbated by a changing climate. The IPCC estimates that it is very likely that a mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future and that the frequency of heavy precipitation, or the proportion of total rainfall from heavy rainfalls, will increase in the 21st century over many areas of the globe (Seneviratne et al., 2012).

ER 1.3 Climatological Events Climatological events such as heat waves, cold waves, extreme summers or winters, droughts wildfires etc. can cause damage or impact the operability of infrastructure. For instance, airports may have to suspend operations when temperatures exceed the operable limit of certain aircrafts, high temperatures can cause railway tracks to buckle or wrap, and damage to the paving material such as asphalt can impact operations of roads and runways under extreme conditions. High temperature co-existing with drought can drive subsidence risks, which can have cause infrastructure to collapse. Proactive risk management can enable an infrastructure company deal with these type of events, such as using building materials that are more flexible to ambient temperature, incorporating cooling measures such as green roofs where applicable, etc. However, implementing emergency plans and processes to cope with events such as wildfires can mitigate safety and introduce operational risks associated with these events.

While these are natural events, research shows that can be exacerbated by a changing climate. IPCC models project substantial warming in temperature extremes by the end of the 21st century (Seneviratne et al., 2012),

B. Impact-Risk Relationships

with the finding that anthropogenic forcing may have substantially increased the risk of extreme temperatures and drive the projected increase in the frequency of wildfires.

ER 1.4 Meteorological Events Meteorological events such as tropical storms, cyclones, tornadoes, snowstorms, blizzards etc. can cause physical damage to infrastructure by inundation, wind loading and debris impact. Tall thin structures such as transmission towers and wind turbines can be damaged by the debris carried by storms. Freezing rain can accumulate glaze ice on power lines and increases their catenary load., which can cause the line to break or distribution poles and transmission towers to collapse. Storms in coastal areas may affect transmission and distribution networks by increasing the amount of saltwater deposits on electrical equipment. Storms can also lead to disruptions of power and telecommunication services (Karagiannis et al., 2019).

While these are natural events, research shows that can be exacerbated by a changing climate (Collins et al., 2019). Risk management can include siting the project after a climate risk assessment, incorporating design features that increase physical protection of assets, and adopting technology both to anticipate risks (early warning systems) and to mitigate their impact on service disruption (having a backup power source that enables faster system restoration among other things). In addition, implementing emergency response measures, systems and process can help to manage the safety risks arising from such events.

ER 2 Access to natural resources

All companies require inputs in the form of resources to carry out their activities. Examples of natural resources are air, water, wood, oil, wind energy, natural gas, iron, and coal. Both anthropogenic activities and climate change can alter the quantity or quality of the natural resources required for the daily operations of a company, posing both short- and long-term risks to its business continuity.

ER 2.1 Resource loss risk Infrastructure companies can drive the quality risk of natural resources by means of degrading, depleting or polluting the natural environment from which they obtain these resources. Quantity risk is driven by consuming resources at a rate higher than they can be replenished (such as water, forests, soil etc.) or consuming non-renewable resources such as minerals and ores at a rate that depletes reserves to a level at which they cannot be mined due to technological or economic constraints. In addition, diversion of water bodies like rivers, permanently or temporarily, can have adverse impacts on hydrological flow regimes, causing both quality and quantity impact on connected water bodies (NIWA, 2009; Flatley et al., 2018).

Infrastructure's contribution to climate change also drives both the quality and availability risk of natural resources. Changes in average climatic variables over periods of time, or climate induced natural disasters, can cause a sudden or gradual change in the quality (for example, floods carry with them contaminants such as soil, animal waste, salt,

B. Impact-Risk Relationships

pesticides, and oil that can alter the quality of water supplies) and quantity of required resources (for example, hotter summers or droughts causing the loss of water bodies).

Proactive risk management by means of using resources sustainability, actively preserving and protecting natural resources and climate risk preparedness can aid in the management of risks associated with the quality and availability of natural resources.

B.2 SOCIAL PILLAR

B.2.1 SOCIAL IMPACTS

SI 1 Human Well-being

Infrastructure is constructed and operated to provide specific services. The services provided by an infrastructure company, and its associated activities, policies and practices, can have an impact on the well-being of its customers, on the community and society at large and on its workforce. Negative impacts on these aspects can drive both reputational risks for the company and can lead to industrial action by the employees, both of which can further serve as sources of business risk for the company.

SI 1.1 Collective welfare Provision of infrastructure services helps in the inclusive development of the community, as access to infrastructure services can enable communities to receive their human rights (such as access to education, transport, health and to basic services such as water and electricity). However, construction of infrastructure - which is usually large and requires connected parcels of land - can cause displacement of local and indigenous communities and infringe on their human rights. Further, the policies and practices of an infrastructure company can also infringe on the human rights of its workforce (such as the use of child and forced labour for construction).

The activities of an infrastructure company can also significantly impact the health and safety of surrounding local communities. The pollution from infrastructure projects can cause a nuisance to members of the public. For example, residents of areas close to busy highways, train routes or airports are constantly disturbed by noise, light and vibration arising from traffic, trains and aircrafts. The waste disposal practices of infrastructure assets can have both short- and long-term health and wellbeing impacts on members of the public, resulting from polluted water sources used by the community, air pollution etc. Further, the construction and operational activities of all companies can cause hazards to the local public, such as flooding caused by storm water runoff from construction sites etc. Finally, if the infrastructure offers a poor quality service (such as roads that are not well-maintained, water supply networks that supply water of poor quality etc.) it can pose hazards to public health and safety.

The construction and operation of infrastructure can also have a significant impact on the heritage and culture of a community. The pollution generated during the lifecycle of the asset, such as noise and vibrations, can cause damage to historic buildings and protected areas, damaging the heritage

B. Impact-Risk Relationships

and culture of a given region. In addition, construction over connected pieces of land might require breaking down or damaging buildings of historic significance, altering the visual landscape or dmaging the sentiment of associated communities. Conversely, infrastructure companies can have a positive impact by enhancing the local landscape and by taking active steps in preserving the heritage and culture of the impacted communities.

The above impacts can be managed by means of implementing strong policies, process, mechanisms and systems to ensure that the company complies with both internal guidelines and relevant legal requirements. In addition to this, strong engagement with impacted stakeholders can enable companies to ensure that potential impacts (human rights infringement, health, safety and disturbance risks and impacts on heritage and cultural aspects) are identified and the compensation or remedy proposed by the company is adequate, effective and acceptable.

SI 1.1 Workforce wellbeing An infrastructure company can have an impact on its workforce by means of its policies and practices surrounding the health and safety of the workforce and the employment conditions and benefits it offers.

Impacts on the wellbeing of workers can be managed by means of implementing strong policies, process, mechanisms and systems to ensure that the company complies with both internal guidelines and relevant legal requirements. In addition, implementing impact-management process that engage the workforce and ensure that their grievances are accounted for and addressed can also help to ensure that the workforce is satisfied with the physical and mental pressures associated with the job.

SI 2 Economic development

The role of infrastructure in promoting socio-economic development is well known and well documented. The United Nations has stated that the provision of adequate infrastructure, along with macroeconomic stability and a long-term development strategy, is one of the necessary conditions for sustainable economic and social development (UN, 1994).

Economic development can have a positive impacts on human development (improvement of the standard of living of impacted communities, increasing the quality of human capital and enabling the community to lead a long and healthy life) and on the value of assets such as land, real estate, business and related infrastructure.

SI 2.1 Human development Infrastructure by generating employment to construct, operate and maintain its assets can improve the economic health and quality of life of impacted communities. Further, education services and infrastructure that enables access to them pay a role in increasing the human capital associated with any given community. Similarly health and social care services and access to them enabled the impacted community to lead a long healthy life.

B. Impact-Risk Relationships

It is established that infrastructure plays a critical role in achieving and marinating high human development (Mohanty et al., 2016), however this is not driven by other impacts and risks identified in the ESG taxonomy.

SI 2.2 Assets Values The wider indirect economic benefits generated by the operations and activities of the infrastructure company can impact the market value of related assets. This could be by means of 1. Increasing the land value surrounding infrastructure. Land values are highly sensitive to infrastructure investment and urban economic growth. Public works projects such as road construction, water supply, and mass transit investment produce benefits that are immediately capitalised into surrounding land values (UNDP in Ghana, 1997); 2. Increasing the surrounding real estate value. Just as with land value, the availability of infrastructure assets and economic growth leads to a rise in real estate value given the increased levels of accessibility and connectivity associated with the piece of real estate; 3. Developing local businesses to support the daily operation and maintenance requirements of infrastructure companies or by means of providing opportunities for local businesses and start-ups (e.g. restaurants and hotels set up at rest points of highways); and 4. By increasing the value of other infrastructure assets connected physically or digitally to any given infrastructure. This network effect increases the value or utility a user derives from a good or service (infrastructure in this case) and leads to an increase in related infrastructure asset value.

These impacts are not driven by other impacts and risks identified in the ESG taxonomy.

B.2.2 SOCIAL RISKS

SR 1 Social Acceptability

Social acceptability is the outcome of a collective judgment or collective opinion of a project or company. This judgment may be positive or negative and is never set in time. It is made up of what people feel about a company, based on their experience, what they have heard/read about it, or other available facts.

A poor social acceptability, or the lack of a social license to operate, can lead to reputation risks and ultimately lead to regulatory constraints which undermine the usefulness of the infrastructure asset and/or the profitability of the company.

SR 1.1 Customer Infrastructure is financially viable because it provides a service that users pay for. Given the monopolistic nature of infrastructure services, while it may not always be possible for a customer to stop using any given service, acceptability from users poses a risk to infrastructure companies directly as they may lose customers and - with that being their source of revenue - this may lead to the company gaining a poor reputation or even to regulatory interventions.

These risks can manifest if the quality of provided services isn't acceptable to the users (such as poor quality of roads, poor water quality in taps, intermittent power supply etc.), if enough customers cannot access the service (no or inconvenient access to roads

B. Impact-Risk Relationships

from certain locations, low number of connections to the water or power supply in certain regions, no disabled access to public train stations) or if the services are priced such that they are unaffordable to a large part of its potential customer base (at least the top of the bottom economic quartile. Further if the infrastructure company fails to keep up with the evolving needs of customers, it could undermine the usefulness and usability of the asset in the long run.

The quality of a service can be monitored and maintained by implementing processes that identify and address problems systematically and in a timely manner and ensure that services are reliable and meet international quality standards.

Customer engagement can help understand the problems that customers face and can help the company to manage associated risks, build customer loyalty, address their concerns in a timely manner and identify areas in which asset performance has to be improved. Further impact and risk management, including planning and keeping up with future demands and (demographic and other) changes, can help anticipate and mitigate risks associated with the quality and accessibility of services provided by infrastructure companies.

SR 1.2 General Public Infrastructure companies face risks from the general public with which they interact. This can manifest in the form of political risk, ultimately leading to the imposition of regulatory constraints which can undermine the usefulness of the infrastructure asset and/or the profitability of the company.

Negative perceptions can be about an infrastructure sector as a whole, such as the negative perception associated with safety aspects of nuclear plants in some locations or increasingly the negative sentiment associated with power plants utilising fossil fuels given their role in driving climate change. The social acceptability of companies can also be driven by the general notion that the public holds about private infrastructure.

Social acceptability (negative or positive) can also be associated with specific companies. This stems from both the good and bad practices of individual companies and encompasses multiple aspects - such as how they manage their environmental impacts, or the social and governance impacts which result either from successful or failed processes or intentional activities and actions. In addition, the social acceptability of a company is driven by the quality, accessibility and affordability of its services. The involvement of infrastructure companies in lawsuits stemming from their failure to comply with regional, national and international regulations or guidelines can also have an adverse effect on their reputation of companies, as can their involvement - that of top management - in controversies and scandals such as bribery and corruption.

Like other risks, the social acceptability of a firm can be controlled by proactive impact and risk management. For example, transition to a low carbon energy source may help any given company to reduce its impact on

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climate change and gain social acceptability from the general public. In addition to this, strong stakeholder management can enable a company to understand, monitor and address impacts and risks, thereby mitigating their acceptability risks.

SR 1.3 Regulators Infrastructure companies face acceptability risks from regulators if they either fail to align with their ideologies (for example, coal power plants may face increasing regulatory constraints as regulators aim to transition to a low carbon economy) or a backlash from the general public forces the regulator to intervene in the form of fines, nationalisation (where applicable) or even business closure.

Impact and risk management processes and stakeholder engagement (both of regulators and the general public) can help the company to anticipate and mitigate both ideological and political risks in a timely manner.

SR 2 Workforce Availability

SR 2.1 Industrial action Industrial action arises for a number of reasons, though principally in response to economic conditions (defined as an economic strike and meant to improve wages and benefits) or labour practices (intended to improve work conditions). Other strikes can stem from sympathy with other striking unions or from jurisdictional disputes between two unions (Britannica, 2011). Thus industrial action is driven either by the employment conditions offered by the workers which includes the worker health and safety practices of the company or the remuneration and benefits policies of the company. The risk of industrial action can be mitigated by ensuring that employees are satisfied with their working conditions. This can be done by impact and risk management process that include provisions for two-way communications between the management and the staff, availability of anonymous grievance mechanisms etc.

SR 2.2 Labour market The labour market, also known as the job market, refers to the supply of and demand for labour, in which employees provide the supply and employers provide the demand. The unavailability of trained, educated, or experienced segments of the workforce that are suitable and competent to carry out the tasks and activities of the infrastructure company can lead to a workforce unviability creating a business risk for the company. These risks stem from broader socio-economic issues and are not driven by other ESG impacts and risks outlined in the taxonomy.

B.3 GOVERNANCE PILLAR

B.3.1 GOVERNANCE IMPACTS

GI 1 Organisations

The business objectives of the management of any organisation are to organise and coordinate the company's activities in order to achieve pre-set company goals and targets in a given timeline, maintain a healthy cashflow and offer quality services to its customers. These objects require good governance, which stems from designing and implementing good corporate policies, strategies and plans and also from managing relationships with and expectations of external stakeholders.

B. Impact-Risk Relationships

GI 1.1 Company management There are necessary conditions for an infrastructure company to be effective and meet desired targets in a specific time frame. They include a competent team and appropriate strategic planning, clear visions, policies and strategies as well as their subsequent and successful implementation. Additionally, an essential aspect of good governance is strong impact and risk management, focused on anticipating, monitoring and addressing organisation problems (ESG issues in this case) by means of revising or developing policies and strategies and implementing or improving processes that enable the organisation to comply with internal guidelines and external reporting and compliance requirements.

GI 1.2 External relationships One of the biggest challenges to good governance is that infrastructure has multiple stakeholders. Involving stakeholders such as users, regulators, civil society organisations, the general public, contractors and suppliers and the private sector, where appropriate, can improve the quality of planning efforts and ultimately the effectiveness of the asset.

Maintaining external relationships requires infrastructure companies to be transparent in sharing information about their activities and impacts, accept responsibility for their actions and take appropriate steps to remedy them where relevant, and finally engage their stakeholders in a meaningful manner.

The maintenance of external relationships is driven by the risk management of the company (engagement with stakeholders and contractors and suppliers to ensure that they are satisfied), and the presence of processes that drive reporting (to enable transparency) and compliance (to aid in accountability) by the company. Conversely the absence of management processes can lead to a negative impact on the management of external relationships.

B.3.2 GOVERNANCE RISKS

GR 1 Organisations

Mismanagement or poor governance is a major reason why infrastructure projects fail to meet their timeframe, budget and service delivery objectives. Infrastructure projects with deficient governance often deliver cost overruns, delays, underperformance, underutilisation, accelerated deterioration due to poor maintenance and, occasionally, in expensive "white elephants" (OECD, 2015). These failures stem from both the absence of quality of processes and systems used by the company, or ones that are of poor quality, as well the competency and integrity of its staff.

Governance risks manifest in the form of financial losses for the company and interventions by the government and regulators that can hamper the ability of the management to govern the company effectively.

GR 1.1 Process failure All organisational activities rely on specific processes or systems to conduct and monitor the various activities of the company. Well-developed and well-implemented processes aid good governance of a company as they ensure that its activities are operating as intended thus mitigating their impacts (examples include

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process that ensure that the waste streams meets applicable regulations) and help the company to anticipate and adapt to potential risks (such as process that trigger emergency safety responses in cases of system failure, floods etc.).

Incompetent staff and poor impact and risk management, by not reviewing the appropriateness and quality of process systematically, can result in the development of process that are difficult to use, poorly designed or poorly implemented, which can pose a risk to the governance of the company. For example, failure of processes that enable the company to comply with existing laws, regulations and international commitments increases the risk of fines imposed by the government or regulators and can cause reputational damage to the company.

GR 1.2 Absence of processes As mentioned above, strong processes are an integral component of governance. The absence of mandatory processes (e.g. to ensure workforce safety, the quality of services etc.) and other processes (to set remuneration and benefits of employees etc.) can pose a governance risk to the company, manifesting in the form of fines from regulators or social acceptability risks. Missing processes are caused by the poor impact and risk management practices of a company, wherein a company is unable to anticipate the need to design and implement processes necessary for conducting business activities.

GR 2 Staff failure

Staff failure is the inability of the team as a whole to successfully or efficiently complete company activities. Effective governance of a company can be hampered either by worker incompetency (lack of skills, educations or experience to carry out all business activities) or by a lack of integrity among workers, where certain members of the staff indulge in criminal (fraud, bribery, corruption etc.) and negative but non-criminal activities (not practicing accountability, having a poor work ethic etc.). Both of these can pose a governance risk to the company manifesting as business, social or regulatory risks.

GR 2.1 Competency Appropriately skilled staff at all levels are essential for the success of any organisation. Hiring unskilled, unqualified or incompetent staff can lead to lower productivity levels, safety risks stemming from a staff inability to operate equipment properly, lower workforce satisfaction, and failed business activities leading to poor service quality etc.

The risks of not having competent staff are driven by: 1. The ineffectiveness of the company management in managing staff resources resulting in the inability to identify the right balance of skills required to run the company; 2. The absence of recruitment and selection processes that enable adequate screening of candidates before hiring them or process that ensure that the employees receive training and up-skilling when necessary; and 3. The unavailability of skilled, educated, or experienced segments of

B. Impact-Risk Relationships

the workforce in the locations required by the infrastructure company.

GR 2.2 Integrity Integrity is the quality of the workforce having strong ethical and moral principles that should be followed at all times. A lack of integrity can lead to dishonest behaviour on part of the employees and can cause a company to be part of criminal activities. One of the major issues faced by large infrastructure project is that of corruption allegations. The extent of public officials' discretion on the investment decision, the size of the projects and the multiplicity of stages and stakeholders involved make them more prone to corruption. Thus an infrastructure company needs strong processes and risk management to ensure that it is not exposed to social acceptability and regulatory risks stemming from dishonest staff. In addition to this, a lack of integrity within staff can also lead to behaviour that, while not criminal in nature, can have an impact on the effectiveness and management of the company. This is inclusive of a poor work ethic, alack of accountability or a lack of respect for company property and processes. Associated risks can similarly be managed by strong risk management and internal processes.

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About Natixis

About Natixis

Natixis is a French multinational financial services firm specialized in asset & wealth management, corporate & investment banking, insurance and payments.

A subsidiary of Groupe BPCE, the second-largest banking group in France through its two retail banking networks, Banque Populaire and Caisse d'Epargne, Natixis counts over 16,000 employees across 36 countries.

Its clients include corporations, financial institutions, sovereign and supranational organizations, as well as the customers of Groupe BPCE's networks.

Listed on the Paris stock exchange, Natixis has a solid financial base with a CET1 capital under Basel 3(1) of €12.1 billion, a Basel 3 CET1 Ratio(1) of 11.6% and quality long-term ratings (Standard & Poor's: A+ / Moody's: A1 / Fitch Ratings: A+).

(1) Based on CRR-CRD4 rules as reported on June 26, 2013, including the Danish compromise - without phase-in. Figures as at 31 December 2020

About EDHEC Infrastructure Institute-Singapore

About 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.

Origins

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.

A 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-II framework to long-term investments in infrastructure.

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

A Profound Knowledge Gap

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

Capturing these benefits, however, requires answering some difficult questions:

1. **Risk-adjusted performance measures** are needed to inform strategic asset allocation decisions and monitor 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, among 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 of 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

About EDHEC Infrastructure Institute-Singapore

investors with valuable insights about their strategic asset allocation choices in infrastructure, as well as to 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 EDHEC*infra* 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 EDHEC*infra*'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 more efficient and more transparently reported. 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 investment decisions.

Partners of EDHEC*infra*

Monetary Authority of Singapore

In October 2015, 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:

About EDHEC Infrastructure Institute-Singapore

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 organisations have already recognised the value of this project and have joined or are committed to joining the data collection effort. They include:

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

EDHEC Infrastructure Institute Publications

EDHEC Infrastructure Institute Publications

EDHECinfra Methdologies & Standards

- The Infrastructure Company Classification Standard (TICCS) - Updated March 2020
- Credit Risk Methodology - April 2020
- Infrastrcuture Index Methdology Standard - Updated March 2020
- Global Infrastructure Investment Data Standard - Updated March 2020
- Unlisted Infrastructure Valuation Methodology - A Moderm Approach to Measuring Fair Value in Illiquid Infrastructure Investments - Updated March 2020

Selected EDHEC Publications

- Amenc, N. & F. Blanc-Brude. "The Cost of Capital of Motorway Concessions in France - A Modern Approach to Toll Regulation" (September 2020)
- F. Blanc-Brude & A. Gupta. "Unlisted Infrastructure Performance Contribution, Attribution & Benchmarking" (July 2020)
- Whittaker, T. & R. Tan. "Anatomy of a Cash Cow: An In-depth Look at the Financial Characteristics of Infrastructure Companies." (July 2020)
- Amenc, N., F. Blanc-Brude, A. Gupta, L. Lum. "Investors Should Abandon Absolute Returns Benchmarks - Lessons from the Covid-19 Lockdowns" (June 2020)
- Amenc, N., F. Blanc-Brude, A. Gupta, J-Y. Lim. "2019 Global Infrastructure Investor Survey - Benchmarking Trends and Best Practices" (April 2019)
- Whittaker, T., S. Garcia. "ESG Reporting and Financial Performance: The case of infrastructure." (March 2019)
- Blanc-Brude, F, J-L. Yim. "The Pricing of Private Infrastructure Debt - A dynamic Approach" (February 2019)
- Blanc-Brude, F., C. Tran. "Which Factors Explain Unlisted Infrastructure Asset Prices?" (January 2019)
- S. Garcia, F. Blanc-Brude, T. Whittaker. "Tome La Siguiente Salida (Take the Next Exit) - A Case Study of Road Investments Gone Wrong, Spain, 1998-2018" (March 2018)
- Amenc, N., F. Blanc-Brude "Selecting Reference Indices for the Infrastructure Asset Class" (February 2018)
- Blanc-Brude, F., T. Whittaker, and M. Hasan. "Cash Flow Dynamics of Private Infrastructure Debt" (March 2016).

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