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# Flights of fancy – green infrastructure and airports

**G**reen infrastructure is clearly a challenge in a world that is increasingly impacted by climate change. In this issue of EDHEC*infra* Research Insights, we examine and challenge many of the prevailing beliefs surrounding green and ESG characteristics, while also looking at the impact of transition risk on airports and the impact of the war in Ukraine on the specific case of Russian airports.

In our first article, we show that there is empirical evidence of historical outperformance of green infrastructure investments (defined narrowly as wind and solar power projects). We consider whether this finding implies continued future outperformance. In line with the literature, we argue that more sustainable infrastructure investments should ultimately have lower expected returns than less sustainable ones, but that the recent shift in investor preferences in favour of greener power investments temporarily created excess demand, explaining realised performance during the past decade.

We then consider whether natural gas should be included in the EU Green Taxonomy or not, given the latter's distorting effect on the cost of capital for energy projects. Excluding gas from the taxonomy would not increase the cost of capital of gas generation and thus would not create any risk of underinvestment in natural gas as a 'transition fuel'. However, including gas in the Green Taxonomy creates genuine price distortion, not to mention a perverse incentive to limit future investments in renewable energy technologies. Our conclusion is that there is no good financial reason to include gas in the EU Green Taxonomy.

Our third piece relates to a recent EDHEC*infra* survey, in which we asked infrastructure investors why they need to have access to ESG data – ie, non-financial data – for the assets they hold or want to hold. As ESG in general and climate change in particular are increasingly becoming the focus of regulators who aim to intervene in markets to prevent or mitigate the non-financial consequences of economic activities, we expected regulatory reporting to be the main reason why investors would want to have access to non-financial data about their portfolio investments in roads, power plants, airports, etc. The survey showed that regulatory reporting is indeed one of the main motivations for accessing such data, but not the most frequent or highest-rated one. Instead, investors said they wanted access to non-financial data because they needed to manage their risks!

We then look at the potential loss of value of Russian airports due to the war in Ukraine. Drivers of impact include the closure of a number of national airspaces to Russian airlines as well as related sanctions that have been imposed since the start of the invasion. We find that the immediate impact on the cash flows of Russian airports so far remains very limited, and it is equity holders who will suffer most; the increase in the price of equity risk is many times more painful for investors marking to market. However, we show that this cost will increase rapidly the longer the conflict and the sanctions continue.

Continuing the airport and climate themes, we show an application of a transition risk estimation approach to airport infrastructure, which represented 12% of global transport emissions in 2019, has highly regulated activities and relatively good data coverage. Despite considerable reductions of emissions per passenger, the constant increase in air transport demand (only recently impacted by the COVID-19 pandemic) has brought increasing pressure on airports to reduce their emissions.

Finally, monitoring social sentiment around large infrastructure projects and sectors can be important for investors and provide an understanding of the social risks created by such projects. However, traditional monitoring methods, which include surveys, are costly and time consuming. EDHEC*infra* proposes a different approach, using machine learning and newspaper and other articles, to create an index of social sentiment around infrastructure projects and companies.

**Frédéric Blanc-Brude, Director, EDHEC*infra***

# The pricing of green infrastructure

## The realised and expected financial performance of green power infrastructure investment, 2010–21

**Noel Amenc**, Professor of Finance, EDHEC Business School;  
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It is often argued that more sustainable investments should coincide with better financial performance. This opens two distinct questions:

- Firstly, is there any empirical evidence of superior performance by more sustainable or greener investments? And if so, what might explain such outperformance, and can it be expected to persist in the future?

- Alternatively, is it the result of an identifiable transition in investor preferences resulting in a positive shift in asset prices (higher realised returns) but not in higher expected returns?

In this paper, we show that there is indeed empirical evidence of historical outperformance of green infrastructure investments (defined narrowly as wind and solar power projects). We then consider whether this finding implies continued future outperformance. In line with the literature, we argue that more sustainable infrastructure investments should in fine have lower expected returns than less sustainable ones, but that the recent shift in investor preferences in favour of greener power investments temporarily created excess demand, explaining realised performance during the past decade.

The existence of a systematic difference in pricing and expected returns between sustainable and less sustainable investments is examined in recent academic research (see Pastor et al [2022], Alessi et al [2021]). Pastor et al summarise the reason why greener investments should have low expected returns: either investors bid up asset prices because they have increasing

preferences for them, or the customers of greener businesses shift their demand towards their services, increasing their revenues and profits, and consequently their market value. As asset prices rise in response to greater demand, their cost of capital falls. In other words, the premise that greener companies and services – and the positive externalities they create – are increasingly valuable to investors and desirable to consumers (and the reverse for less green companies) implies that the market price of their equity must be higher, their cost of capital lower and their expected return (which, in equilibrium, must equal their cost of capital) also lower. As long as we accept the hypothesis of weakly efficient financial markets, in equilibrium risk must be adequately priced, which leaves little hope for the continued high performance of green infrastructure investments in the near to long term.

Of course, in this context, it is still possible for greener investment to outperform during a period of persistent changes in investor preferences; for example, excess demand can drive up asset prices because investors expect preferences for green assets to have durably shifted from their previous level. As market prices increase and capital gains accrue to investors, these investments outperform but also exhibit increasingly lower expected returns.

As Pastor et al (2021) and others point out, the inverse relationship between price and expected return or yield is at its simplest in the case of bonds. For a buy-and-hold investor, the yield of a bond is the best estimate of its expected return,

as bond prices change, its yields and expected returns change inversely. This is because bonds have no exposure to the upside, ie, the growth of the borrowers' business. The same mechanism applies to the price and yield on the most clear-cut type of sustainable investment: green power infrastructure.

Green infrastructure can take several forms but, at its greenest, it can be narrowly defined as wind and solar power projects: new investments producing electricity (largely) without emitting greenhouse gases and potentially displacing existing power sources that do. In other words, with constant energy needs, wind and solar power projects are carbon-negative investments. This category of investments thus provides a convincing case of what the greenest types of green infrastructure investments might look like.

The way such projects are created and financed is what makes them resemble a bond. Solar and wind farms are typically incorporated as a standalone special-purpose company with a finite life based on the economic life of the physical asset and on its business model, typically a long-term power purchase agreement (PPA) or a regulated electricity market. Such projects raise asset-backed finance once, sink capital into a finite physical asset, and its investors are repaid over a period of 25 to 30 years. Like bonds, such a company has very limited upside or growth options. Wind farms can be repowered and PPAs extended, but infrastructure assets are capacity-constrained by design. Infrastructure companies thus have a maximum



potential revenue, defined mostly by ex-ante choices of size and technology. Hence, like many other project-based infrastructure investments, wind and solar project equity investments are akin to a bond with risky coupons.

It follows that if increasing demand for green infrastructure leads to higher performance through capital gains, it must be because their yield or costs of capital is falling. Once excess demand has been absorbed by the market, the long-term performance of greener infrastructure should be lower than that of less green infrastructure investments.

In the paper, we consider the question of what drives the past and future financial performance of green infrastructure in several steps.

We first review the historical performance of investments in unlisted wind and solar project equity using the *infraGreen* index.<sup>1</sup> We show that green infrastructure investments have indeed outperformed the market, including core infrastructure, which is a natural benchmark for such projects (figure 1). Until 2019, they also outperformed core-plus infrastructure, a riskier subset of unlisted infrastructure investments. In effect, over the past 10 years, green infrastructure has exhibited a very attractive risk-adjusted return profile, with higher annualised returns than core infrastructure and lower volatility than core-plus infrastructure.

We then follow the literature and examine the difference of performance between two portfolios created using asset-level data available in the EDHEC-*infra* database: a green power portfolio of unlisted equity investments in wind and solar projects only, and a brown power portfolio of unlisted equity investments in coal and gas power projects only. As argued above, we consider all the investments in the first portfolio to be equally (and highly) green. Likewise, coal and gas power projects are net contributors to greenhouse gas emissions. Conventional power generation emitted 13.5Gt CO<sub>2</sub> equivalent in 2020, ie, it is the first contributor to total energy-related emissions (31Gt CO<sub>2</sub> equivalent – IEA [2021]) before the transportation and industry sectors. Even though the greenhouse gas emissions of coal and gas power projects vary and can, to some extent, be reduced or captured, even with

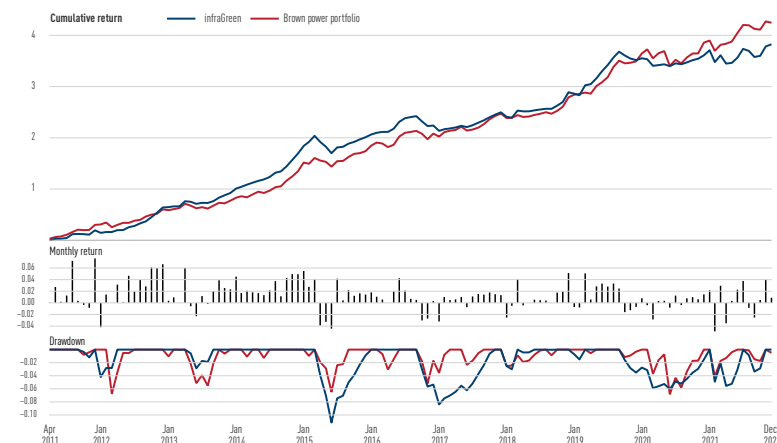
## 1. Cumulative performance of *infraGreen*, *infra100 Global Core* and *infra100 Global Core+* indices\*



Source: *infraMetrics*, calculations EDHEC*infra*, data as of December 2021

\* t-test of the difference in mean between green and brown portfolios

## 2. Cumulative performance of *infraGreen* and brown power



Source: *infraMetrics*, calculations EDHEC*infra*, data as of December 2021

constant energy demand, these investments are always carbon positive. In other words, our green power portfolio is always greener than our brown power portfolio.

Over a period extending from 2011 to 2021, the brown power portfolio outperformed green power by a cumulative 138bp (figure 2). However, during that period, green power outperformed or matched the performance of brown power between 2012 and 2015 and also between 2018 and 2020. We show that these are also the two periods during which the cost of capital spread between green and brown power widened significantly as the market value of green power assets increased.

Next, we examine the differential performance of green and brown power

investments through a 'green minus brown' (GMB) portfolio of their returns over the past decade. Controlling for the effect of well-documented risk factors such as size, leverage and profits, this portfolio produces a statistically significant negative 'alpha'. The realised green or brown power excess returns are also better explained by adding a GMB 'effect' to the usual set of risk factors. Prima facie, this result could be interpreted as the presence of a 'green' risk factor in the returns of green and brown power infrastructure investments (figure 3).

To determine the potential persistence of this effect, we examine the expected returns of green and brown power using data from *infraMetrics* and show that there is a significant and increasing spread

<sup>1</sup> The *infraGreen* index is available on the *infraMetrics* platform of EDHEC*infra*.

<sup>2</sup> Irrespective of the debate on the inclusion of natural gas generation in the EU taxonomy (see Blanc-Brude et al [2021]).

between the weighted average cost of capital of the two portfolios. The weighted average cost of capital (WACC) spread or green price premium between the green and brown power portfolios is consistently negative and growing: in 2021, it has widened to reach almost -350bp from about -100bp a decade earlier (figure 4).

High realised performance has been accompanied by a significant decrease in the cost of capital of green power infrastructure. In effect, all infrastructure investments have become more popular among investors in the past decade and have seen a reduction in their cost of capital, including brown power. However, green power has seen a much larger decrease. Between December 2011 and December 2021, the infrastructure market saw a global reduction in WACC of 177bp (from 7.23% to 5.45%), while green power saw a greater reduction of 263bp, but the WACC of brown power is only 11bp lower in 2021 than it was in 2011 (figure 5).

We show that the evolution of cost of capital spread of the two legs of the GMB portfolio explains away its negative alpha. In other words, taking yield compression into account, standard pricing factors suffice to explain the realised performance of the GMB portfolio.

We argue that the yield compression observed since 2011 is at least in part due to excess demand in the market for green power infrastructure – ie, demand that cannot be met immediately by a supply of green power investments. To show this effect, we construct a measure of excess demand for green power investments using the share of secondary transactions in all investments made by infrastructure investors in green energy (figure 6). We argue that periods during which secondary transactions represent a smaller fraction of the overall market transaction volume are periods of lower liquidity – during which excess demand for green power assets is likely to have been higher. We show that this measure of the green power market liquidity is strongly related to the performance and WACC spread of the GMB portfolio, as well as the realised performance of the green power portfolio.

### 5. Mean WACC in green and brown power infrastructure until 2015 and since 2016 and 2018

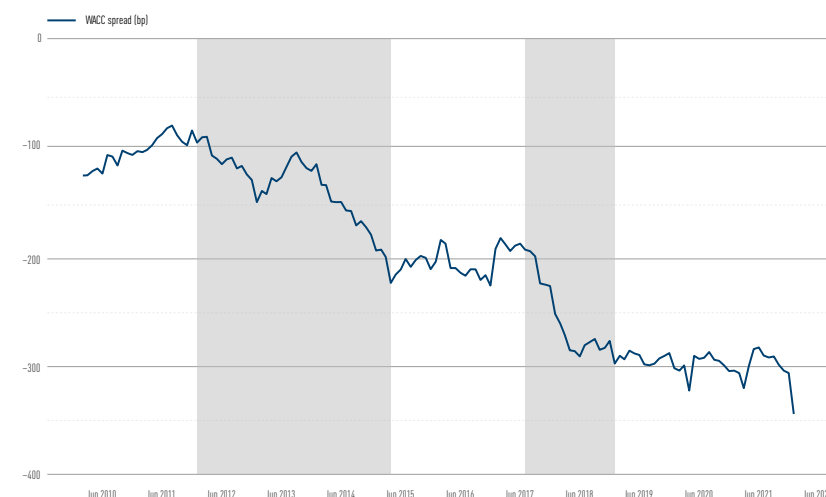
	Green power	Brown power	Broad market	t-test
Mean until 2015	0.074	0.087	0.085	-7.106
Mean since 2016	0.043	0.069	0.052	-34.828
Mean since 2018	0.042	0.072	0.051	-33.207

### 3. Green, brown and GMB returns, 12-month rolling, local currency



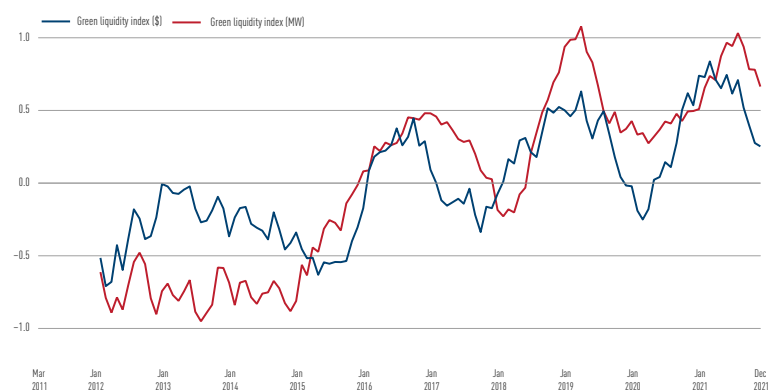
Source: infraMetrics, calculations EDHECinfra, data as of December 2021

### 4. Green premium (spread) in the cost of capital of green and brown power portfolios



Source: infraMetrics, calculations EDHECinfra, data as of December 2021

### 6. Green liquidity index



Source: infraMetrics, calculations EDHECinfra

In other words, when the market for renewable power projects is less liquid and excess demand is more likely to build up, we tend to see an increase in the performance of the GMB portfolio and in the WACC spread between green and brown assets (figure 7).

We conclude that, while green power assets have experienced a period of strong performance (realised returns), they are likely to deliver lower returns going forward since this performance was largely driven by the compression of their cost of capital, itself largely related to the build-up of excess demand in the market for green assets (figure 8). Moreover, while the green price premium has increased in line with excess demand, the supply of green power investments has also increased considerably and the GMB WACC spread has been flat since 2019. As green infrastructure plays an increasingly important and ubiquitous role in investors' portfolios, a consensus on the price and expected returns of green power is increasingly likely and new shifts in demand for such assets less so. In effect, green power may be one the few asset classes in which green pricing has already peaked (around mid 2019).

These results are important in understanding the role that renewables and conventional energy are likely to play in investors' portfolios going forward, since increasing allocations to green energy should not be based on returns assumptions derived from historical returns. Indeed, as the supply of renewable investments has increased and, in some markets, become one of the dominant sources of energy, investor preferences for such assets should stabilise and excess demand disappear. A recent peer-group survey of asset allocations within the infrastructure asset class found that renewable energy already represents one quarter to one third of most investors' infrastructure portfolios (Blanc-Brude et al [2022]). While investment in green infrastructure is likely to keep increasing on aggregate, its weight in infrastructure portfolios is unlikely to keep increasing monotonically.

Durably lower expected returns and cost of capital for green power is of course a good thing, since it reduces the overall cost of the energy transition. However, investors should not expect to receive high returns while contributing to the energy transition (have a positive impact)

## 7. WLS regression of the GMB portfolio excess returns including the effect of month-on-month changes in the green price premium

	DV = GMB								
	2011-21			2011-15			2016-21		
	Beta	SE	p value	Beta	SE	p value	Beta	SE	p value
(Intercept)	-0.0025	(0.001)	0.01502	-0.0031	(0.0016)	0.05668	-0.003	(0.0013)	0.02341
Size	-0.1666	(0.0478)	0.00067	-0.3505	(0.0818)	0.00008	-0.0557	(0.061)	0.36448
Leverage	0.2147	(0.0834)	0.01122	0.351	(0.1634)	0.03621	0.0301	(0.1186)	0.80042
Profit	-0.1214	(0.0629)	0.0558	-0.1474	(0.1203)	0.22591	-0.0865	(0.0783)	0.27346
Investment	0.2311	(0.0734)	0.00204	0.4386	(0.1652)	0.01039	0.1321	(0.0892)	0.1433
Green premium delta	-0.0005	(0.0001)	0.00001	-0.0005	(0.0002)	0.05552	-0.004	(0.0001)	0.0023
Deg freedom	126			54			66		
Adj-R2	33.07%			51.29%			14.8%		

## 8. Cumulative GMB portfolio performance with and without the impact of excess demand



Source: infraMetrics, calculations EDHECinfra

as long as they are only exposed to a pure, unleveraged basket of green power investments.

This paper builds on the growing literature on green vs brown investments (see Pastor et al [2022], for a summary) but provides a new perspective by examining the behaviour of asset prices in the market for unlisted infrastructure equity, complementing available evidence from listed assets. The literature has investigated the existence of a green factor using long-short portfolios of assets weighted by their greenness (Pastor et al [2021]). Focusing on infrastructure assets enables a cleaner identification of green exposure compared to listed assets: while the shares of listed companies correspond to exposures to a range of climate-relevant assets and projects in different locations, the analysis of well-identified infrastructure energy projects provides a direct measure of exposure to greenness.

Hence, the existence of a green premium may be measured more reliably in infrastructure markets than in public markets.

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# The cost of capital of brown gas

## Would excluding natural gas from the green taxonomy prevent the financing of transition fuels?

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In this article, we consider whether or not natural gas should be included in the EU green taxonomy given the latter's distorting effect on the cost of capital for energy projects. Excluding gas from the taxonomy would not increase the cost of capital of gas generation and thus would not create any risk of underinvestment in natural gas as a 'transition fuel'. However, including gas in the green taxonomy creates a genuine price distortion, not to mention perverse incentive to limit future investments in renewable energy technologies. Our conclusion is that there is no good financial reason to include gas in the green taxonomy.

### The role of brown gas as a transition fuel

Europe needs gas as a transition fuel to meet its demand for power until renewable energy generation and storage capacity exists on a sufficient scale. Hence, it is arguable that investment in gas projects needs to continue for several decades. While this in no way makes gas a green fuel, there is an argument that investing in gas today supports the transition to a greener energy sector. Consequently, the regulator needs to allow such investments to take place in order to ensure an orderly energy transition.

With its green taxonomy, the EU aims to promote investments in renewable energy by signalling to the market what the desirable types of future investments are today. In turn, this may lower the cost

of capital of those investments labelled as green. One may then argue that excluding gas projects from the green taxonomy would penalise their cost of capital, leading to underinvestment, insufficient generation capacity and a disorderly energy transition.

However, this argument is not credible – excluding natural gas from the EU green taxonomy is very unlikely to have a detrimental effect on the cost of capital of gas power projects. Rather, the continuous increase in renewable capacity, combined with the closing of coal generation facilities, has made natural gas increasingly valuable as the generator of last resort to meet Europe's power demand when the weather fails renewables. As a result, the cost of capital for gas projects, which is already around record lows, is unlikely to increase until renewable energy generation becomes both truly dominant and more predictable.

Moreover, including gas in the green taxonomy has a perverse side effect: it protects (and potentially increases) the option value of natural gas investments that arises from their producer-of-last-resort status, which could even limit capital flows into new renewable energy projects and technologies.

### A green taxonomy, a green premium and a brown discount

The role of the green taxonomy is to promote investments in certain sectors by acting as a signpost to the future. The reasoning is that capital markets do not have all the necessary information to

make investment choices that fully reflect future risks, notably transition risks. If all the relevant information about the path of future energy transition was available today, markets could allocate capital to the appropriate projects – and a clear green taxonomy acts to fill some of these information gaps.

By creating excess demand for certain investments, the green taxonomy may drive down the cost of capital of the type of investments it promotes – ie, create or increase an existing green price premium. Conversely, it may increase the cost of capital for those investments that it excludes from the green label.

In effect, investors have already started identifying investments as green, especially when it comes to their impact on the global climate, and they have been willing for some time to pay a price premium (receive a lower return) to hold greener stocks (see, for example, Alessi et al [2021]) or unlisted infrastructure equity in sectors such as wind or solar power projects. Existing renewable energy investments have already become expensive. Firstly, they are less exposed to certain risks than conventional energy projects, but also they are in higher demand. Secondly, investors aim to manage climate risks but also have a positive impact and, beyond financial considerations, support the energy transition. As a result, even before the EU introduced its taxonomy, greener infrastructure assets have benefited from a lower cost of capital: as of Q3 2021, the five-year average cost of equity in

European wind farms is 50bp lower than in the core infrastructure segment in Europe, and 80bp lower than in the contracted project finance segment, also in Europe (infraMetrics [2021]).

The EU taxonomy may further amplify this positive effect on greener asset prices. A consequence is that it could also limit the supply of capital to less green sectors, especially brown ones that rely on fossil fuels such as coal and gas, and drive up their cost of capital – in effect creating a brown discount. It is in this context that the inclusion of gas in the EU green taxonomy is being considered since it is a useful transition fuel despite the fact that it is by no means a zero-emission fuel. The concern raised is that a brown discount on gas projects in the short term could be counter-productive in achieving the transition to renewable energy.

Thus, a seemingly reasonable argument to include gas in the green taxonomy is the following: the taxonomy will cause capital to flow disproportionately to activities labelled as green by the regulator, and the cost of capital of brown energy sources will soar and lead to underinvestment in natural gas, which is the most important transition fuel for Europe.

Without enough gas-fired generation, the continent would continue to experience a prolonged energy crisis until renewable capacity and storage have had a chance to catch up with the effective demand for power. Brownouts, high energy costs, etc, would become the norm for decades and the energy transition would be very disorderly. Conversely, including gas in the taxonomy ensures that a much-needed transition fuel enjoys an even playing field in terms of the cost of capital.

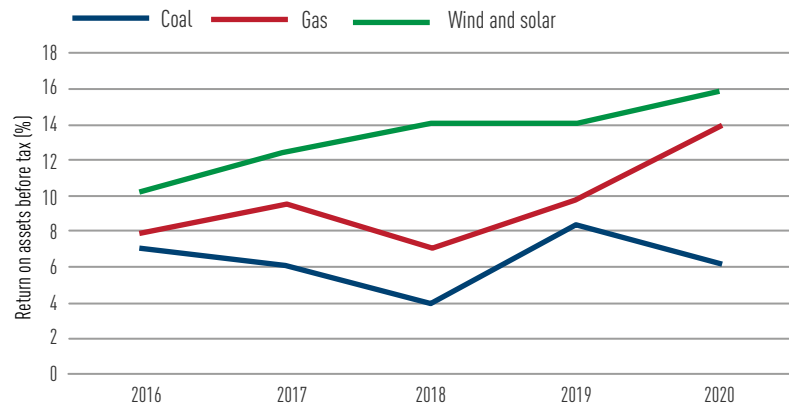
Whether or not a green taxonomy truly has this effect on asset prices is an empirical question. It partly depends on which assets are being labelled as green or not. Arguably, the market already prices in a degree of greenness. However, giving a green label to a type of asset that is not green would create a genuine price distortion.

### But brown investments are doing well

There is plenty of evidence that, even as renewables have developed, investments in fossil fuels have been doing very well indeed.

Figure 1 shows the profitability (return on assets) of coal, gas and renewable (wind and solar) projects in Europe over the past five years. While the profitability of renewables in Europe is the highest, gas power projects have enjoyed a significant increase in their profitability, as have coal-fired projects, for reasons we return to below.

## 1. Profitability in European coal, gas and renewable energy projects



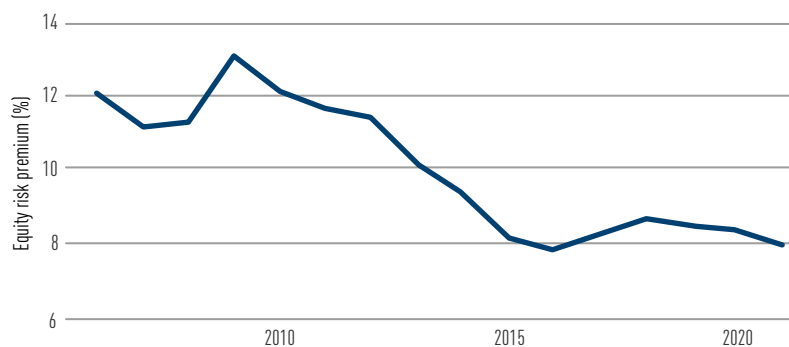
Source: infraMetrics, 2022

## 2. Average dividend payout ratios in coal, gas and renewable energy projects in Europe

	2015	2016	2017	2018	2019	2020
Coal	10%	8%	8%	10%	10%	10%
Gas	19%	18%	18%	17%	16%	15%
Wind and solar	20%	22%	23%	25%	28%	31%

Source: infraMetrics, 2022

## 3. Cost of equity in European gas-fired power projects (2005–21)



Source: infraMetrics, 2022; excludes the last three years of closing coal plants

EDHECinfra research has shown that profitability is a key determinant of the cost of equity in unlisted infrastructure projects, including energy. Infrastructure companies typically exhibit negative profits during their riskier greenfield phase and, as they develop positive and stable revenues, an increase in profitability is a signal of the successful development and stability of the business. Options to reinvest profits in infrastructure projects are limited, since almost all capital is sunk upfront, and higher profits are a strong predictor of future dividends. The level of dividend payouts (as a

proportion of revenues) for these three sectors is shown in figure 2. Dividends have stayed healthy in the gas and coal power sectors, albeit lower than in wind and solar projects. Coal projects continue to pay 8–10% of their revenues as dividends, gas projects 16–18% and renewables 25–30%. In this light, neither gas nor coal power look like junk. In fact, the costs of capital of gas projects in Europe has been near its record lows in recent years. Figure 3 shows the average equity risk premium of gas-fired power projects in Europe since 2005. After a peak in 2009, the attractiveness of gas power



projects led to a steady decrease in their cost of capital. Since 2015, it has hovered around 8% and even fell below that level in 2021.

### Gas is now the generator of last resort

While an increasing share of generation is provided by renewables in Europe, this portion is still far from being large enough to meet demand. In the first half of 2021, 40% of electricity generation in the EU was provided by renewable energy sources such as wind, solar and hydro (excluding nuclear – EMBER [2021]).

As a result, the reliability of power supply has become more exposed to the vagaries of the weather, as was the case in 2021 with large financial costs incurred by companies and consumers. During that period, Europe experienced an unprecedented ‘wind drought’, with wind speeds down by about 15% (Science|Business [2021]).

To meet power demand, resources further up the ‘electricity merit order’ are required to generate enough electricity.<sup>1</sup> In other words, until enough renewable power and storage can become available, backup generation must be produced by fossil fuel plants (coal and gas). As a result, even coal generation increased significantly in 2021 (Wind Power Monthly [2021]) due to the combined lack of wind with a significant increase in the price of natural gas.<sup>2</sup>

But we know that coal is being phased out with quasi-certainty. The EU reports that the majority of its member states have a policy to phase it out (European Commission [2021]). While policies differ across these states, major econo-

mies such as France, Germany and Italy have set expected phase-out dates by 2022, 2035 and 2025, respectively (Beyond Coal [2021]). States that are dependent on coal for electricity generation, specifically Poland, have not yet set any date to end the life of coal power plants but the lack of a plan does not mean that these power plants will not close. The EU’s carbon market is already forcing coal power plants to shift to gas (Politico [2021]).

While fossil fuels may be removed from electricity generation entirely in the future, this will not be the case for several decades. In the medium term, gas generation will be the primary stop-gap to manage the variability of generation from renewables. And as soon as coal is completely out, gas will be the de facto ‘generator of last resort’ to meet European power demand.

From a cost of capital standpoint, the implications are evident: gas power generation is valuable today because in low-wind states of the world, it is the only option to avoid Europe-wide brownouts.

In combination with more variable weather patterns, the current transition to a larger proportion of renewable energy generation increases the volatility of the power generation system and further increases the value of the ‘gas option’. The high value (and profitability) of gas projects confirms that their cost of capital remains low, irrespective of their treatment under the EU taxonomy. Thus, from this point of view, it is not useful to create an additional incentive to invest in gas infrastructure by giving it a green label while it really is not a green source of energy.

### The role of investment taxonomies and their potential adverse consequences

While excluding gas generation projects from the green taxonomy would not increase their cost of capital, including them is more likely to have the inverse effect: while the market may already be pricing the greenness of renewables, ‘green gas’ would almost certainly benefit from an even lower cost of capital and become even more valuable to investors.

While this would ensure investment in the designated ‘transition fuel’, it may also slow down the transition away from gas. For instance, with a distorted cost of capital, gas projects will be able to weather a potential carbon tax more easily, making such measures less effective at creating economic incentives to phase out fossil fuels in due course.

As shown above, the ‘gas option’ is already very valuable in a world without enough renewable energy capacity and predictability. ‘Green gas’ thus creates a genuine misallocation of capital since its very existence contradicts the opportunity to invest in better renewable technologies, especially energy storage.

Thus, while excluding gas from the taxonomy would not contribute to a disorderly energy transition, in our view, including it could well slow down this transition. Indeed, the main risk today is not that the energy transition does not take place, but that it takes place too slowly. Any investment incentive created by the regulator must aim to accelerate the evolution of the energy mix towards reduced GHG emissions. While it is desirable to remove coal from the energy mix, even in the medium term, coal must not be replaced by gas but by renewable sources of energy. Any incentive that delays this switch is working against an effective energy transition.

In conclusion, there is no good financial reason to include gas in the EU green taxonomy.

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<sup>1</sup> The merit order is the order in which electricity is dispatched. Generally, electricity with the lowest marginal costs of production is dispatched first, followed ever increasingly by electricity with higher marginal costs of production. Renewables with no fuel costs have essentially zero marginal cost. Gas and coal resources have fuel and carbon emissions to take into account before they are dispatched.

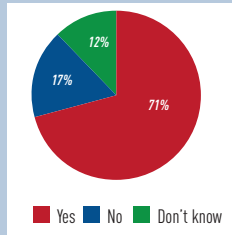
<sup>2</sup> The price of gas has increased 250% since January 2021. With the increase in the price of gas, coal-fired electricity became more competitive in the market.

## The view in the investment community

After we first published our views on keeping brown gas out of the EU green taxonomy, we presented our findings at a seminar, and conducted a survey of the global infrastructure investors, managers and consultants who attended. Some 81 individuals from around the world took a detailed poll about our position. Overall agreement with our analysis was very strong.

### The gas cost of capital is low enough

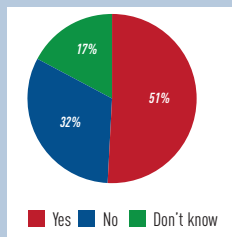
**What we asked:** In the EDHECinfra research note, The cost of capital of brown gas, the authors assert that its cost of capital remains low, and it is therefore not useful to create an additional incentive to invest in gas infrastructure by giving it a green label under the EU taxonomy, when it is not really a green source of energy. Do you agree?



**How investors responded:** Investors strongly agreed that there is no need to provide fresh incentives for gas production investment, with some 71% voting yes.

### Excluding gas would not send the cost of capital soaring

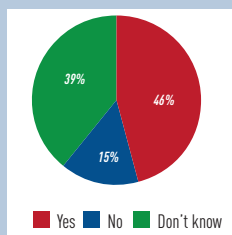
**What we asked:** Do you agree that excluding gas from the EU taxonomy would not increase the cost of capital of gas generation and thus would not create any risk of underinvestment in natural gas as a 'transition fuel'?



**How investors responded:** Investors broadly agreed that excluding gas wouldn't threaten to send its cost of capital soaring, with some 51% voting yes, though it's clearly a more nuanced question.

### Natural gas projects' cost of capital is at a record low and producer profitability is rising

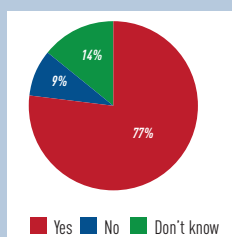
**What we asked:** Are you convinced by the EDHECinfra researchers' indicators pointing to the already record low cost of capital of gas power projects and their increasing profitability?



**How investors responded:** More people agreed than disagreed here (46% voted yes versus 15% no) but a large proportion of respondents (39%) did not know about the level of cost of the capital or profit margins in gas projects. If we were to exclude these, 68% of respondents would be in agreement.

### Gas is needed as the stop-gap while we transition to renewables

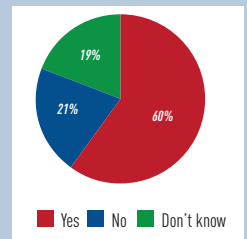
**What we asked:** Do you agree that, although fossil fuels may be removed from electricity generation entirely in the future, this will not be the case for several decades and, in the medium term, gas generation will be the primary stop-gap to manage the variability of generation from renewables?



**How investors responded:** Investors strongly agreed that it will take decades to wean ourselves off fossil fuels and that gas will be the key source to bridge the gap, with some 77% voting yes.

### Including gas in the taxonomy would distort prices and act against green investment

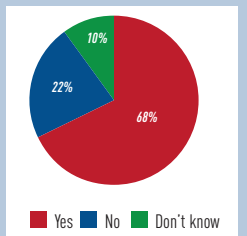
**What we asked:** Do you agree with the report's assertion that including gas in the EU taxonomy creates a genuine price distortion and a perverse incentive to limit future investments in renewable energy technologies?



**How investors responded:** Investors strongly agreed that including gas risked acting against the aims and intentions of the taxonomy, with 60% voting yes.

### We need to ensure that coal is replaced by renewables, not gas

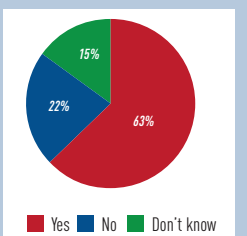
**What we asked:** The report states that while it is desirable to remove coal from the energy mix, even in the medium term, coal must not be replaced by gas but by renewable sources of energy. Any incentive that delays this switch is working against an effective energy transition. Do you agree?



**How investors responded:** Investors strongly agreed that ensuring coal production is replaced by renewable sources, not gas, is essential, and that the EU green taxonomy must not act to delay this switch.

### There's no good reason to include gas

**What we asked:** Finally, do you agree with the authors that there is no good financial reason to include gas in the EU green taxonomy?



**How investors responded:** This was a conclusion that the investment community strongly agreed with, and 63% voted yes.

### Summary

The survey results show that the investment community broadly agrees with our findings: including natural gas in the EU taxonomy of green activities is not needed and potentially counter-productive.

Source: EDHECinfra



# The Infrastructure Company Classification Standard (TICCS®)

2022 Edition – includes NACE, EU Taxonomy and CPRS Mappings



 **EDHECinfra**  
Documentation

May 2022

## Know your TICCS® Understand your (climate) risks

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# If ESG risks are already priced, why report non-financial data?

**Nishtha Manocha**, Senior Research Engineer, EDHECinfra;  
**Darwin Marcelo**, Project Director, EDHECinfra

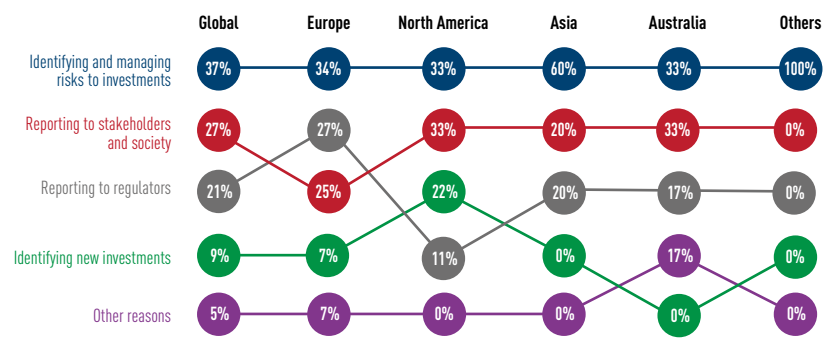
In a recent EDHECinfra survey, we asked a large sample of investors in infrastructure why they need to have access to ESG data, that is, non-financial data, for the assets they hold or want to hold.

As ESG in general and climate change in particular increasingly become the focus of regulators who aim to intervene in markets to prevent or mitigate the non-financial consequences of economic activities, we expected regulatory reporting to be the main reason why investors would want to have access to non-financial data about their portfolio investments in roads, power plants, airports, etc.

The survey<sup>1</sup> showed that regulatory reporting is indeed one of the main motivations for accessing such data, but not the most frequent or highest-rated one. Instead, investors said they wanted access non-financial data because they needed to manage their risks!

Figure 1 shows the aggregate ranking of investors' demand drivers for ESG data across geographies. We find that identifying and managing risks is the most important reason, often well ahead of stakeholder or regulatory reporting. In Europe the regulator looms larger, but in the US it is not even in the top three. We

## 1. Drivers of demand for ESG data



also found no significant difference between asset managers and asset owners.

The logical and theoretically sound interpretation of this finding is that (most) ESG risks are not priced by markets today.

### Risk management beyond asset prices

Financial markets can be expected to be reasonably efficient at transforming all the information available today into asset prices. From there, risk management is the science of understanding the drivers of the variance of asset prices (volatility) and how it may be managed to create the portfolio that best meets an investor's objectives and horizon. In other words, asset prices encapsulate information on risks and risk management is usually the sole domain of financial data.

For investors in infrastructure to argue that they need access to non-financial data to manage risks is a clear indication that these risks, of which investors are keenly aware, are not already captured by asset

prices. Otherwise, investors would not need any other information than these (at least for the purpose of risk management).

Why are these risks not priced? We can think of two key reasons: first, the current knowledge about these risks is too imprecise and only understood at a very high level of aggregation. Climate change projections are developed using global-scale models. Asset prices can be difficult to relate to macro-level factors such as the average increase in temperature in a region or average sea level rise in a  $30 \times 30\text{km}$  area (that's  $900\text{km}^2$ !). Likewise, new regulations on carbon taxes or environmental protection are not predictable until they come to be.

Second, academic research has shown that markets price risks around the average (the business cycle) quite well, but not extreme risks. Some of the risk associated with ESG are not only unknown but also part of extreme scenarios, including some that we do not know how to model well at all – eg, climate feedback loops.

<sup>1</sup> The study used the findings of two surveys, which were conducted by EDHECinfra between April 2021 and January 2022. The first survey was answered by 58 asset owners and asset managers, while the second one received 77 responses. By nature of respondents, 80% were asset managers, 13% were institutional investors, 4% were consultants while 3% were of other types (such as media, academics, suppliers, etc.). By geographic distribution, 59% of respondents were based in Europe, 23% in North America, 8% in Australia, 6% in Asia, and 4% in other parts of the world.

The survey also shows that investors in infrastructure are mainly concerned with climate risk (physical and transition risks), which is ranked first or second by almost 80% of respondents among all other ESG risks.

With non-financial data, investors can hope to pre-empt some of the risks associated with climate change: asset prices are relative, hence knowing how much certain assets are exposed to a known hazard relative to all other comparable assets held in the market can be a first filter to assess the amount of ESG risk exposure in a portfolio. For instance, many digital infrastructure assets are responsible for large contributions to greenhouse gases because of their high energy consumption, hence are liable to pay a theoretical carbon tax. But not all data centres have the same Scope 2 profile. With enough data, investors could ensure they hold only top quartile assets in terms of energy efficiency, thus partly protecting themselves from the drawdown that the introduction of carbon taxes would create.

With robust cross-sectional data on the factors that are related to ESG and

climate risks, investors could also ensure that they diversify any concentrated exposures in certain types of risks.

Such applications and more can be conceived as ways for investors to manage their risk beyond the current level of asset prices precisely because the latter do not integrate these risks, even though they are notionally understood by investors.

### Regulatory reporting is also risk management

Some of these risks are created by regulatory interventions, especially transition risks. The introduction of a carbon tax, for example, however orderly, would be a shock to asset prices.

While the survey found that investors differ a lot regarding the role of ESG regulation as a driver of the need for non-financial data, such disparities can be attributed to the fact that ESG regulations are still emerging and evolving globally. For example, in the EU, the European Commission on Sustainable Finance has put forth an EU taxonomy. The Corporate Sustainability Reporting Directive (CSRD) requires companies to report the taxonomy-aligned sustainability of their

activities. At the same time, the Sustainable Finance Disclosures Regulation (SFDR) imposes mandatory (EU taxonomy-aligned) ESG disclosure obligations for asset managers and other financial market participants. In the US, conversely, currently there are no regulations at the federal level.

As ESG regulations evolve globally, infrastructure investors will need data to meet compliance requirements, and regulatory reporting may become an important driver of ESG data demand in the future.

As climate regulation and climate change itself begin to have an impact on businesses, the use of non-financial data will thus become a more permanent input in an asset and risk management process that used to rely almost entirely on asset prices. Markets will of course integrate as much of this new information into prices as possible. But the continued evolution of the climate and its impact human and economic life, as well as the choices made by regulators to try to control to mitigate this evolution, create a form of uncertainty that investors are only beginning to learn to live with, but have also clearly understood.

# The costs of international sanctions to investors in Russia's airports

## What do airspace closures, compound interest and aircraft manual subscriptions have in common?

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**Tim Whittaker**, Research Director and Head of Data, EDHEC*infra*

In this research note, we look at the potential loss of value of Russian airports due to the war in Ukraine. Drivers of impact include the closure of a number of national airspaces to Russian airlines as well as related sanctions that have been imposed since the start of the invasion. We find that the immediate impact on the cash flows of Russian airports so far remains very limited, and it is equity holders who will suffer most; the increase in the price of equity risk is many

times more painful for investors marking to market. As a one-off immediate shock, the loss of value for investors exposed to Russian airports in March 2022 is estimated to be less than 5%. However, we show that this cost will increase rapidly the longer the conflict and the sanctions continue. Domestic traffic will be quickly – and severely – reduced by Russian airlines' inability to keep foreign-made planes flying and the compounded effect of higher discount rates will rapidly burn through the net asset value (NAV) of these assets.

## Introduction

Since Russia invaded Ukraine on 24 February, several countries have closed their airspace to Russian airlines. In this note, we consider what the impact of these and other sanctions have been so far for investors in Russian airports, and what they might be in the future.

We use a sample of international airports to estimate the impact on the asset values of degraded revenues from cancelled flights on both Russian and non-Russian airports. We also consider the impact on Russian airports of a more-or-less permanent increase in the discount rate implied by the isolation of Russia from the international financial system.

We find that, to date, the immediate harm inflicted on the Russian airport sector is small (less than 5% of NAV) and mostly the result of financial sanctions rather than airspace closures. The latter have had a limited impact on the future cash flows of these airports, which translates into a very small impact on their NAV. By contrast, the implied loss of value due to the spike in the price of airport equity risk is almost eight times larger. In turn, the aggregate impact on the non-Russian airport sector is extremely small, making these sanctions not very costly.

However, in the longer term, a drawnout conflict will create increasingly

## 1. Impact of sanctions on flights in and out of Russia

Panel A					
	Global flights	Flights to/from Russia	Flights within Russia	Total Russian air traffic	Domestic share
28 Jan 22–11 Feb 22	1,366,902 (47,491)	10,251 (25)	22,847 (49)	33,098 (74)	69%
	0.78%	1.73%	2.50%		
25 Feb 22–11 Mar 22	1,487,211 (35,890)	9,699 (1,301)	22,701 (867)	32,400 (2,168)	72%
	0.58%	1.50%	2.08%		

Panel B	
Russian + NATO member flights	Flights to/from NATO/Russia
28 Jan 22–11 Feb 22	684,522 (24,261)
	0.56%
25 Feb 22–11 Mar 22	768,404 (8,298)
	0.35%

Source: OAS, Flight24, EDHEC*infra* 2022. Multiple approaches were used to aggregate the relevant air traffic data. The margin of error is estimated to be below 5%. Note: cancelled flights in parentheses.

larger financial losses. The Russian airport sector will lose more revenues due to the increasing inability of Russian airlines to keep flying foreign-made jets that have been cut off from their maintenance and technical support. Moreover, until the Russian risk premium returns to its pre-war level, fair-value losses will keep mounting exponentially.

These findings are a reminder of the different types of risks to which investors in infrastructure are exposed. On the one hand, long-term cash flows ensure the resilience of asset values to extreme but short shocks to the top line, as the COVID-related lockdowns also demonstrated. On the other hand, the discount rate and its impact on the present value of cash flows has a much greater ability to cause damage to investors. Shocks to risk premia or to base rates can create significant uncertainty about the financial value and performance of long-term investments like airports. This case also shows that infrastructure can be exposed to systemic risks, as its use becomes dependent on global supply chains and access to non-domestic technologies.

The main airports in Russia<sup>1</sup> are owned directly or indirectly by oligarchs such as Oleg Deripaska or Valery Kogan. But international investors in infrastructure are also exposed to Russian airports and have invested at least \$10bn over the past decade.<sup>2</sup> The resilience of their investments will be greatly tested by the current crisis.

### Airspace closures and Russian airport traffic

We compare the volume of flights involving Russian airports with the global flight volume for two 15-day periods: between 28 January and 11 February 2022 (pre-invasion) and between 25

February and 11 March 2022 (post-invasion).

Figure 1 (Panel A) shows the number of flights to and from Russia, within Russia and the total Russian air traffic pre- and post-invasion. It also shows these quantities as a share of global air traffic. At first the impact of airspace closures can seem dramatic. As a share of global flights, the traffic to and from Russia has decreased by almost 30% since the sanctions (from 0.78% to 0.58%). But global flights have also increased in volume during this period (by about 10%) due to many economies reopening international travel post-pandemic. In this context, air traffic to and from Russia has really fallen by 20% (from 10,226 flights to 8,398).

Next, figure 1 also shows that Russian air traffic is predominantly domestic: before the sanctions, 69% of flights leaving a Russian airport also arrived at a Russian airport. Since the closure of NATO and other airspaces to Russian airlines, this proportion has risen to 72%. Air traffic within Russia is also 4.3% lower since sanctions were imposed and, while this may be due to some disruptions of the Russian airspace and airport activities, it could also be a seasonal effect. In effect, the absolute number of flights to and from Russian airports has fallen by 8.8% (from 33,024 to 30,232) since the war began. If we consider only NATO countries (Panel B), which include almost all the countries that have closed their airspace to Russia,<sup>3</sup> we see that the total number of flights between NATO members and Russia was small to begin with; it accounted for just 11.1% of all Russian air traffic before the sanctions and about 8.7% since. Looking at all NATO member and Russian air traffic data, the number of flights between the two zones has fallen by 23% since the

<sup>1</sup> Moscow–Domodedovo, Moscow–Sheremetyevo, Moscow–Vnukovo, Novosibirsk–Tolmachevo, Saint Petersburg–Pulkovo, Sochi, Yekaterinburg–Koltsovo.  
<sup>2</sup> International investors include the Sojitz Corporation, Japan Airport Terminal, Japan Overseas Infrastructure Investment Corporation for Transport & Urban Development, Changi Airports International, Mubadala, Strabag, Copelouzos, Fraport, Vienna Airports and the Qatar Investment Authority, as well as flagship development funds such as the Russian Direct Investment Fund and the Russia-China Investment Fund.  
<sup>3</sup> Singapore and Finland are also among the countries that have closed their airspace to Russia.

## 2. Impact of sanctions on airport traffic

Loss in flight volume	
Russian airports	-18.00%
Non-Russian airports	-0.22%

Source: EDHEC*infra* 2022.

## 3. Revenue sensitivity of different types of airports to changes in flight volume

Sensitivity to a 1% change in flight volume	
Mostly domestic airports	0.72
Mostly international airports	1.07

Source: EDHEC*infra* 2022.

sanctions were imposed, as of the cut-off date in the data.

Thus, the immediate impact of airspace sanctions on the total traffic volume of Russian airports has so far been limited by the substantial proportion of Russian air traffic that is domestic and by the fact that only some countries have banned flights to and from Russia.

Estimating the loss of air traffic as of mid-March 2022 requires a counterfactual by which there are no sanctions and Russian air traffic would also have benefited from the 10% average global growth of traffic. On this basis, we estimate that non-Russian airports lost a limited 0.22% of traffic due to the sanctions, while Russian airports had to forgo about 18% of their total air traffic (see figure 2).

### Loss of revenues

A 1% change in the volume of flights arriving or departing an airport does not necessarily translate into a one-for-one change in revenue. Looking at a range of airports around the world, we observe two patterns of revenue sensitivity to changes in flight volumes, as shown in figure 3. Note that these results are calibrated using data for the years 2019 to 2020 – ie, the sudden stop in air traffic created by the COVID-19 pandemic and the ensuing lockdown. Hence, these results capture the impacts of large shocks.

Figure 3 shows that when airports are largely domestic, their revenue model and tariff structure are such that revenues are less sensitive to traffic shocks than those of airports that are focused on international traffic, in which case the ‘beta’ of the traffic is higher than one. In the case of global hubs like Heathrow airport in the UK, the sensitivity of revenues to traffic in 2019–20 was 1.13, meaning that for each 1% drop in flight volume, the

airport lost 1.13% of its revenues. This is due to the differential pricing used by many airports for domestic, regional and international flights.

As we saw above, Russian airports are mostly focused on their domestic market (somewhat in the manner of those in Australia or the US) while the airports to and from which Russian flights have been banned are more likely to be international airports. As a result, the revenues of Russian and non-Russian airports are impacted differently by the sanctions: per cancelled flight the sanctions are costlier to non-Russian airports than they are to Russian airports.

On aggregate, however, the immediate loss of revenue is greater for the Russian side: with a drop in the total volume of flights of about 18% in March, aggregate airport revenues in Russia can be estimated already to have fallen by about 10.8%. Conversely, non-Russian airports can be expected to suffer aggregate revenues losses of only -0.28%.

Of course, if economic sanctions were to remain in place and Russian airport revenues to continue to be degraded, perhaps increasingly so, the impact would be greater, especially as the companies’ dividend payout behaviour is forced to become more conservative.

It should also be noted that airspace closures are not the only type of sanction impacting Russian airports. Since most Russian air traffic is domestic, the ability of domestic or national airlines to keep flying is essential to maintain the revenue stream of local airports.

In this context, the loss of maintenance support from international aircraft manufacturers, all of which have already excluded Russian airlines from their service, will have an increasing impact. It will gradually make the Russian modern jet fleet less reliable and, eventually, unusable. Modern aircraft require specific maintenance and part replacement on a regular basis, at least once every six years.

Indeed, Russian airlines mostly use foreign-made aircraft. For example, Aeroflot currently maintains a fleet of 180-plus aircraft, 170-plus of which are made by Airbus and Boeing.<sup>4</sup> The dozen remaining SU-100 Superjets in service at Aeroflot use engines made in France.<sup>5</sup> Reports suggest that out of 861 passenger and cargo planes currently in service in Russia, 332 are Boeings, 304 are Airbuses and many more by other international manufacturers. Only 136 civilian aircraft are Russian-made.<sup>6</sup>

Such dependence on foreign technology, which is now out of bounds, can be expected to greatly compound losses of traffic and revenues for Russian airports.

In what follows, we consider the immediate effect on revenues as it can be estimated today, as well as a forward-looking scenario involving five years of sanctions and the loss of one quarter of the fleet each year for the first three years.

Indeed, if three quarters of the fleet is foreign-made and the limit for a jet aircraft to keep flying without maintenance is six years then, on average, we can assume that one third of these aircraft will reach this limit every year going forward. The resulting loss of revenue from lower traffic is included in our analysis of the expected loss of financial value in the sector.

### Loss of financial value

Next, we consider the financial loss resulting from these sanctions. We first consider the impact of lower revenues on the NAV of airports. While we do not have access to the direct valuation of Russian airports, we can do a sensitivity analysis using the large and medium-sized international and domestic airports tracked in the *infraMetrics* database. *infraMetrics* has documented 140 airports in 25 countries and actively tracks the financial performance of 30 airports in eight countries over the past 20 years.<sup>7</sup> We assume that investors in Russian airports would be exposed to similar types of medium-to-large assets and that the *infraMetrics* basket of international airports is representative of the business profile of investments made in the Russian airport sector. We estimate the impact on the market value of this basket of non-Russian airports given a commensurate revenue shock and/or discount rate shock and use it as a proxy of the impact of such shocks on the NAV of Russian airports.

### Change in NAV due to a fall in revenues

Figure 4 (Panel A) shows that a one-off negative shock on revenues has a small impact on the NAV of a basket of airports with a temporary (intra-year) revenue drop of 10.8% the NAV is reduced by about 0.5% on average, leaving both the discount rate and the dividend payout ratio unchanged. This is due to the long life of

<sup>4</sup> See, for example, <https://www.planespotters.net/airline/Aeroflot-Russian-Airlines>

<sup>5</sup> In mid-March 2022, reports already highlighted a dramatic rise in the use of Russian-made jets within Russia (<https://simpleflying.com/russia-huge-increase-sukhoi-ssj100-flights/>).

<sup>6</sup> Data from Cirium, 2022.

<sup>7</sup> Germany, France, Chile, Australia, UK, Portugal, New Zealand and Italy.



such assets and the many remaining future dividends that enter the present value calculation. Hence, the immediate revenue shock of March 2022 has had a rather limited impact on the NAV of Russian airports.

However, once we consider the impact of a forward-looking scenario including five years of sanctions, and declining domestic traffic due to the issues with the maintenance of the international aircraft fleet highlighted above, the impact on the NAV of Russian airports of lower revenues is much larger at -18.3% of the NAV at the 2026 horizon (Panel B).

In fact, these estimates are conservative since this scenario would trigger other effects, including potential defaults and greater asset preservation on the part of Russian airport companies. In this scenario, the cash flow profile of the investments returns to its pre-war path after five years, which could also be considered optimistic.

#### Change in NAV due to an increase in discount rates

Since the conflict started, the price of risk has increased for Russian investors, as have interest rates, and the one-month increase on Russian corporate bonds credit spreads is about 900bp.<sup>8</sup> Meanwhile the Russian central bank has increased interest rates from 9.5 to 20%.<sup>9</sup> These changes imply an increase of the discount rate of Russian airports of the 2,000bp order of magnitude.

The discount rate shock impacting Russian airports in March 2022 is large. Hence, rather than using a measure of key rate duration (sensitivity to discount rate risk at one point in time) which is based on a linear approximation for small changes in rates, we recomputed the impact of such a shock directly for the same basket of international airports.

Assuming that the sanctions are a one-time hit on the risk premium that would disappear after a year indicates a limited loss of 4.2% (see figure 4, Panel A). Conversely, if this increase in the risk premium was to apply for the next five years, the loss from that change in the price of risk alone would be 15.2% (Panel B).

The long-term nature of airport

#### 4. Average impact on NAV of a one-time revenue shock

Panel A: Immediate loss (March 2022)			
	Revenue only**	Risk premium only	Revenue and premia
Shock	-10.8%	20.0%	Combined
Mean loss	-0.5%	-4.19%	-4.67%

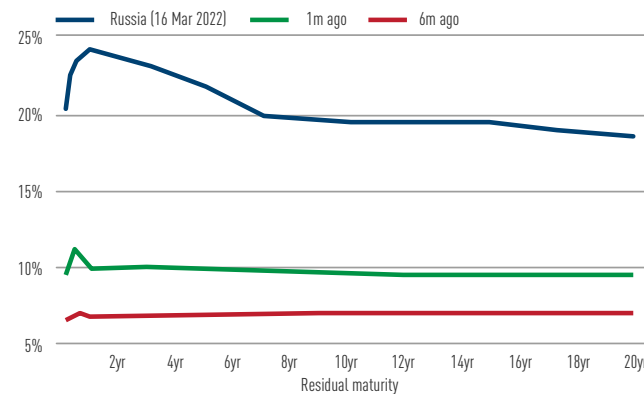
Panel B: Five-year scenario			
	Revenue only	Risk premium only	Revenue and premia
Shock	Five-year decline*	20.0%	Combined
Mean loss	-18.3%	-15.14%	-25.78%

Panel C: Permanent impact on the discount rate	
Shock	
Mean loss	-71.72%

Source: EDHECinfra 2022, \*Revenues drop from base case of 22% in 2022 (full year), 33% in 2023 and 75% in 2024–26. Discount rates increase by 2,000bp in 2022–26. \*\*No change in discount rates, no change in dividend-to-revenue ratio.

#### 5. Russian yield curve



Source: World Government Bonds

investments makes the compounded effect of large shocks to the risk premium so powerful that if Russia was considered to be a much riskier investment destination on a permanent basis (or until further notice), international investors in Russian airports could have to write off these assets entirely. Should discount rates for Russian assets remain permanently at this level, with this increase applying to discounting all future periods, then investors in Russian airports would be looking at losses in excess of 70% of NAV (Panel C). At the moment, the inverted hump of the Russian yield curve suggests that the next five years are priced as riskier than the following two decades (see figure 5).

#### Conclusions

The combined impact of airspace closures, commercial sanctions and the higher costs of capital for Russian airports amounts to a loss of approximately 4.7% in March 2022 (figure 4) for investors exposed to this sector. However, this calculation assumes that the world returns to its pre-invasion state very soon, which currently seems most unlikely.

Assuming a somewhat protracted war

and enduring sanctions, our five-year scenario considers a) the combined loss of access to NATO airspace, b) the expected rapid collapse of Russian domestic traffic due to the loss of technical support from international aircraft manufacturers, and c) the impact of much higher discount rates on the NAV of these assets. We find that investors can expect to lose at least a quarter (-25.8%) of the value of these investments, assuming a return to base case after five years.

The longer the current situation continues, the larger will be the impact on Russian airport asset values. As we have shown, this impact is not primarily due to airspace closures, given the mostly domestic nature of the Russian airline market. Instead, the negative impact stems almost entirely from the loss of access to technical support from international firms (the limits of Russia's technological sovereignty) and the increase in the risk premium on Russian investments.

Of course, the Russian state may not worry about market fair value, but international investors do, whether they are oligarchs or pension and sovereign wealth funds.

8 MSCI (2022). Russian Corporate Bond Markets: Braced for Default? Available at <https://www.msci.com/research-and-insights/russia-ukraine-war/russian-corporate-bond-markets>

9 Bank of Russia (2022). Bank of Russia increases the key rate to 20% p.a. Accessed at <https://www.cbr.ru/eng/press/keypr/>

# Measuring the carbon emissions of infrastructure assets: the case of airports and beyond

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As the demand for data on climate risks increases for investors in real assets, EDHEC*infra* is developing a global data collection and carbon dioxide (CO<sub>2</sub>) emission estimation exercise across the asset class.

The continued increase in the concentration of atmospheric CO<sub>2</sub> and the creation of regulations to limit carbon emissions create risks for investors in infrastructure assets. Transition risks are magnified by the long lifespan of these investments and must take an ever-increasing role in investment decisions. The management of such risks calls for accurate emission predictions but directly reported data is often lacking for these assets, predominantly due to their private ownership.

EDHEC*infra* has developed a systematic approach to estimate transition risks across all infrastructure assets. This approach:

- uses CO<sub>2</sub> emissions as a proxy for transition risks;
- employs a common analytical framework to model emissions as functions of location-dependent variables (climate, elevation, etc), structural variables (dimensions, areas, etc) and capacity indicators;
- applies that framework to the specificities of each asset type; and
- extracts the most relevant metrics for investors.

Since it is common usage, we make a distinction among metrics according to their scopes:

- **Scope 1:** direct emissions from stationary or mobile combustions, fugitive emissions;
- **Scope 2:** indirect emissions from purchased electricity, heat and steam; and

- **Scope 3:** other indirect emissions from sources not owned by the infrastructure, such as upstream or downstream purchases of goods and services, business travel, commute of employees and users, transportation, etc.

In what follows, we show an application of this approach to airport infrastructures which represented 12% of global transport emissions in 2019<sup>1</sup>, have highly regulated activities and relatively good data coverage. Despite important reductions of emissions per passenger, the constant increase in air transport demand (only recently impacted by the COVID-19 pandemic) has brought increasing pressure on airports to reduce their emissions.

## Airports' Scope 1 and 2 emissions

Airports come in different sizes and shapes as we consider them around the globe. However, due to their interdependence and reliance on the same aircrafts, operating airlines, and regulations, airports also share common characteristics.

It is fair to assume that a limited set of parameters is sufficient to understand their emissions. These parameters are often the numerical quantities reported in sustainability reports.

We model Scopes 1 and 2 based on the current literature<sup>2,3,4,5,6</sup> and the factors that are the most relevant for direct emissions and electricity consumption: patronage, local temperature, geospatial characteristics, airport-owned power plants and air traffic. Such data was gathered with the highest possible coverage of features for several thousand airports and served as the basis for modelling.

Relying on publicly disclosed sustainability reports, it is possible to relate real scope emissions to the above regressors on a reduced set of airports and evaluate the most important factors explaining their emissions. For that, a statistical approach covering multiple combinations of regressors was implemented to find the best linear regressions as well as minimising explanatory factors. The models for

<sup>1</sup> Air Transport Action Group. Facts & Figures. <https://www.atag.org/facts-figures.html>

<sup>2</sup> Ahn, Jognhoon, and Soolyeon Cho (2015). Energy Performance Benchmark Model for Airport Terminal Buildings. Proceedings of BS2015: 14th Conference of International Building Performance Simulation Association, Hyderabad, India, 7-9 December

<sup>3</sup> Bo Li, Wen Zhang, Jianping Wang, Junku Xu and Jixiang Su (2017). Research and Analysis on Energy Consumption Features of Civil Airports. IOP Conference Series: Earth and Environmental Science, Volume 94, Third International Conference on Energy, Environment and Materials Science (EEMS 2017) 28–30 July 2017, Singapore.

<sup>4</sup> Kang, Minkyung, Mario Bergés and Burcu Akinci (2017). Forecasting Airport Building Electricity Demand on the Basis of Flight Schedule Information for Demand Response Applications. Transportation Research Record: Journal of the Transportation Research Board 2603(1).

<sup>5</sup> Gu, Xianliang, Jingchao Xie, Zhiwen Luo and Jiaping Liu (2021). Analysis to energy consumption characteristics and influencing factors of terminal building based on airport operating data. Sustainable Energy Technologies and Assessments 44. 101034. ISSN 2213-1388.

<sup>6</sup> Kim, Sang-Chul, Hyun-Ik Shin and Jonghoon Ahn (2020). Energy performance analysis of airport terminal buildings by use of architectural, operational information and benchmark metrics. Journal of Air Transport Management 83: March. 101762.

Scopes 1 and 2 metrics that resulted from this approach were then used to predict emissions of airports which are not known or publicly reported, based on the same set of best-fit regressors.

Figure 1 shows Scopes 1 and 2 emissions against one of their most relevant regressors (assessed from their p-value). Current Scope 1 and 2 models can explain half of the variance of observed emissions. K-fold cross-validation was applied to confirm predictability and these models were then employed to predict Scope 1 and 2 respectively for several thousand airports across the globe.

Thus, using a set of observable airport characteristics, we can predict the Scope 1 and 2 emissions of thousands of airports globally and build robust rankings of the carbon performance of individual airports by comparing them to thousands of cases in the cross-section. This is an important improvement to existing rankings which rely on too little data to be robust: using only available reported and contributed data, it is not possible to tell which asset is more exposed than others. Our approach creates thousands of estimates calibrated from actual asset-level data and allows investors to begin to understand how exposed they are to transition risk.

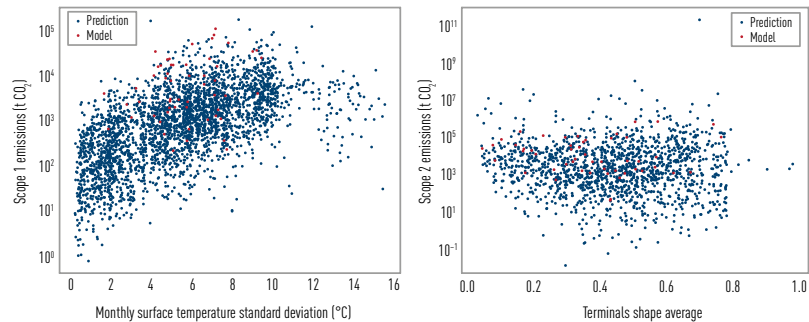
### Airports' Scope 3 emissions

In general, airport owners limit the reporting of Scope 3 emissions to their landing and take-off cycle (LTO) operations, ground support equipment or tenants' activities such as heating, electricity purchase and vehicles usage. To the authors' knowledge, Heathrow airport is the only one reporting departure cruise emissions. This diversity of emission sources and the lack of directly reported data makes the estimate of Scope 3 more involved than Scopes 1 and 2.

Nevertheless, the use of air traffic data allows the estimate of LTO emissions, which often dominates Scope 3 (although passengers' and employees' commutes can also be significant), and further allows the estimate of cruise emissions, almost never reported. After these two effects are captured, other sources of Scope 3 can be seen as next-order corrections. Based on these considerations, several models were developed by EDHEC*infra*, among them a distance-based model of cruise and a time-based estimate of LTO emissions at aircraft levels. In this setting, sustainability reports have brought precious information to validate yearly metrics and calibrate higher frequency metrics.

As shown in figure 2, cruise and LTO emissions were estimated for more than

## 1. Scope 1 and 2 emissions for c. 3,000 airports



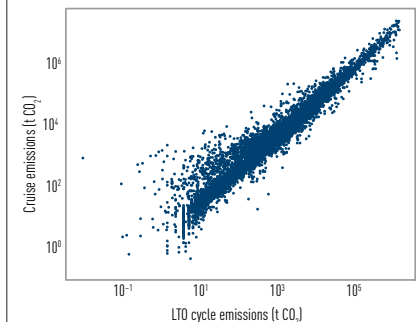
Red points represent the calibration data; blue points are the predictions made from the model on other assets.

8,000 airports. Based on these estimates, we can see that LTO emissions represent on average ~26% of the departure cruise emissions. This number varies significantly between airports, as visible through the dispersion in the plot. Numerous derived metrics relevant for investors' decisions can be extracted from these high frequency estimates, such as emissions by countries or by airline companies, emissions per passengers or revenues, etc.

### Towards transition risk rankings for all infrastructure assets

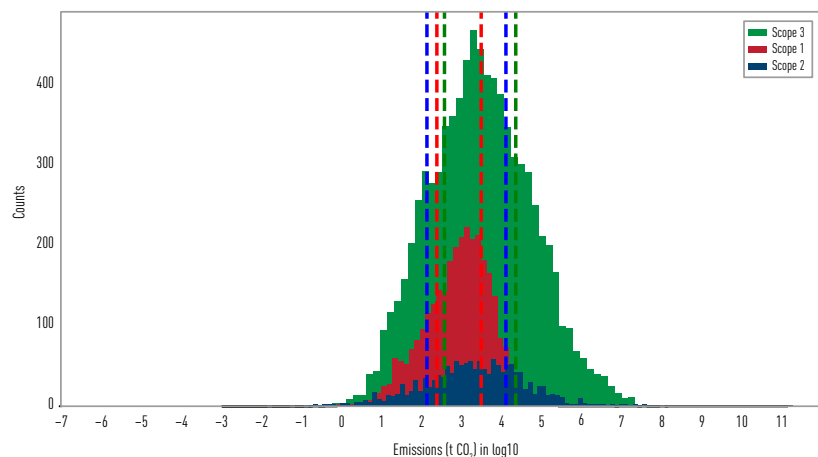
Based on physical and operational characteristics of infrastructures, EDHEC*infra* data can palliate the lack of emission reporting. Figure 3 shows the distribution of estimated emissions for thousands of airports and allows ranking not only these assets but any asset for which investors have emission estimates (at least for Scopes 1 and 2).

## 2. Scope 3 emissions for c. 8,000 airports



This approach provides a systematic and reliable assessment of transition risks and satisfies the need of infrastructure investors for consistent metrics across countries and asset types.

## 3. Summary of predictions for c. 8,000 airports



Vertical lines correspond to 1st and 3rd quartiles.

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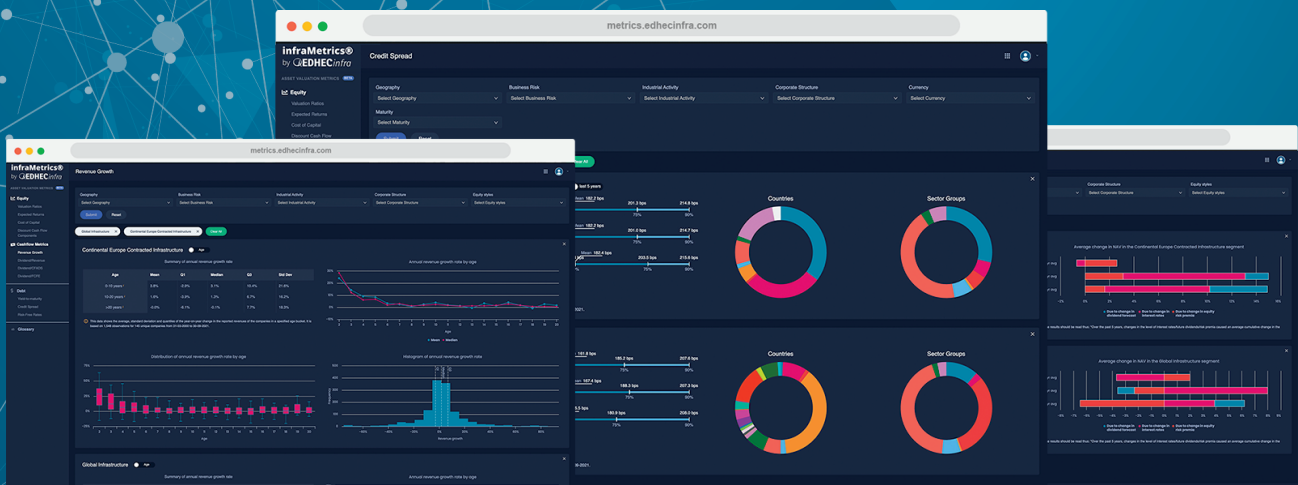
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# Towards a social acceptability index of infrastructure assets and services

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Infrastructure development has the power to enrich communities but can also be very disruptive for those it serves and others. Failure to monitor and react to public sentiment can result in disruptions through protests, increases in government regulation or outright cancellation of projects.

As a result, monitoring social sentiment around large infrastructure projects and sectors can be important for investors and provide an understanding of the social risks created by such projects. However, traditional monitoring methods, which include surveys, are costly and time consuming. EDHEC*infra* proposes a different approach using machine learning and newspaper and other articles, to create an index of social sentiment around infrastructure projects and companies.

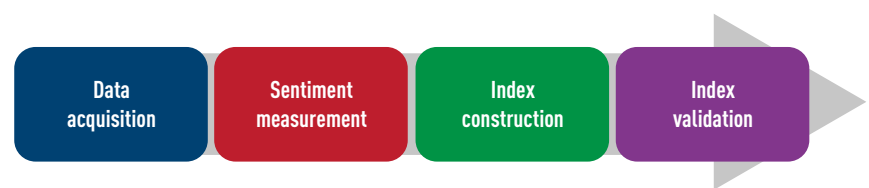
With such data, investors will be able to understand and predict the social impact of their investments in infrastructure as they are reflected in the public sentiment.

## Methodology

News is a well-established information source and summary of people's daily life. Mossberger et al (2007) demonstrated that news can shape and influence public opinion while also providing a voice to the public. Compared against other types of text information – for example, Twitter or Facebook – news articles are presented in a relatively well-organised format and as a result, make the analysis easier and more informative.

Typically, there are the four major steps of building a sentiment index from news articles: data acquisition, sentiment measurement, index construction and index validation as illustrated in figure 1,

## 1. Sentiment index methodology



which summarises the steps put forward in the academic and technical literature research (Shapiro, Sudhof and Wilson [2022]). We use a similar structure of analysis to construct an index of social acceptability for different infrastructure asset types as defined under the TICCIS taxonomy.<sup>1</sup>

### Data acquisition

We use major news sources covering a wide range of news articles globally and published by both international, local and business news agencies in different languages. We select news articles that reflect public sentiment towards infrastructure from the raw data using the following criteria:

- **Industrial sectors:** We identify specific infrastructure sectors and related news and include all the infrastructure sectors based on the TICCIS taxonomy. In practice, the exercise is completed on a sector-by-sector basis.
- **Geography:** We select a geographically representative subset of the database, starting with the five major English-speaking countries: US, UK, Canada, Australia and New Zealand, and gradually

adding other countries (both English and non-English speaking).

- **News agencies:** The same event could be reported by multiple news agencies. This could influence public opinion in differing ways. Therefore, we consider both major international news agencies and local news agencies.

- **Content:** We focus on the ESG domain and include only news articles containing ESG-related topics. These topics are identified using the EDHEC*infra* Infrastructure Taxonomy and Exposure Profiles for individual TICCIS infrastructure activity subclasses. We thus build a classifier to identify the ESG news articles using unsupervised topic modelling to detect common topics in the articles and manually cross-checking these topics with the ESG expert knowledge in the EDHEC*infra* ESG Exposure Profiles. Finally, we refine and mine the topics in the news articles by choosing articles that contain keywords that relate to the EDHEC*infra* ESG Exposure Profile. This allows us to create a dataset of articles for

<sup>1</sup> See docs.edhecinfra.com

which the classifier has detected a significant number of sentences containing topics of interest, particularly on ESG themes.

The extracted raw news articles are preprocessed to normalise their format and remove noise (unrelated content) to create the usable news article database for further analysis.

### Sentiment measurement

There are two common approaches to measuring the sentiment expressed in news articles. These are the lexicographic and machine learning approaches. The lexicographic approach, as described by Shapiro et al (2022) involves creating a dictionary of words with their associated valence (1, 0, -1 for positive, neutral and negative sentiment, respectively). To measure sentiment under the lexicographical approach, essentially you count the number of occurrences of the words, combined with the associated sentiment and estimate the prevailing sentiment in the text.

While the lexicographic approach is simple to implement, it does have some significant drawbacks. By including only words in the pre-specified dictionary, the lexicon approach loses information around the context of how the words are used in a sentence. These modifiers (words such as very, severe and slightly) can have a significant impact on the inferred sentiment in the passage of text. Furthermore, such dictionaries are domain-specific (see Loughran and McDonald [2011]) and the sentiment expressed in words is not stable over time (see Hamilton et al [2016] and Lukes and Søgaard [2018]).

The alternative approach, and the one applied in our research, is to employ human annotators to label a piece of text as either positive, neutral or negative and then apply machine learning techniques to build a model to predict the sentiment expressed in the model. One of the most important advantages in the machine learning approach is to catch the semantic information in the surrounding context. The inclusion of contextual cues is important as it allows the model to learn and then subsequently look for modifiers, and other contextual cues to develop a more accurate model of

sentiment within a piece of text.

To harness the benefits of both approaches, we develop a language model to estimate the sentiment polarity (eg, positive, neutral or negative) through computing the frequency of the sentiment words appearance, as well as their contextual cues in the news articles. We first have human annotators annotate a selection of text, comparing results and where the annotators have agreed on the sentiment, compile the passages of text into a 'ground truth' dataset. The data for annotation is sampled from the news database to ensure a balanced distribution over multiple axes – eg, countries, news sources, publication years, article length, etc, to serve the purposes of evaluating a language model robustly.

We then develop a model that takes a portion of the 'ground truth' dataset and train our language model on it. Testing the predictive performance of the model on another section of the 'ground truth' dataset to ensure it has predictive performance on text that is as yet unseen. Once we have obtained suitable predictive ability, we can deploy the model to estimate the sentiment of all articles within our full dataset. Once all articles have an estimate of their sentiment, we then construct an index of sentiment for the interested infrastructure sectors.

### Index construction

We follow the literature and create an index of social acceptability, where the sentiment of news articles is explained by two components: the systematic fixed effect reflecting the overall public attentions and individual article indicator showing the idiosyncratic character of each article. The article  $a$ 's sentiment can be formulated as:

$$s_a = f_t + f_{p(a),j(a)} + \varepsilon_a$$

where:

$s_a$  is the net positivity score for article  $a$  obtained from the language model;  
 $f_t$  is a sample-month ( $t$ ) fixed effects  $t$  and,  $f_{p(a),j(a)}$  is the indicator reflecting the article's idiosyncratic characters – for example, measuring the frequency of opinionated words, such as 'think' or 'believe'.

As in Shapiro et al (2022), we employ newspaper systematic fixed effects controls for different public voices in our sample over time. Once we have obtained

the sentiment for the different articles from the language model, we estimate the systematic fixed effect as the social acceptability index at month ( $t$ ).

### Index validation

We validate the constructed index against other information sources to check the capability and robustness of reflecting public opinion. The other information sources can be in the form of opinion polls or surveys (eg, UK government BEIS surveys<sup>2</sup>) directly measuring public sentiment. Other sources can include non-survey data, such as the number of projects awarded, to enable an indirect measure of the popularity of a particular infrastructure asset.

### Conclusion

Social acceptability is critical during an infrastructure asset's lifecycle as it can determine the success or failure of the project or company. EDHECinfra is constructing a social acceptability index to measure and monitor the evolution of public sentiment towards an infrastructure sector over time. This will provide an additional dimension to understand the performance of the infrastructure asset besides economic and financial angles and will be a piece of strongly complementary information. The results of this analysis will assist investors in the future as it will assist in the quantification of the social or political risks of infrastructure assets in its future application.

*The first EDHECinfra social acceptability analytics are expected to be released in early 2023.*

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