EDHECinfra Research Seminar

London, 7 July 2022, 2pm BST

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Agenda

Part 1 - The pricing of green infrastructure

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Part 2 - Climate and social risk metrics at the asset level

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Project Director, EDHECinfra

The Pricing of Green Infrastructure

Realised vs. expected financial performance of green power infrastructure investment, 2010-2021

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Research question

- It is often argued in the marketing of ‘green’ products that more sustainable investments should coincide with better financial performance.
- This opens two questions:
    1. Is there empirical evidence of superior performance by more sustainable or *greener* investments?
    2. 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?

The Performance of Green Power Infrastructure

10 years of realised returns

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The Performance of Green Power Infrastructure

- Green power infrastructure? Let's consider wind and solar power projects *only* → the **greenest** type of power infrastructure (zero or negative GHG emissions)

- Wind and solar investments: project financed investments, often contracted or with very predictable revenues, finite life, fixed capacity over the investment horizon → resemble a **bond** (with risky coupons)

- **Out-performance** for bond-like assets with limited upside can only come from higher demand (capital gains) implying a lower yield (expected returns) and, ultimately, *lower* performance once excess demand dries up.

Green infrastructure performance

infraGreen index from infraMetrics®

- Tracks the market performance of 100 unlisted wind and solar power projects worldwide. USD15bn of market capitalization of equity.
- Core infrastructure is a natural benchmark for such low-risk investments

17% renewables

5% renewables

Descriptive Statistics, monthly local currency returns (2010-2021)

	infraGreen®	infra100 Global Core	infra100 Global Core+
Mean	0.013	0.010	0.014
Median	0.011	0.011	0.015
StdDev	0.024	0.030	0.035
Semi-Variance	0.023	0.031	0.038
Sharpe ratio	0.496	0.306	0.367
Kurosis	0.250	0.057	0.973
Skewness	0.080	-0.324	-0.552

Bull market Sharpe ratio

Positive skewness

- Green infrastructure **outperforms** the market, including Core infrastructure
- Until 2019, infraGreen index also outperformed the Global infra100 Core+ index

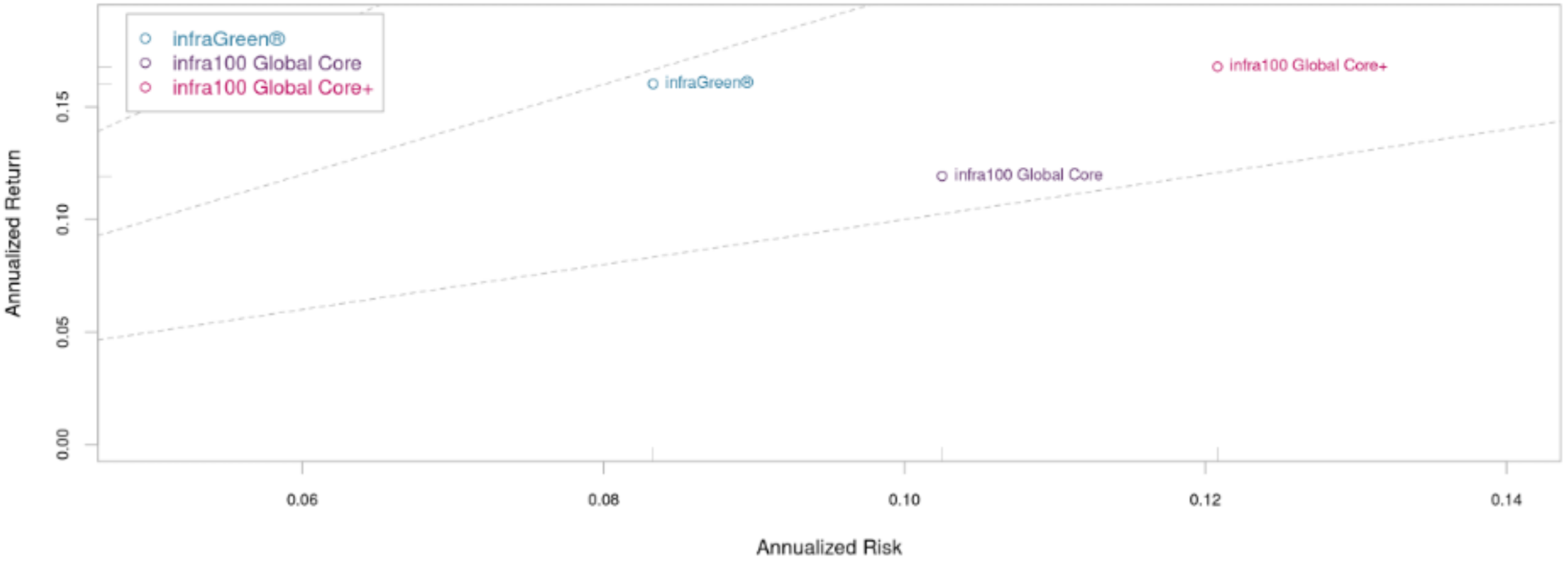
Figure 1: Cumulative performance: infra100 Global Core & Global Core+ and infraGreen indices 2011-04-30 / 2021-12-31

Risk-adjusted return profile 2011-2021:

→ Green infra has higher annualised returns than Core infrastructure

→ Green infra had lower volatility than Core+ infrastructure.

Figure 2: Anualised Risk and Returns: infra100 Core and Core+ and infraGreen indices



Green vs. Brown

Rough shades of green

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Green vs. Brown

- **Brown** power infrastructure? → Coal and gas power projects
  - Positive net GHG emissions contributor. Conventional power is the first contributor to total energy-related emissions (IEA, 2021)
  - Always carbon positive i.e., always *less green* than wind and solar power projects

- Wind+Solar Power vs. Coal+Gas Power is a good proxy of **Green** vs. **Brown**
  - Green = infraGreen index
  - Brown = a global portfolio of c.80 investments in conventional coal- and gas-fired power plants representing USD26bn of market value from the infraMetrics database.

Green vs. Brown

- Overall, in 2011-2021, realised returns in the brown segment are been higher than in the green one, but **before 2016, the reverse was true.**
- Since 2016 the average monthly returns in the green segment have been lower than those of the brown segment.

Descriptive Statistics, monthly local currency returns – Green vs Brown

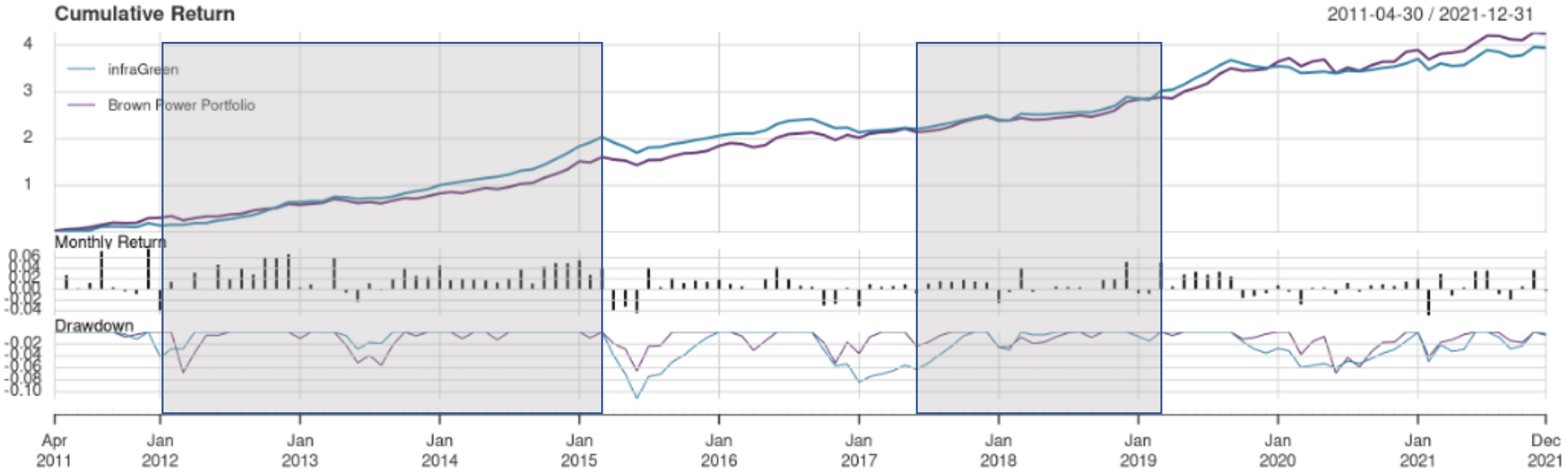
	2011-2021		2011-2015		2016-2021	
	infraGreen	Brown Power Portfolio	infraGreen	Brown Power Portfolio	infraGreen	Brown Power Portfolio
Mean	0.013	0.014	0.020	0.016	0.007	0.009
Median	0.011	0.014	0.018	0.016	0.006	0.009
StdDev	0.024	0.024	0.027	0.025	0.019	0.022
Semi-Variance	0.023	0.026	0.027	0.026	0.019	0.023
Sharpe ratio	0.496	0.526	0.697	0.612	0.322	0.380

Source: infraMetrics 2022

Green vs. Brown

- Cumulatively, brown power portfolio outperforms green power by a cumulative 138bp
- …but green power outperformed or matched brown power between 2012 and 2015 and between 2017 and 2019. Since 2019 the cumulative performance of green power has fallen below that of the brown power

Figure 3: Cumulative performance of the infraGreen and brown power portfolio, lcu total return



Green vs. Brown

- A significant part of the performance of green infrastructure come from **capital gains**.
- Brown power has produced higher cash returns.

Descriptive Statistics, monthly local currency returns – Capital vs, Income Returns (2010-2021)

	Capital Retuns		Income Returns	
	Green capital returns	Brown capital returns	Green income returns	Brown income returns
Mean	0.006	0.003	0.008	0.011
Median	0.007	0.008	0.000	0.000
StdDev	0.031	0.032	0.027	0.028
Semi-Variance	0.033	0.041	0.008	0.010
Sharpe ratio	0.177	0.067	0.269	0.363

Source: infraMetrics 2022

Green *minus* Brown

Expected green returns

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Green *minus* Brown

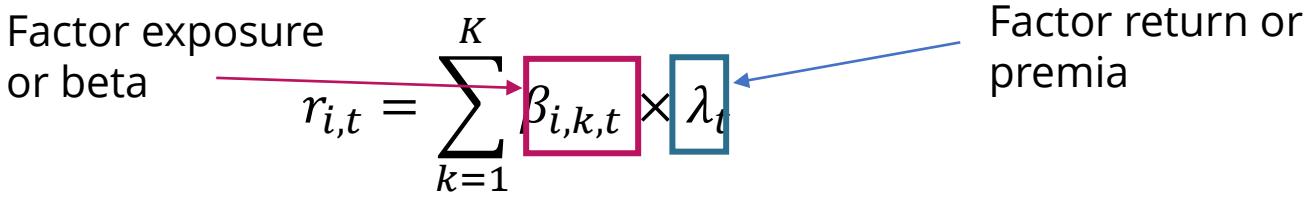
- Asset pricing research uses **factor mimicking portfolios** to find proxies of rewarded risk factors i.e., risk factors that are priced by the market and embody expected (factor) returns at time *t*.
- In practice, researchers build a long-short portfolio for the factor of interest to get a factor return (λ) and regress the factor returns against the index of interest to find its beta (β). For example:

$$\lambda_{Value} = r^{high\ book-to-market} - r^{low\ book-to-market}$$

- If the factor in question is present in asset prices, the returns of the factor mimicking portfolio (λ) or risk premia should **partly explain the (variance of) expected returns** (with a statistically significant β).

Green *minus* Brown

- Unlisted infrastructure equity returns are well-explained by a series of factors, such as **size, leverage, profit and investment** (see Blanc-Brude et al, 2021)



- It is possible that differences in expected performance between green and brown assets are explained by **differences in factor exposures** or $\beta_{i,k}$.
- If not, another factor or effect may be at play.

Green *minus* Brown

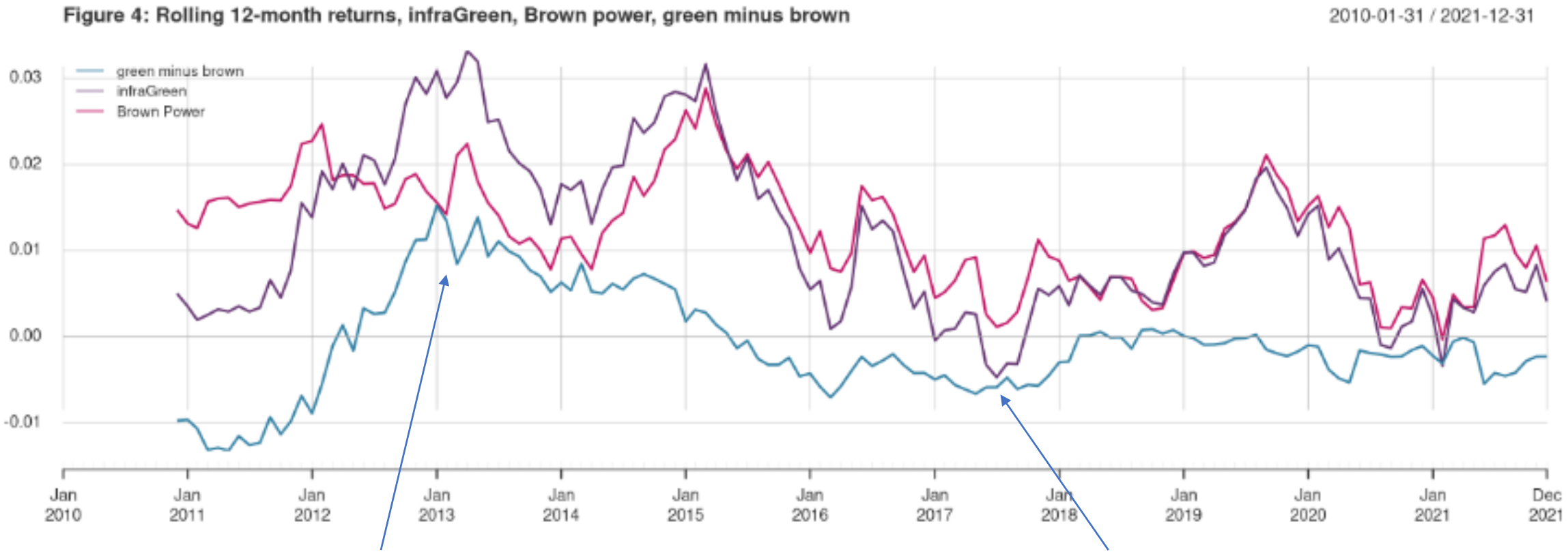
- We build a new *green* factor investment for investments in power using their relative levels of greenness: green *minus* brown (GMB)

$$\lambda_{gmb} = r^{infraGreen} - r^{Brown\ power\ infra}$$

- In our case, high green *minus* low green (brown) ~ wind+solar *minus* coal+gas
- If *greenness* is priced in expected returns it should be picked up by the GMB factor
- Other factor returns are computed using the usual high-minus-low sorted portfolios.
- GMB has a **negative** sign but only after 2015.

	Size	Leverage	Profit	Investment	Green
2011-2021					
Mean	-0.0020	0.0017	-0.0013	0.0020	-0.0007
Median	0.0005	0.0014	-0.0023	0.0026	-0.0013
StdDev	0.0244	0.0145	0.0173	0.0160	0.0154
Sharpe ratio	-0.0821	0.1208	-0.0781	0.1240	-0.0456
Semi-Variance	0.0263	0.0147	0.0148	0.0157	0.0147
Kurtosis	0.8088	2.4233	2.7949	8.4414	1.9351
Skewness	-0.4355	-0.3504	0.9535	0.8834	0.2181
2011-2015					
Mean	-0.0045	0.0022	-0.0020	0.0018	0.0002
Median	0.0002	0.0019	-0.0022	0.0030	0.0004
StdDev	0.0226	0.0149	0.0168	0.0136	0.0171
Sharpe ratio	-0.2004	0.1443	-0.1172	0.1344	0.0099
Semi-Variance	0.0249	0.0154	0.0156	0.0150	0.0175
Kurtosis	1.1858	2.2083	1.1754	1.3264	0.6819
Skewness	-0.6434	-0.5648	0.4563	-0.5251	-0.1756
2016-2021					
Mean	0.0026	0.0010	-0.0002	0.0023	-0.0021
Median	0.0020	0.0008	-0.0025	0.0012	-0.0031
StdDev	0.0269	0.0136	0.0182	0.0198	0.0121
Sharpe ratio	0.0972	0.0733	-0.0122	0.1149	-0.1780
Semi-Variance	0.0274	0.0135	0.0137	0.0166	0.0096
Kurtosis	0.2091	2.8892	4.4068	8.9690	8.0949
Skewness	-0.3730	0.1436	1.6193	1.6081	1.6774

Green *minus* Brown



Before 2015, the GMB portfolio delivers Positive returns.

After 2015, the GMB portfolio has mostly negative returns, indicating that brown power exhibits higher realised excess returns.

Green *minus* Brown

- Factor exposures are **different** between green and brown power portfolios
- Green assets are smaller, more leveraged, more profitable, more capex intensive than brown power assets.
- Brown assets are closer to the market index (infra300) in terms of factor exposures.
- These differences are largely **stable over time.**

	LogSize	Leverage	Profits	Investment
2011-2021				
Green Portfolio	18.317	0.814	0.142	0.101
Brown Portfolio	19.888	0.713	0.123	0.054
Market Index	19.805	0.769	0.110	0.084
2011-2015				
Green Portfolio	18.320	0.821	0.132	0.147
Brown Portfolio	19.977	0.740	0.127	0.067
Market Index	19.751	0.773	0.110	0.102
2016-2021				
Green Portfolio	18.315	0.808	0.151	0.064
Brown Portfolio	19.728	0.666	0.114	0.030
Market Index	19.907	0.763	0.109	0.049

Size: total assets. Leverage: senior debt/total assets. Profits: RoA before tax. Investment: capex /total assets. Source: infraMetrics 2022

Green *minus* Brown

- The GMB portfolio is regressed against standard rewarded risk factors found in unlisted infrastructure
- The variance of GMB is partly explained by movements in other factor returns…
- ..controlling for these effects, GMB retains a significant and negative intercept (alpha)
- GMB returns cannot be fully explained in terms of the traditional factors.
- **Is it a new factor?**

GMB Portfolio Regression

	Beta	SE	p.value
(Intercept)	-0.0029	(0.0012)	0.01597
broad_market_ew	0.0867	(0.0621)	0.16507
Size	-0.2233	(0.0605)	0.00033
Leverage	0.2577	(0.0947)	0.00743
Profit	-0.0386	(0.0741)	0.60311
Investment	0.28	(0.0739)	0.00023
Deg. freedom	126		
Adj-R2	21.26%		

Green factor or green demand?

From expected to realised returns (and back again)

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Green factor or green demand?

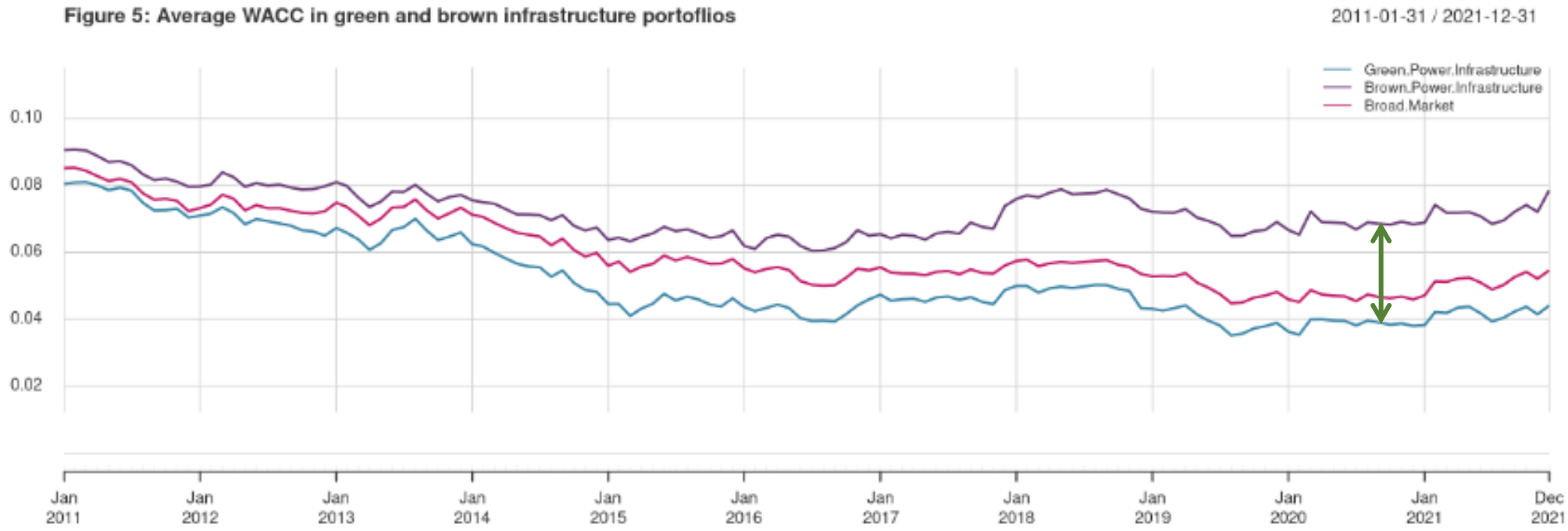
We have found so far:

- Realised green infra returns have been higher than brown infrastructure during some periods (2012-15, 2018-20)
- A ‘green factor’ mimicking portfolio or GMB exhibits negative expected returns.
- When controlling for other factor effects there remains a negative `alpha’

→Green expected returns are lower than brown expected returns but realised green returns have been comparable if not higher in some periods.

→Like bonds perform when yields compress, Green infra performance is consistent with a shift in the cost of capital.

Green factor or green demand?

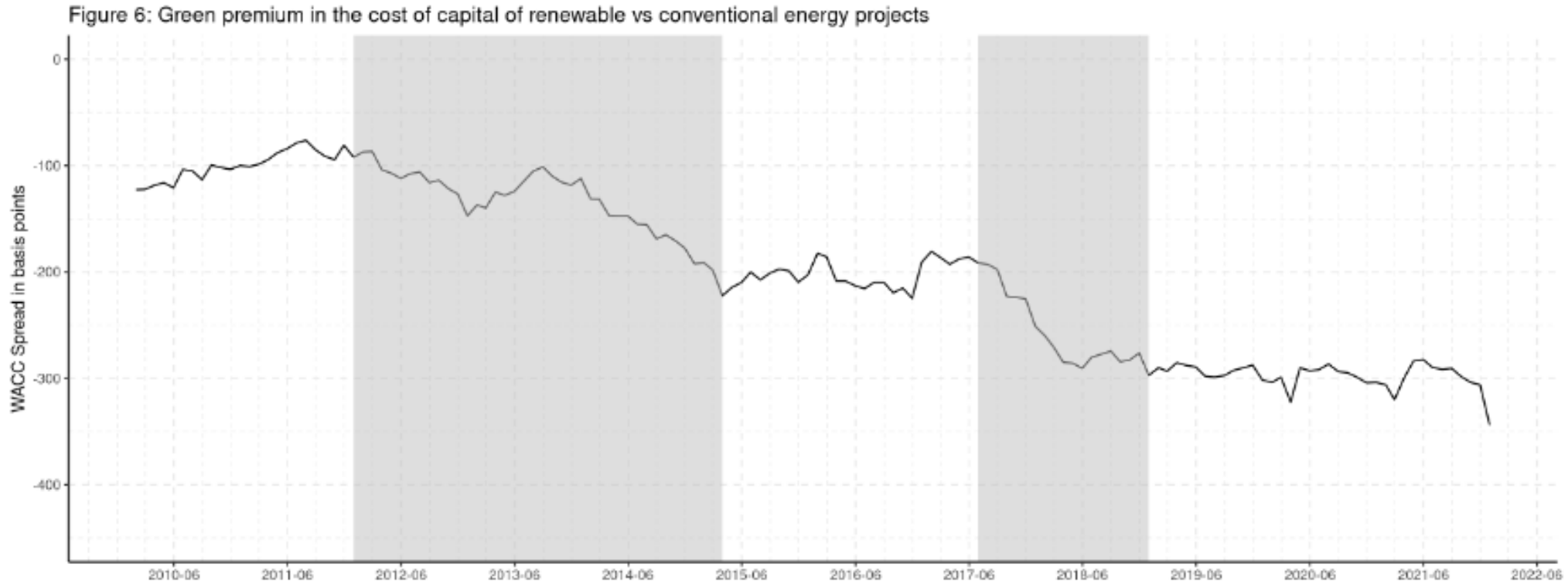


There is a a significant and increasing *spread* between the weighted average cost of capital of the green and brown portfolios. (source: infraMetrics®)

Green factor or green demand?

- All infrastructure investments have have seen a reduction in their cost of capital since 2011, including brown power.
- But green power has seen a much larger decrease.
- Dec 2011 → Dec 2021
  - Global infra reduction in WACC of -177bp (from 7.23% to 5.45%),
  - green power: -263bp
  - brown power: -11bp
- High realised performance of green infra has been accompanied by a significant decrease in its cost of capital

Green factor or green demand?



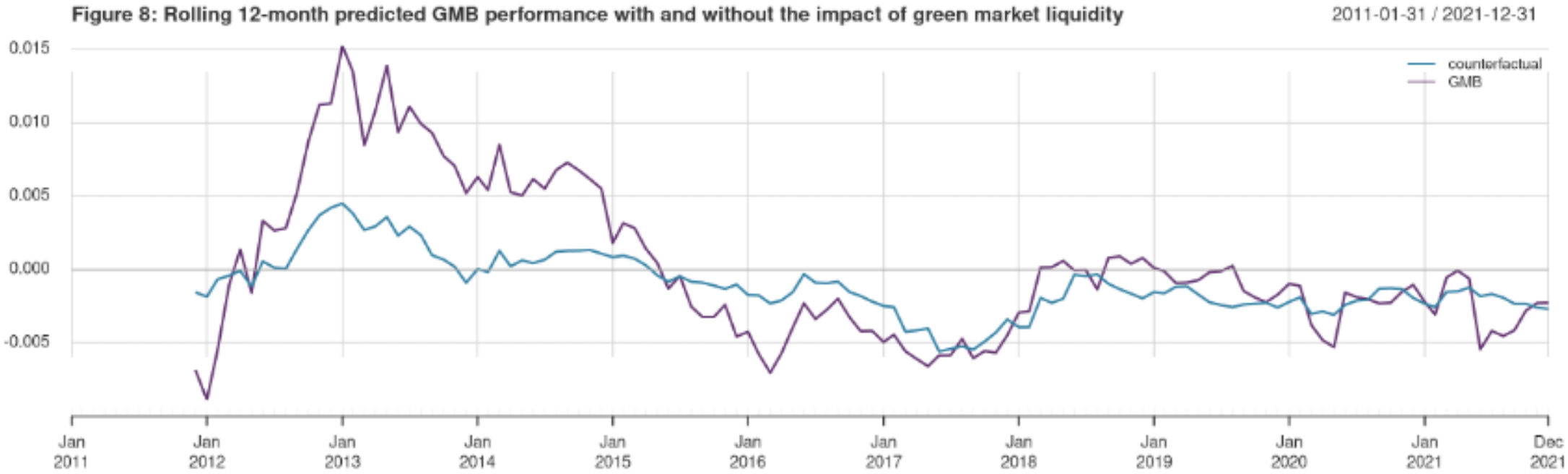
The WACC spread (**green price premium**) between the green and brown power portfolios is consistently negative and growing → in 2021, it has widened to reach almost -350bp from about -100bp a decade earlier.

Green factor or green demand?

If we had this green price premium effect to the regression of GMB returns, it **explains away its negative alpha.**

→Controlling for yield compression – a shift in investor preferences –standard pricing factors do explain the realised performance of the GMB portfolio.

→We predict the returns of the GMB portfolio with the impact of the green price premium and, as a counterfactual, set this effect to zero.



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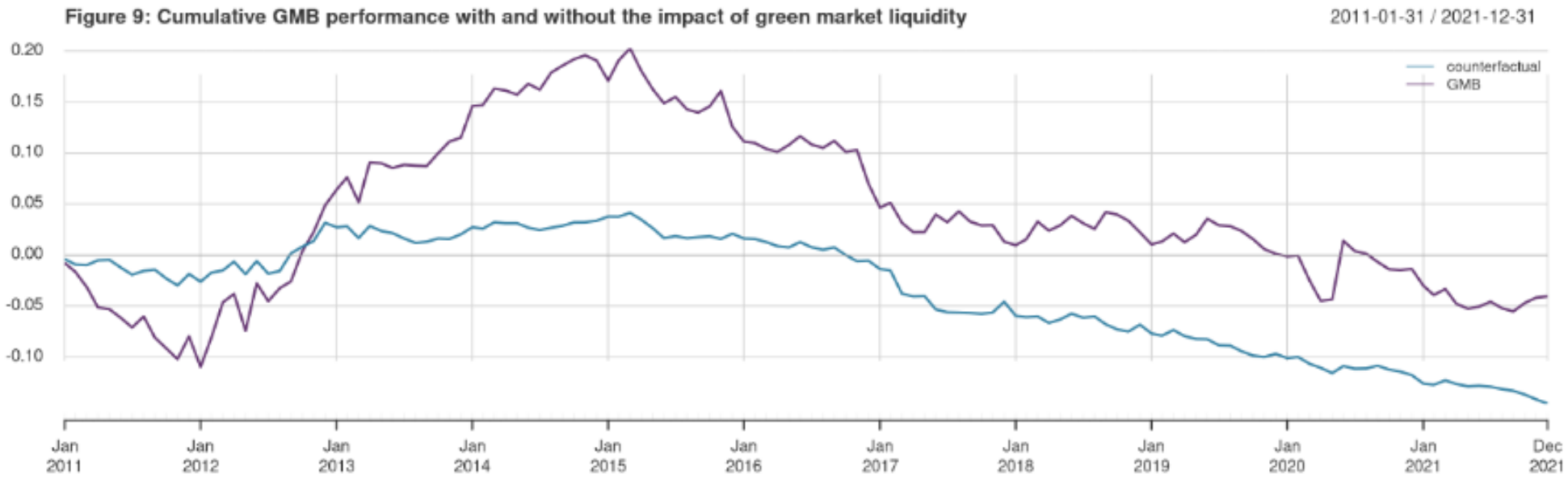


Green factor or green demand?

→ Can we relate yield compression with excess demand?

We build a proxy measure of excess demand for green assets: share of secondary transactions in the global market for investing in green power assets.

- 6,100+ investments made globally in solar and wind power projects by investors in infrastructure between 2011 and 2021 (USD772bn of investment in 922GW)
- Including 2,900+ investments made in the secondary market i.e., they are not new or greenfield projects (545MW of capacity or USD228bn of investment).

(source: inframation)

Green factor or green demand?

Green power liquidity: ratio of the value of secondary transactions (in MW of power or USD invested) to the total value of green transactions (here standardized to have a mean of zero)

Green factor or green demand?

GMB excess returns, the green price premium (GMB WACC spread) and the excess returns of the green leg of the GMB portfolio (infraGreen) are largely related to movements in the liquidity of the market for green infrastructure equity investment.

Regression of the GMB portfolio excess returns, GMB WACC Spread and green power excess returns against the green liquidity index

	GMB Excess Returns			GMB WACC Spread			InfraGreen Excess Returns		
	Beta	SE	p.value	Beta	SE	p.value	Beta	SE	p.value
(Intercept)	0.001	(0.0758)	0.98908	-0.1414	(0.0471)	0.00331	-0.0098	(0.0763)	0.89834
`Green Liquidity Index`	-0.9789	(0.1259)	0	-1.2268	(0.0783)	0	-1.1775	(0.1208)	0
Deg. freedom	115			115			115		
Adj-R2	33.88%			67.85%			44.78%		

Higher green infra liquidity corresponds to

- Lower green realised return
- lower GMB performance
- Lower green price premium (WACC spread)

Conclusions

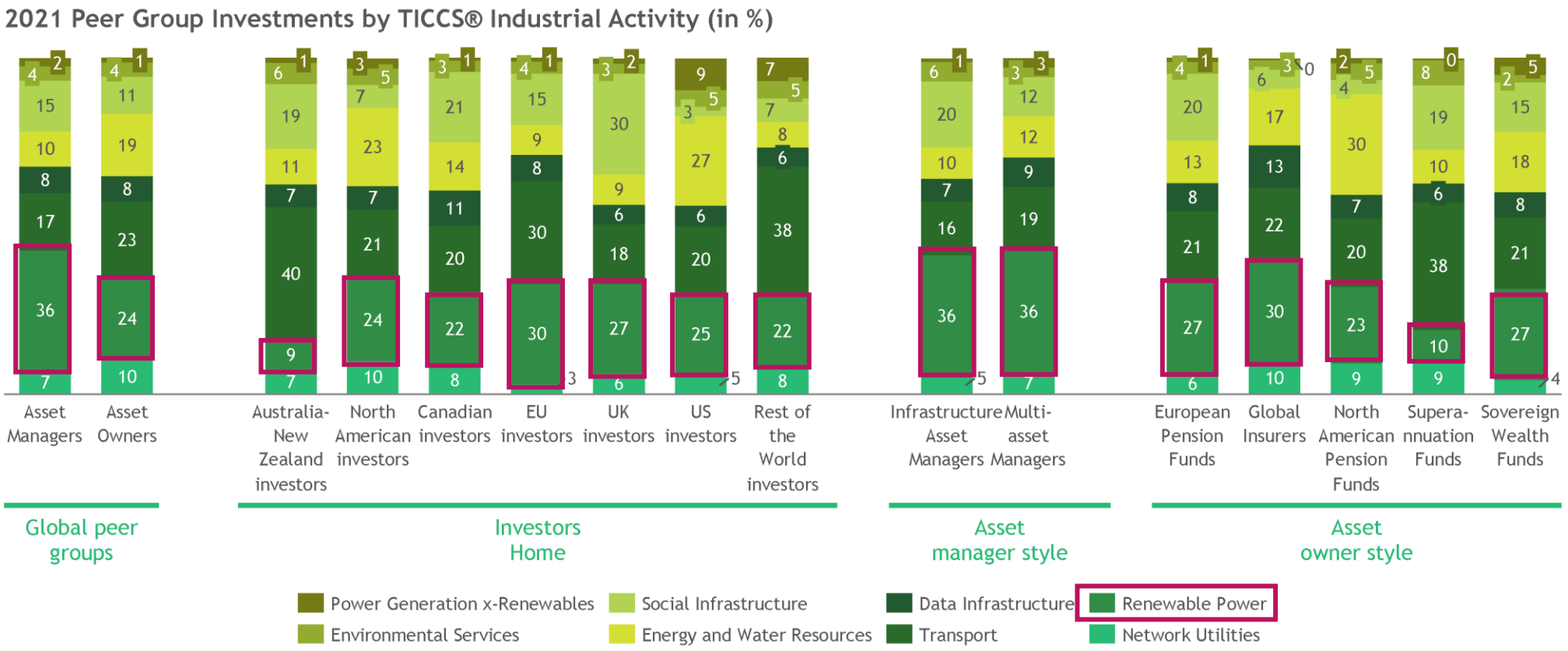
- In 2011, green power projects had expected returns of ~8% and brown power projects ~9%. 10-year annualised total returns in 2021 were 16% and 17% respectively.
- These two figures look close but correspond to very different economic fundamentals.
- High historical performance of green power is explained by a significant compression in yields (expected returns) especially between 2012 and 2015 and the corresponding capital gains.
- The performance of brown power is driven by cash returns and less by yield compression. Brown power investments have seen a small increase in expected returns since 2018.
- The impact on performance of shifts in the demand for green and brown investments **cannot be equated with the appearance of a new 'green' asset pricing risk factor**.
- Instead, demand shocks have led to relatively high realised performance in the green power market but also lower expected returns.

Conclusions

Green infrastructure plays an increasingly important and ubiquitous role in portfolios

→A consensus on the expected returns of green power is increasingly likely and new shifts in demand for such assets less so.

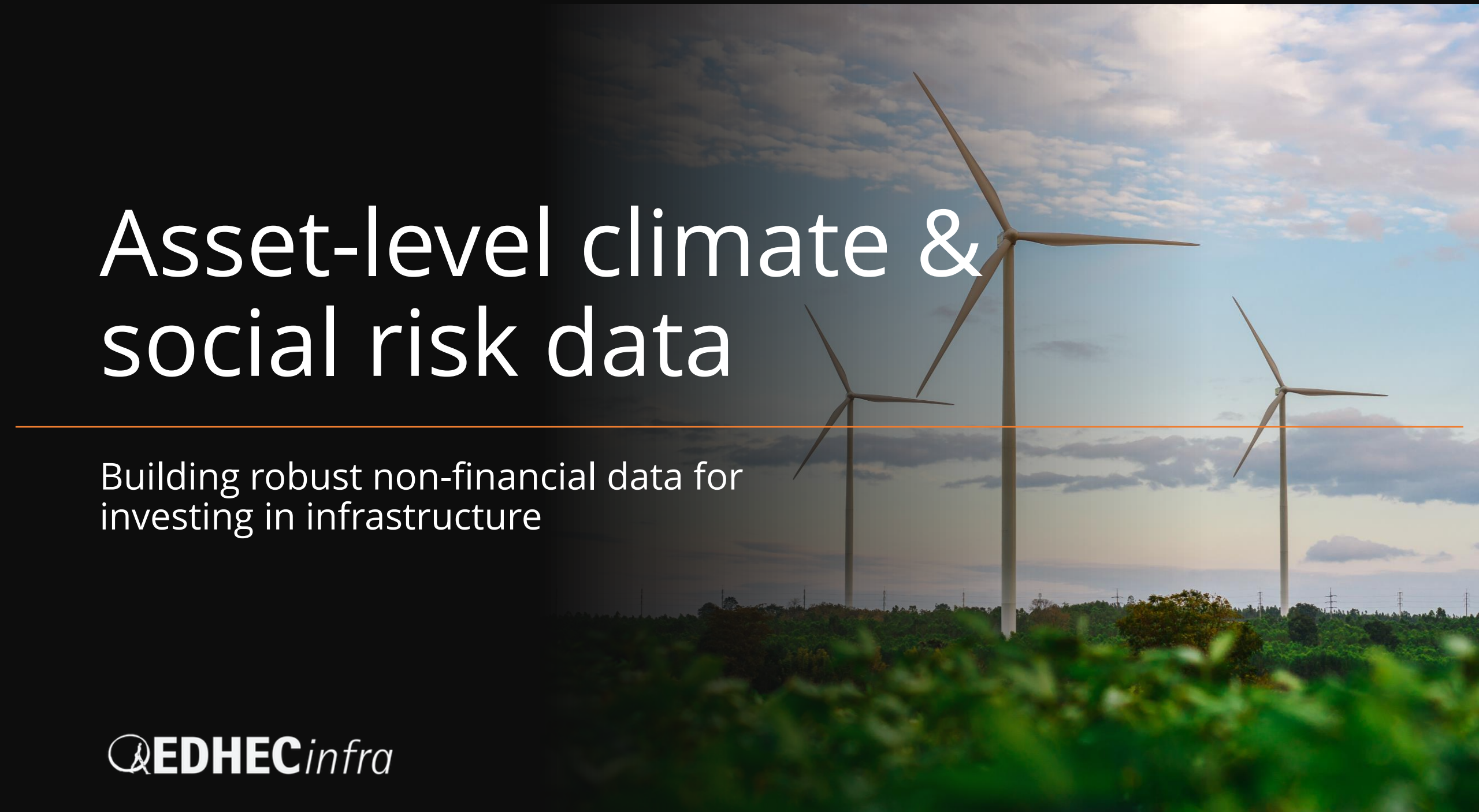
→The GMB WACC spread has been flat since 2019.



Source: EDHECinfra, infraMetrics® 2022

Asset-level climate & social risk data

Building robust non-financial data for investing in infrastructure



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Green InfraMetrics

Contents

1. Motivation
2. Transition Risks
3. Physical Risks
4. Break
5. Social acceptability risks
6. Conclusions and discussion

Green InfraMetrics

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1. **Motivation**
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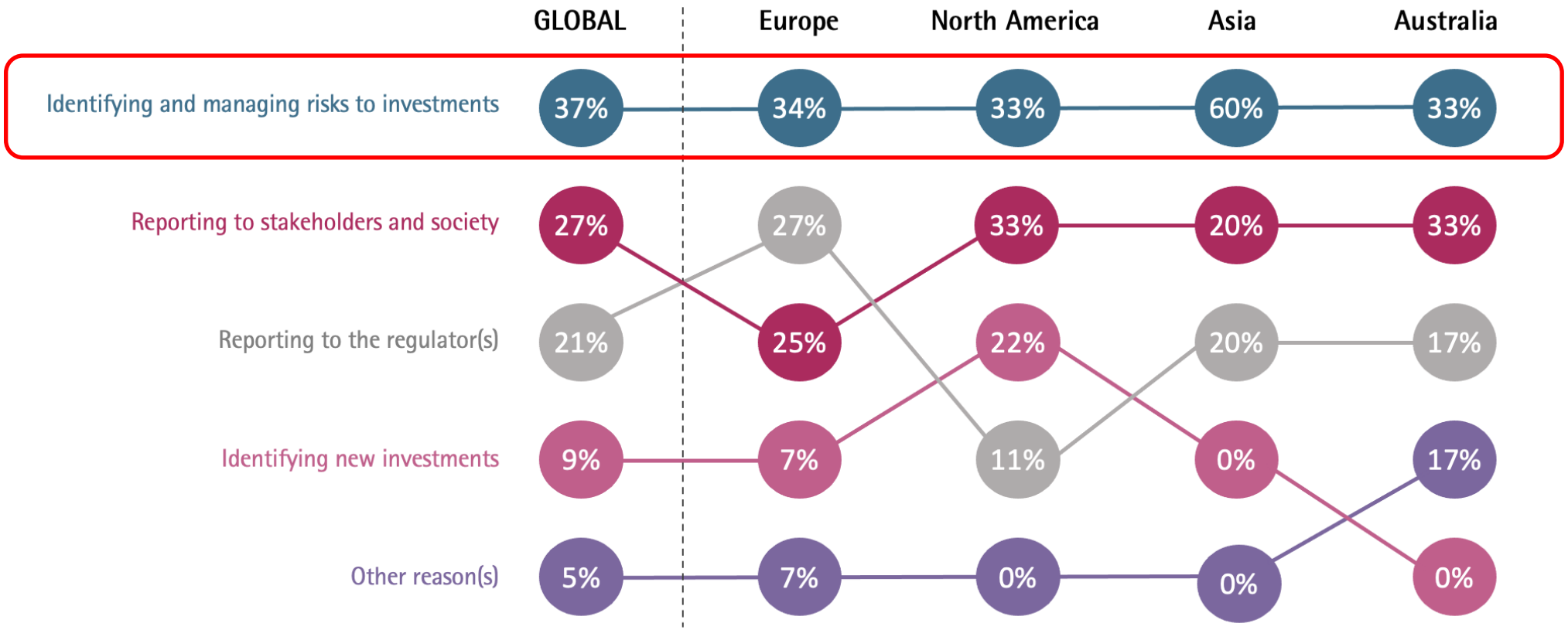
Green InfraMetrics

Motivation: What ESG use cases matter to infra investors?

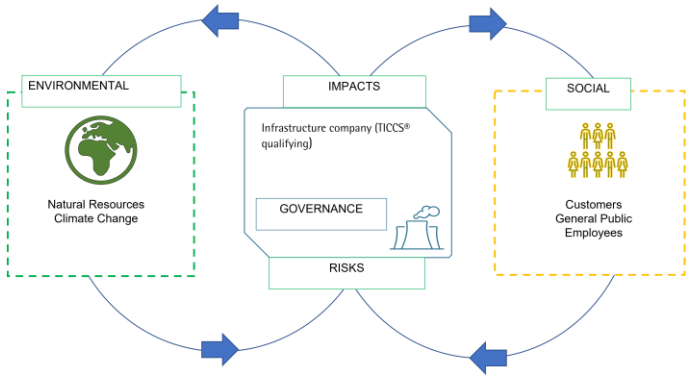
- Risk management is the main driver of the demand for ESG data
  - *Information about ESG risks is not priced nor reflected in market prices*
  - *Regulatory reporting will become the main driver of the demand for ESG data*

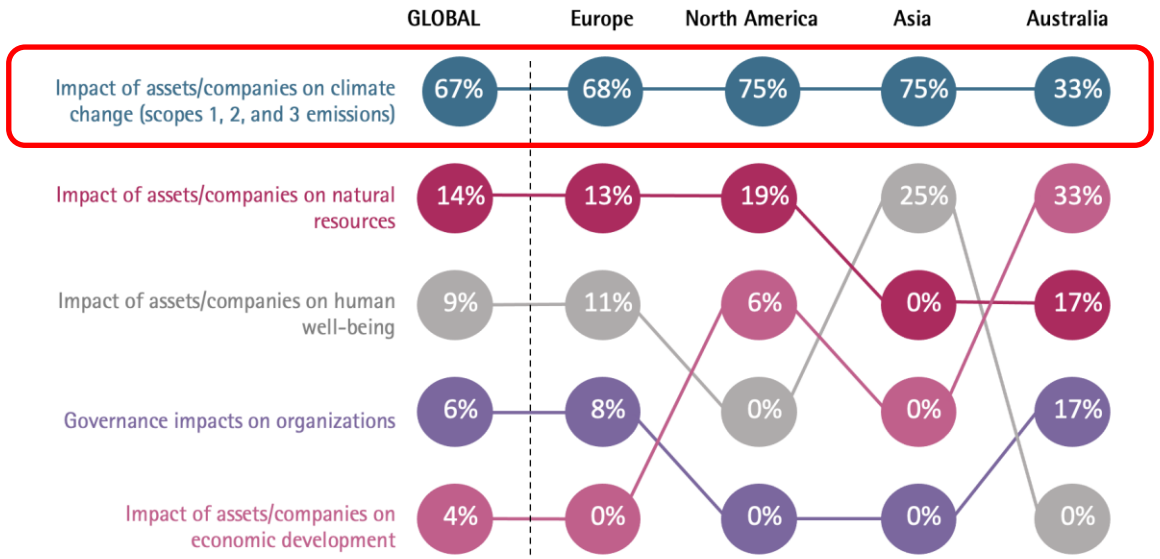


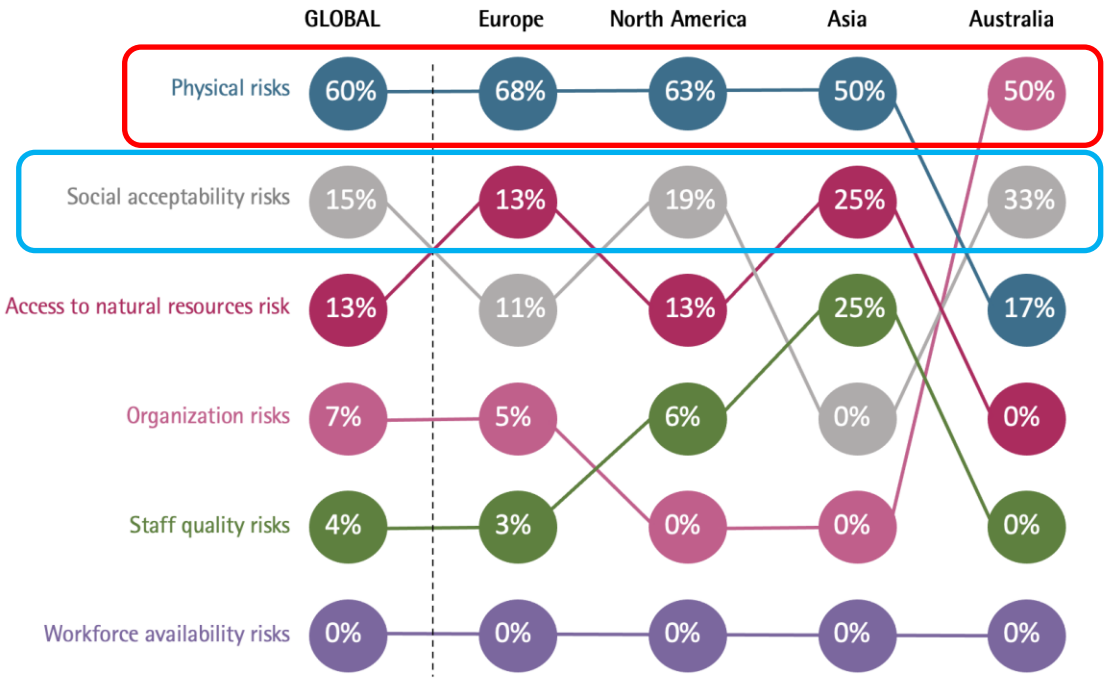
Green InfraMetrics

Motivation: What kind of ESG data do investors need?

- Investors are mainly concerned about climate impact and physical risks
  - *This reflects the double materiality nature of ESG characteristics*
  - *Social acceptability risks also play an important role on ESG data demand*



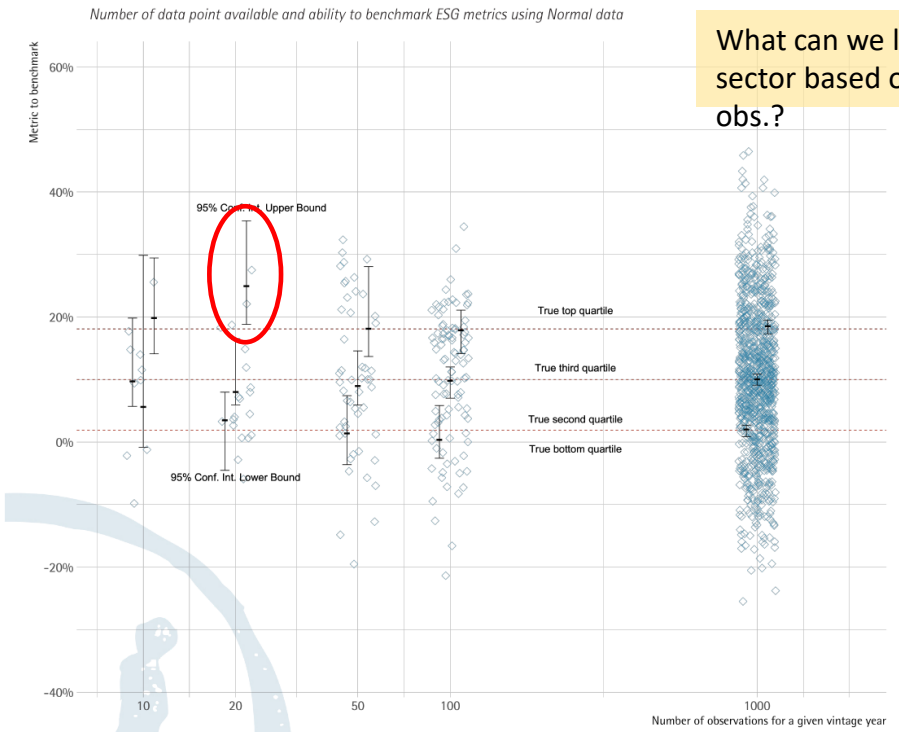




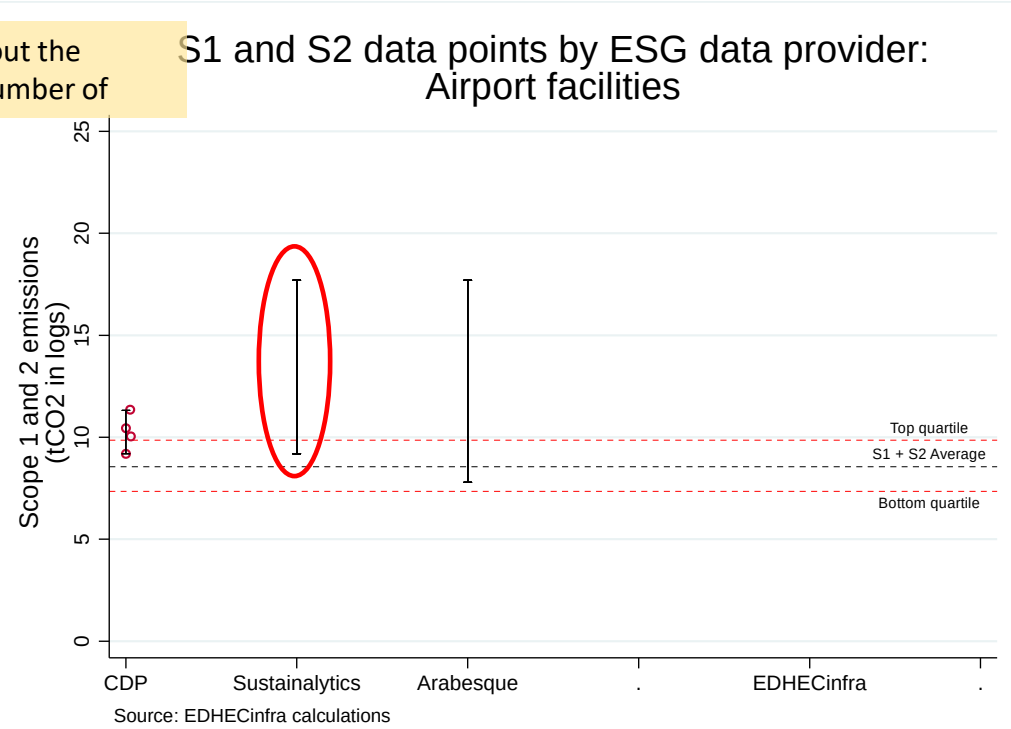
Green InfraMetrics

Motivation: What infrastructure ESG data is in the market?

- There is not enough ESG information for risk management
  - *Most ESG data providers only cover a few infrastructure sectors (mostly services)*
  - *With a few observations per type of asset to benchmark ESG factors (e.g., true mean, true quartiles, true variance)*
  - *There is no information on social acceptability risks*



What can we learn about the sector based on this number of obs.?



Green InfraMetrics

Motivation: EDHECinfra's ESG solution

EDHECinfra is developing the most comprehensive ESG analytics service for investors in infrastructure

- ✓ Initial focus on Transition Risks, Physical Risks, and Social Acceptability Risks
- ✓ Large coverage across all infrastructure sectors
- ✓ Complementing the existing InfraMetrics (800^{+} infrastructure companies)

It is possible to develop these metrics by combining:

- ✓ Big data (e.g., satellite images, open street maps, article news, Wikidata)
- ✓ Contributed data (e.g., construction specifications, company's electricity usage)
- ✓ ML methods (e.g., Natural Language Processing, Sentiment Analysis, Regression)

Green InfraMetrics

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1. Motivation
2. **Transition Risks**
3. Physical Risks
4. Break
5. Social acceptability risks
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1. Asset-level carbon emissions
2. Carbon emission of airport facilities
3. Estimation strategy for S1 and S2
4. Estimation of Scope 3 emissions

Green InfraMetrics

Transition risks in infrastructure: Asset-level carbon emissions

- Financial risks will arise from adjusting to a lower-carbon economy
  - *Policy and regulatory risks e.g., carbon tax*
  - *Technological risks (e.g., use of lower emissions options)*
  - *Market risks (e.g., change in demand for products and commodities)*
  - *Reputational risks (e.g., shareholder, consumer, or investor concerns)*

- The EU regulation and other sustainability-related regulations will increase the need for transition risks metrics
  - *Many companies and sectors are adhering to the GHG protocol, TCDF, SBTi, NZAOA, and other initiatives*

- Transition risks are proportional to the climate impact of assets/companies. Carbon emissions are the best proxy of climate impact
  - *Scope 1 emissions (Direct GHG emissions)*
  - *Scope 2 emissions (Indirect GHG emissions)*
  - *Scope 3 emissions (Other indirect GHG emissions)*

Green InfraMetrics

Transition risks: Carbon emissions of Airport facilities

- The **commercial aviation** industry have seen steady increase in emissions since 2009, going from 633 MTons to 905 Mtons of CO_2 in 2019 (pre-covid)

- Airports which provide the infrastructure for aircrafts and passengers (or cargo) also have growing emissions.
  - *The ACI (Airports Council International) represents 1,950 airports and has committed to reach net zero emissions by 2050*
  - *The Airport Carbon Accreditation (the only institutionally-endorsed, global carbon management certification program for airports) has only certified 149 airports*
  - *CDP, Arabesque, and GRESB have carbon emission information for only a few airports (between 5 and 50)*

- **Airports are getting more exposed to transition risk**:
  - *Directly through their own emissions (e.g., terminals, in-site operations)*
  - *Indirectly through the exposure of airline companies*

Green InfraMetrics

Transition risks: Carbon emissions of airport facilities

Scope 1: direct emissions from facilities and vehicles

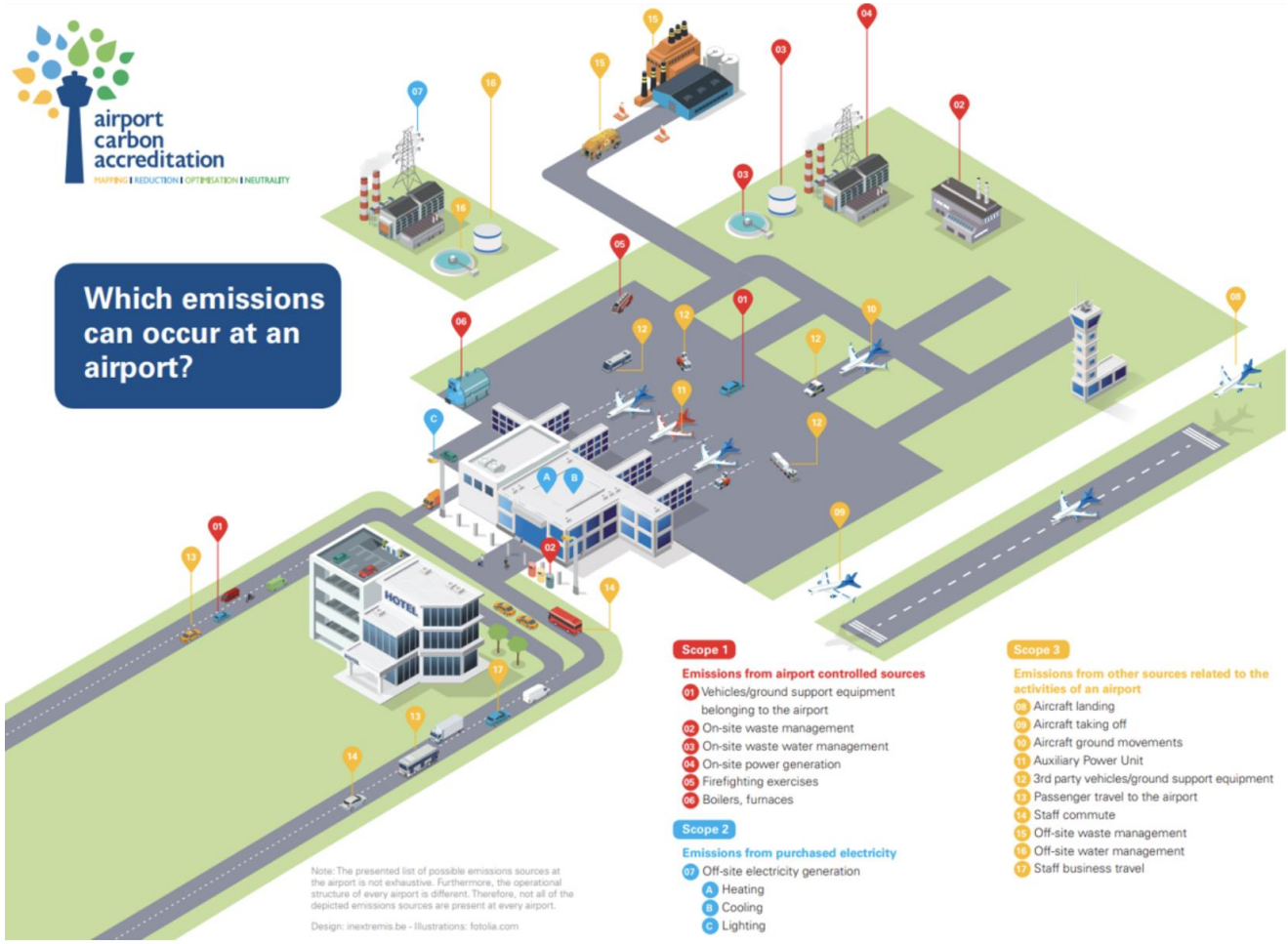
- *E.g., natural gas or oil combustion for heating (boilers), airside vehicle emissions during operations.*

Scope 2: indirect emissions from electricity purchase

- *E.g., for cooling, ventilation, lighting of terminal buildings.*

Scope 3: indirect emissions from upstream and downstream activities

- *E.g., aircraft cruise emissions, their LTO cycle, the use of landside vehicles, employee and passenger commutes.*



Source: Airports International Council

Green InfraMetrics

Estimation of carbon emissions of airport facilities: S1 and S2

Estimation strategy

1. Sustainability Reports (dependent variable)
2. Big data (observable regressors)
3. Regression models (Based on scientific lit.)
4. Emissions predictions

There is scientific research on sector carbon emissions and ways to estimate it

- *Big data and reported data are critical for this task*

✓ Minkyung Kang, Mario Bergés, Burcu Akinci. ***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, Vol 2603, Issue 1, 2017

✓ Xianliang Gu, 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

✓ Sang-Chul Kim, Hyun-Ik Shin, Jonghoon Ahn. ***Energy performance analysis of airport terminal buildings by use of architectural, operational information and benchmark metrics***. Journal of Air Transport Management Volume 83, March 2020, 101762

✓ Bo Li, Wen Zhang, Jianping Wang, Junku Xu and Jixiang Su. ***Research and Analysis on Energy Consumption Features of Civil Airports***. IOP Conf. Series: Earth and Environmental Science, Vol. 94, 2017 3rd International Conference on Energy, Environment and Materials Science (EEMS 2017) 28–30 July 2017, Singapore

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Estimation of carbon emissions of airport facilities: S1 and S2

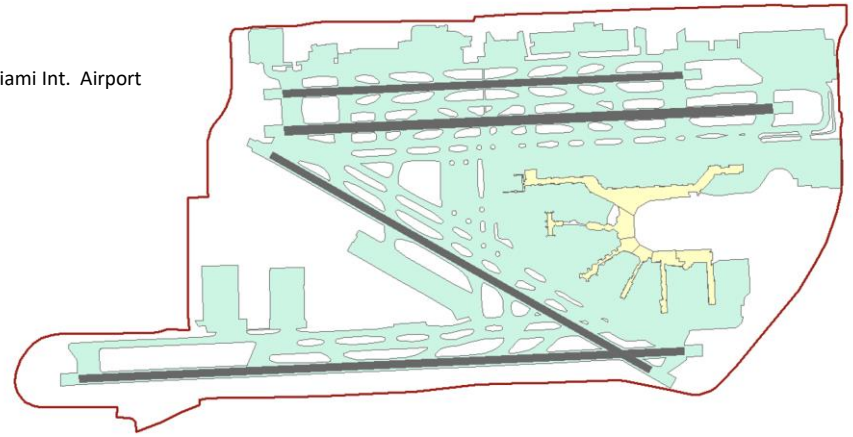
$$Scope_i = \propto + \sum_k \beta_k x_k + \varepsilon_i$$

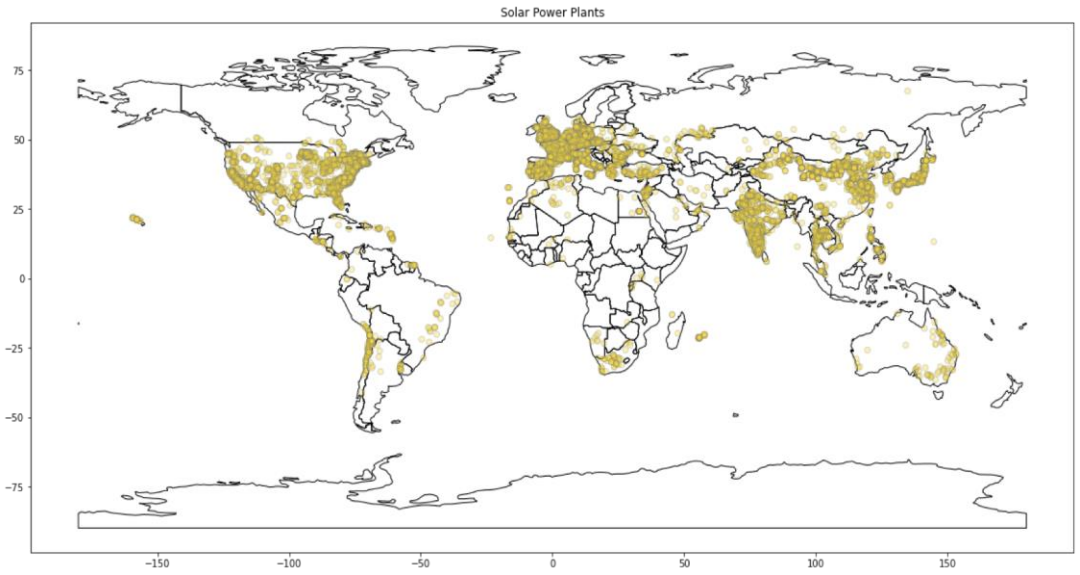
$$\vdots$$

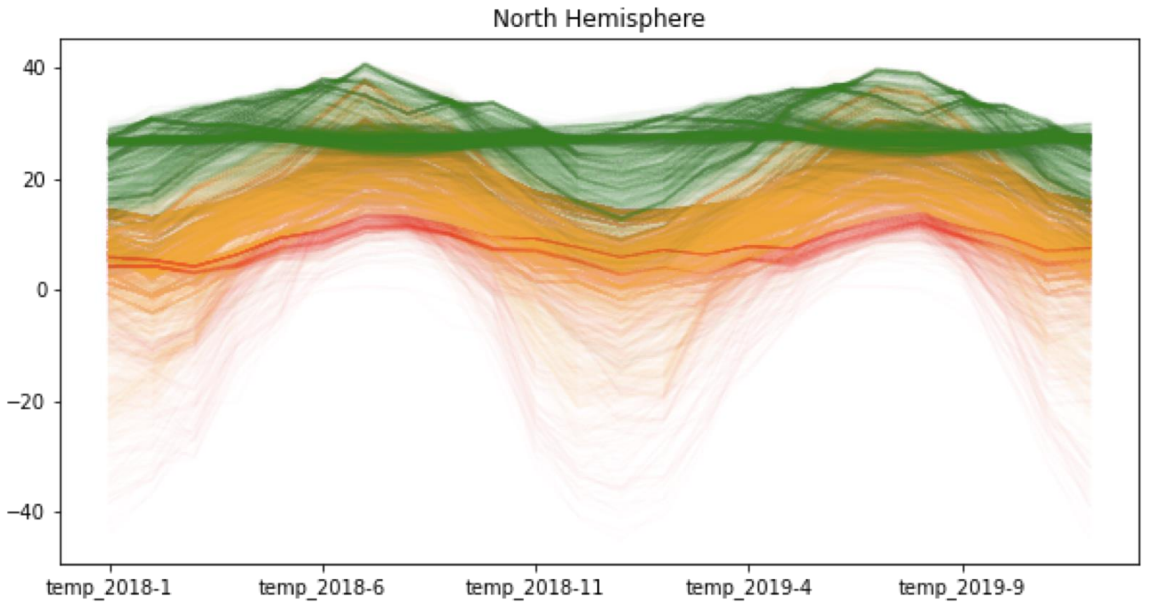
$$where\ x_k\ are\ regressors$$

$$i = 1, 2$$

Miami Int. Airport







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S1 and S2 emissions of airport facilities: Model identification

- Only airports with publicly reported data in sustainability reports were used to identify the right model
- ~10k model configurations (i.e., combinations of potential regressors) were assessed in terms of R^2 and regressors' p-values to identify the best regression model specification
- Predictions are based on best regression model specification

	Scope 1	Scope 2	Scope 1 + 2
# of Data Points	55	52	53
R^2 best fit	0.379	0.221	0.380

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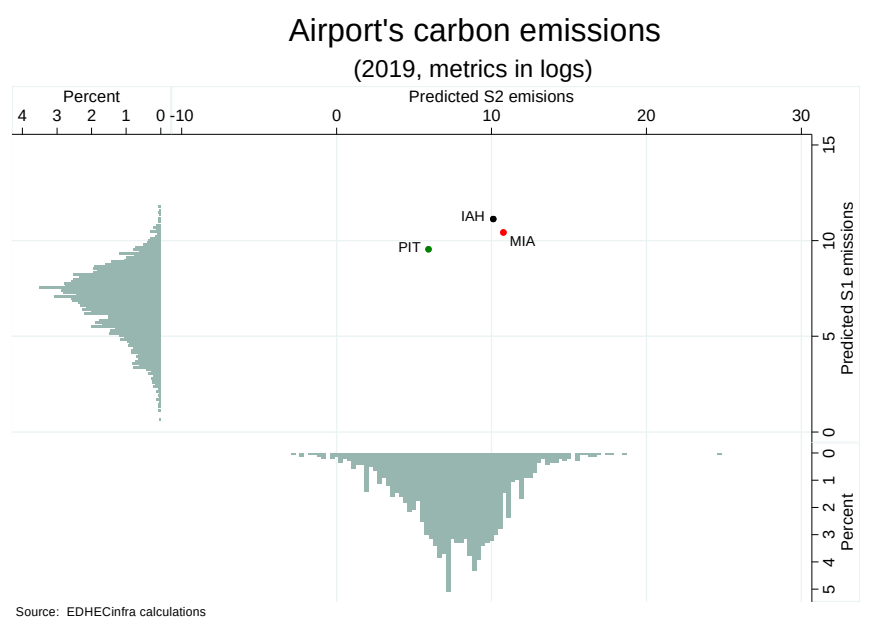
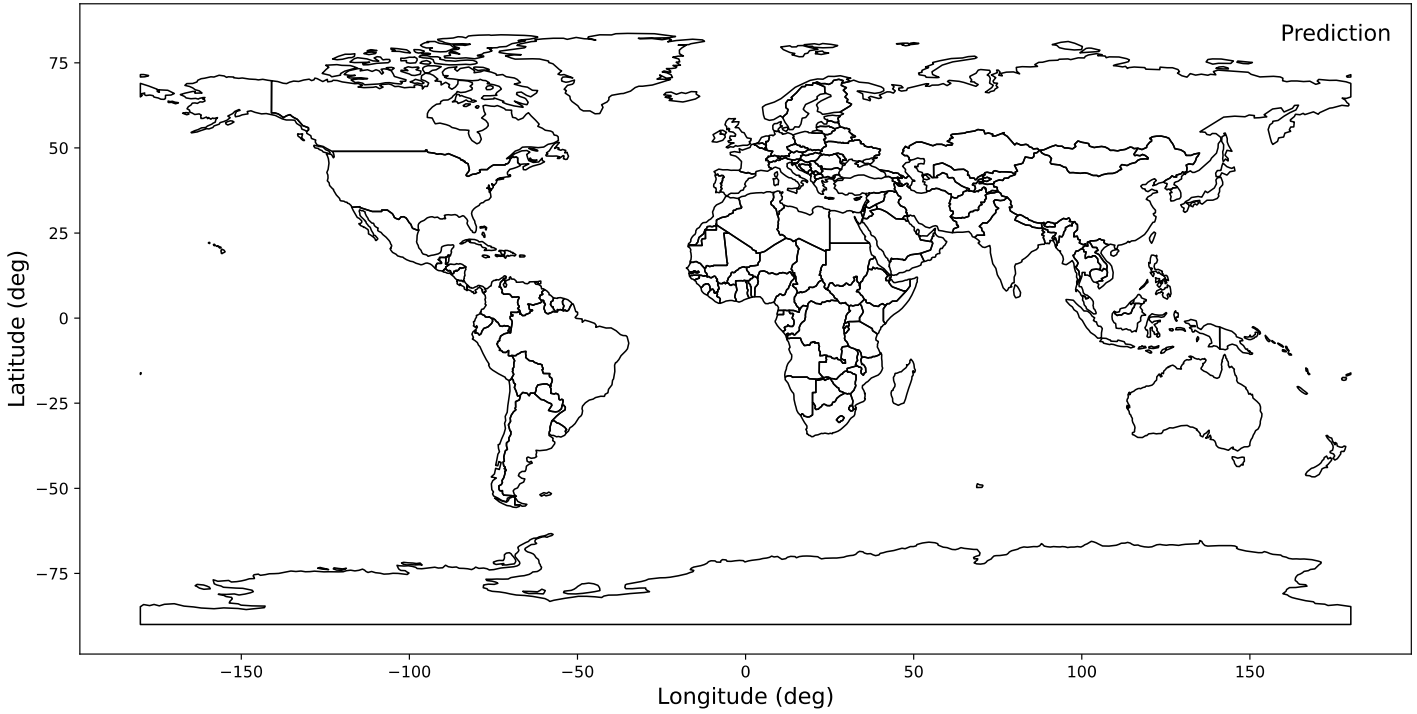
S1 and S2 emissions of airport facilities: Model prediction

- Scope 1: ~3500 airports; Scope 2: ~ 1600 airports; Scope 1+2: ~3200 airports globally
- Estimations allow for benchmark and distribution analysis, market segmentation (e.g., country), and intensity metrics generation





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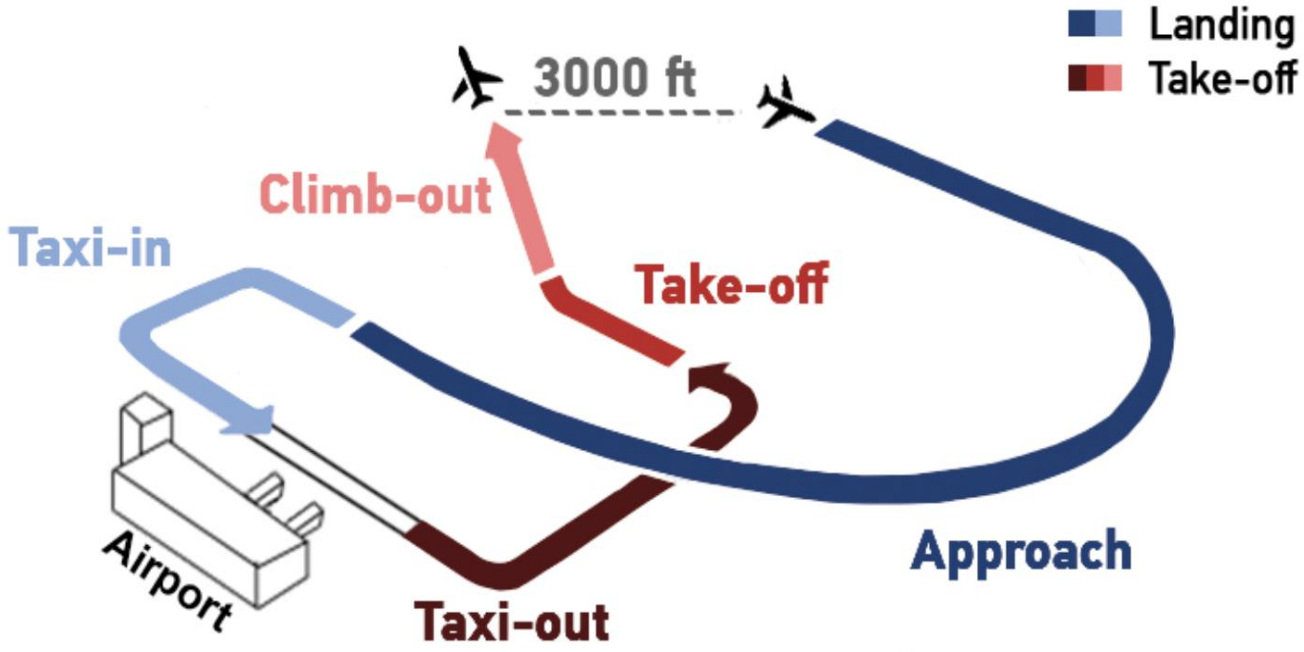
Estimation of scope 3 emissions: Airports

Physical estimate (not a statistical approach)

- *A few airports report scope 3 emissions (~30 publicly)*
- *Airports (except Heathrow) do not report scope 3 emissions from cruise*
- *Flight information in almost real-time (big data) is available*

Two approaches to model scope 3 emissions:

- *Cruise emissions from flights (OAG data), attributed to departing airport.*
  - ***Distance-based** approach with a distinction between aircrafts*
- *Landing and Take-off (LTO) cycle emissions*
  - ***Time-based** approach with a distinction between aircrafts*



- *S3 estimates (not prediction) were made for 8000+ airports*
- *Monthly, quarterly, yearly estimations are possible*

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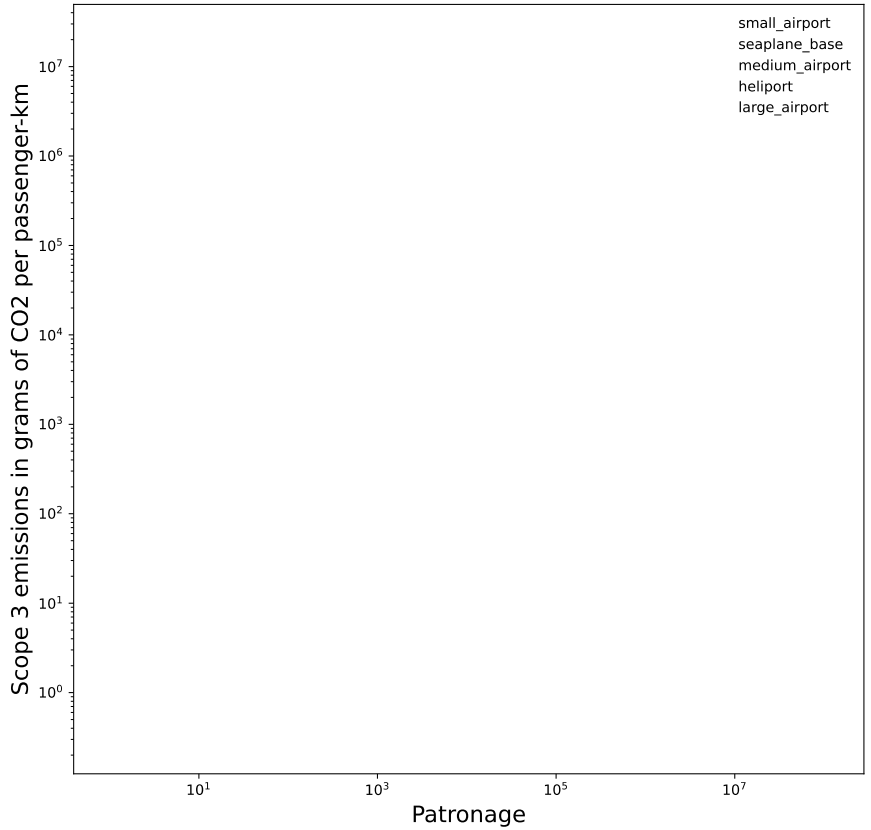
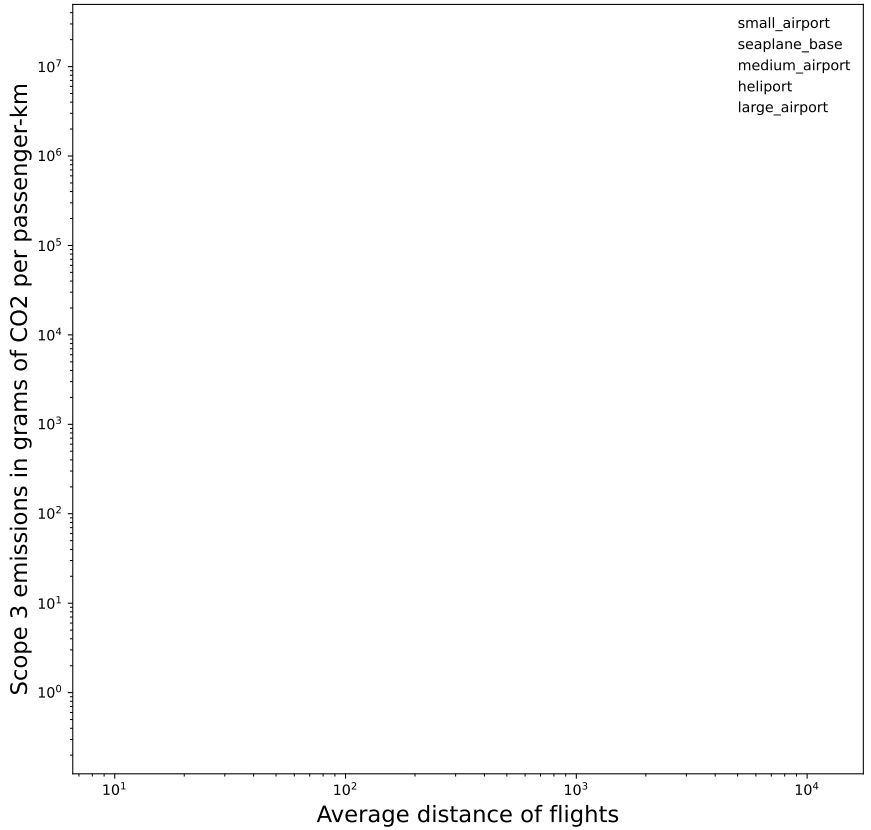
S3 calculations: Result for 8000+ airports globally

- Airports with large number of passengers tend to be more efficient than smaller airports



- Long distance flights tend to be more efficient in terms of emissions per pax, but the is picture is less clear for small airports



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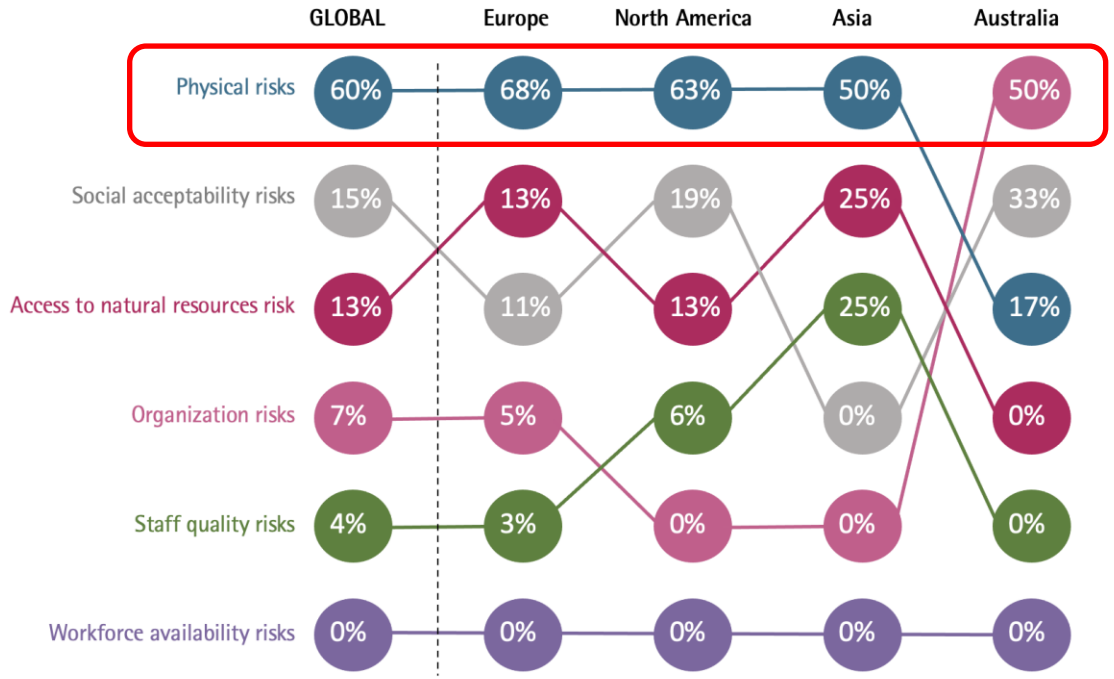
Physical risks: Assets' exposure to physical risks

TCFD recommendations:

- Physical risks may have financial implications for organizations (e.g., direct damage to assets, supply chain disruption)
- Organizations' financial performance may also be affected by physical risks (e.g., water availability, extreme temperature changes)

Investors identify physical risks as the main ESG risks

- EDHECinfra is looking at several types of hazard models (e.g., flooding, sea-level rise, storm, heat stress, earthquake)
- Damage factors for more than 21 infrastructure asset-types



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Estimation of airports' exposure to flood risk

Modeling strategy

1. Asset identification (Asset polygon footprint)
2. Flood hazard models (1:30, 1:50, 1:100 return periods)
3. Identification of damage factors (Based on scientific lit.)
4. Flood damage factor calculations

There is engineering research about damage functions for different types of hazards and asset-types

- *Big data and reported data are critical for this task*

- ✓ Habermann, N., & Hedel, R. (2018). ***Damage functions for transport infrastructure***. International journal of disaster resilience in the built environment, 9(4/5), 420-434.
- ✓ Kok, M., Huizinga, H. J., Vrouwenfelder, A. C. W. M., & Barendregt, A. (2004). ***Damage and casualties caused by flooding***. Highway and Hydraulic Engineering Dept., Delft, Netherlands.
- ✓ Van der Sande, C. (2001). ***River flood damage assessment using IKONOS imagery***. EC Joint Research Centre & SAI, Ispra, Italy, 77.
- ✓ Meyer, V., & Messner, F. (2005). ***National flood damage evaluation methods: a review of applied methods in England, the Netherlands, the Czech Republik and Germany***. UFZ Discussion Papers 21/2005 (2005).
- ✓ Kok, M. et al. Standard Method 2004 Damage and Casualties by Flooding. Standaardmethode 2004 - schade en slachtoffers als gevolg van overstromingen. DWW-2005-005, RWS Dienst Weg- en Waterbouwkunde

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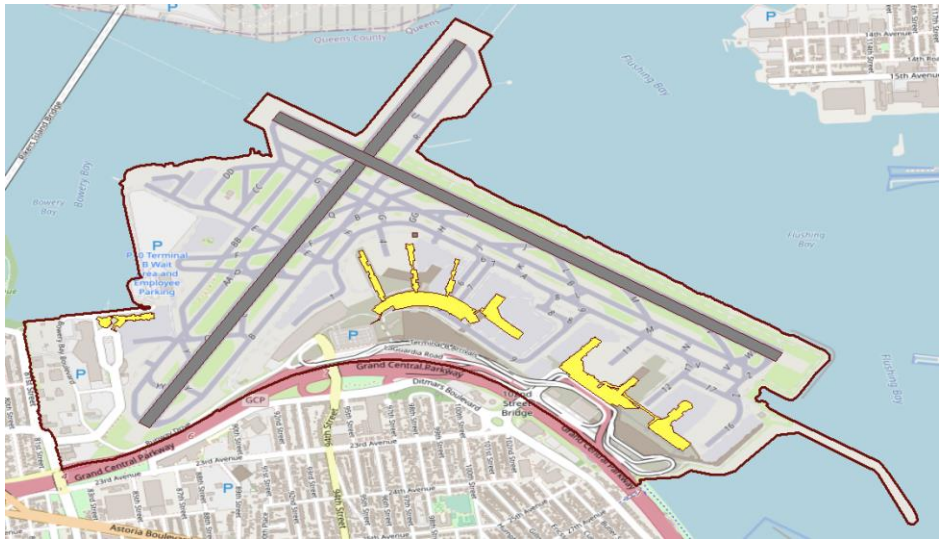
Airports' exposure to flood risk: Asset identification

Knowing the precise location of assets and and their components is critical for a precise damage assessment, specially in the case of flooding

- *Terminals, runways, and other airport facilities' components in the USA were identified (i.e., not as images, but as objects) using Open Street Maps and Geographical Information Systems*
  - *3500⁺ aerodromes*
  - *1300⁺ terminal buildings,*
  - *14000⁺ runways*

Chicago Int. Airport, IL



La Guardia, NY

Austin–Bergstrom International Airport, TX

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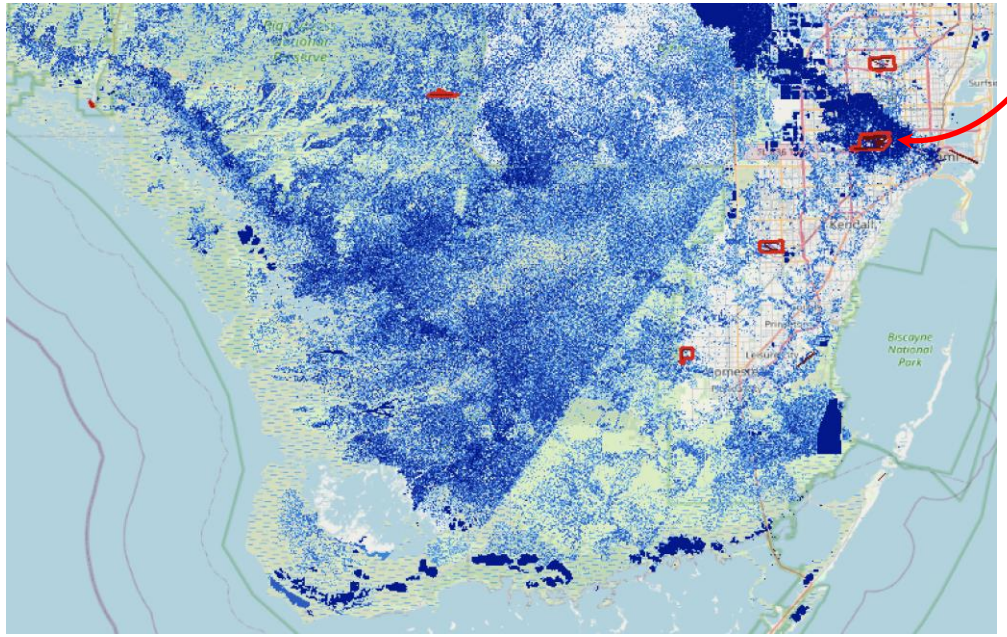
Airports' exposure to flood risk: Flood hazard models

Flood hazard models considering

- *Pluvial and fluvial flood sources*
- *30 m^2 resolution globally*
- *30; 50; and 100 years return periods*

Miami Int. Airport

1:50 years return period



Bangkok's Don Mueang Airport, 2011
(Estimated 10 to 20 years return period flood event)

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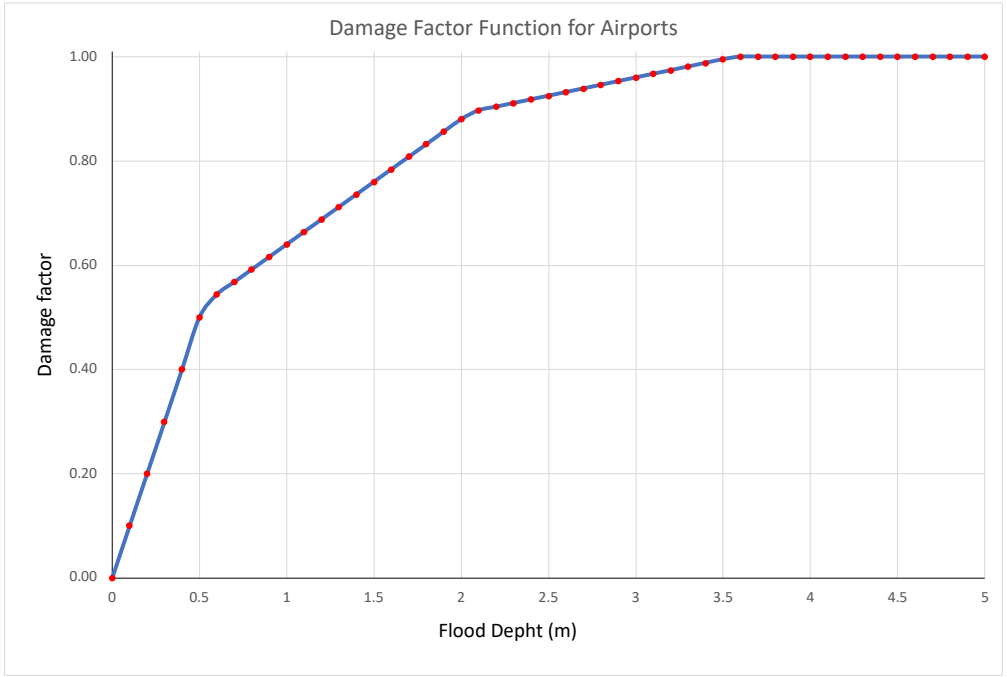
Airports' exposure to flood risk: Damage factors

We applied the flood damage function for airports proposed by the Hydraulic Engineering Institute of the Netherlands' Ministry of Transport, Public Works and Water Management (2005)

- *Calculations for all airport facilities in the USA*
- *Using a 50 years return period model*

Flood Depth Band	Description
1	Up to 10cm
2	10 – 50cm
3	50 – 100cm
4	100 – 150cm
5	150 – 200cm
6	200 – 300cm
7	300 – 500cm
8	Greater than 500cm
100	Lakes & Waterbodies



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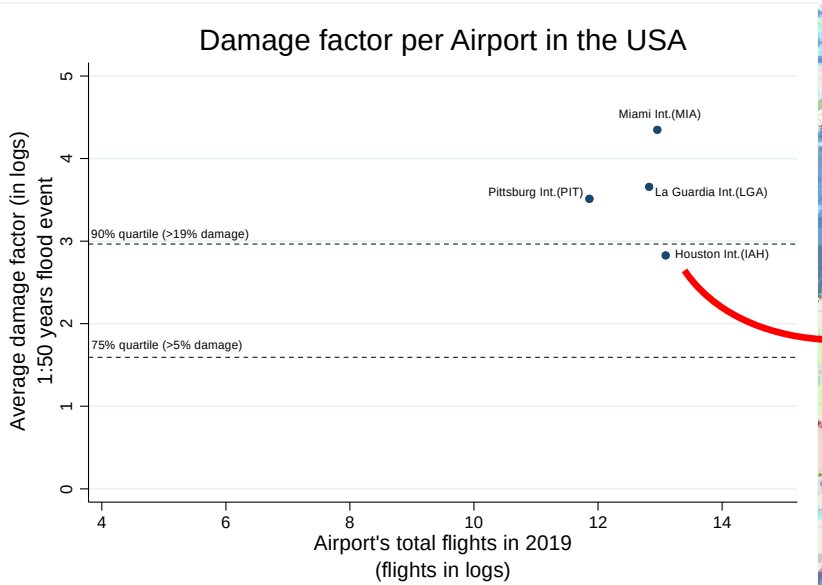
Airports' exposure to flood risk: Results

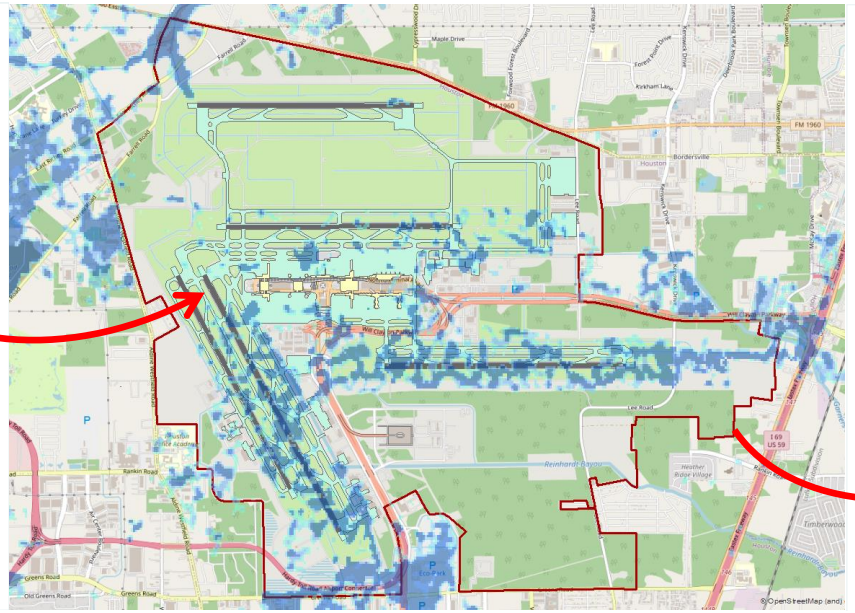
Combination of asset identification + hazard models + damage functions to estimate exposure to physical risks

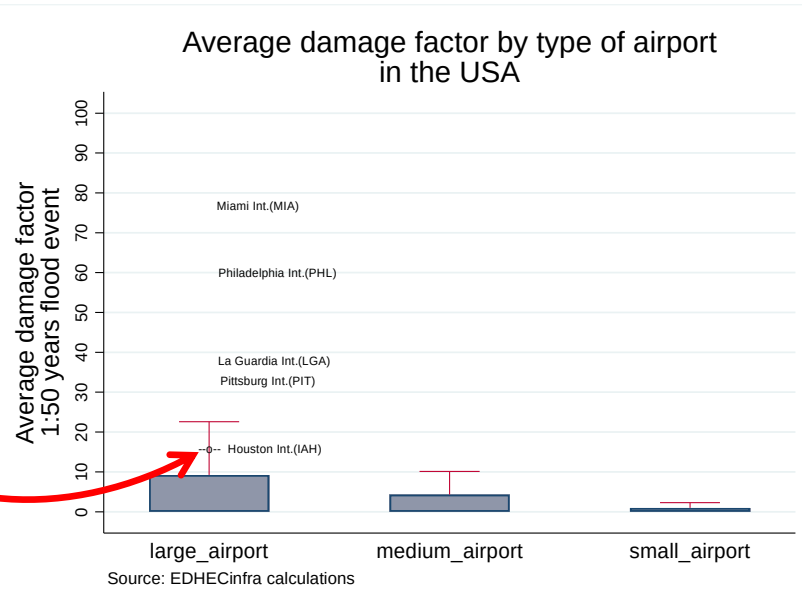
- More than 100k assets have been identified, including 46k polygons for airports, solar farms, and windfarms
- More than 5 types of hazard models (e.g., flooding, sea-level rise, storm, heat stress, earthquake)
- Damage functions for 21 asset-types`

Flood damage functions for ~500 airports in the USA
50 Airports in the USA are in the 90% percentile



Houston Int. Airport (IAH)





Source: EDHECinfra calculations

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   4. Use cases

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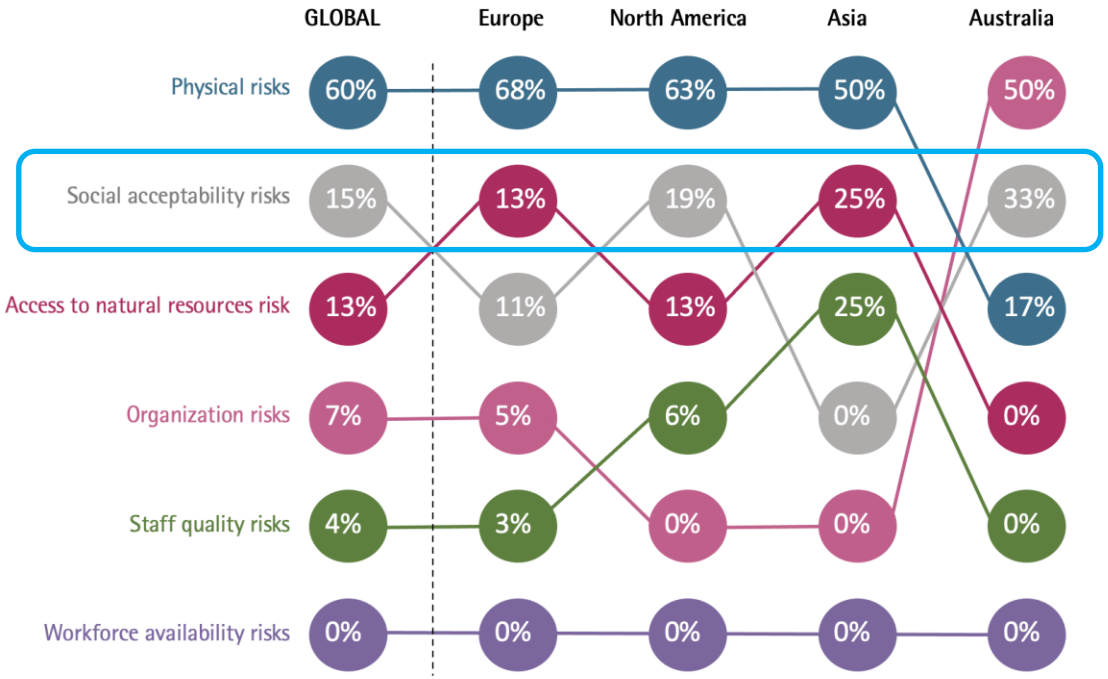
Social acceptability risks

- Infrastructures require social license to operate (i.e., acceptance from the society)
- Failure to obtain social acceptance can result in additional expenses during project construction and operation, and it could also lead to project cancellations

- *In the United Kingdom the HS2 rail project has reported to parliament that protests have cost it £200m (Plimmer & Pickard, 2022).*

- *The East West Link road in Melbourne was cancelled protests and a lack of support for the project (Alcorn, 2015) despite contracts being agreed. (Victoria Auditor Generals Office, 2015) found that this cancellation cost Victorian taxpayers AUD$1.1 billion.*

Investors identify social acceptability risks as a main ESG-related risk factor



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Assessing social acceptability risks: Sentiment Analysis

- Public opinion surveys have been widely used to measure societies' opinions on several topics
  - *Surveys are time-consuming and expensive to conduct*

- Nowadays there are large collections of textual data online (e.g., social media and news) expressing opinions from the public about products and services
  - *This data can be mined to understand and assess social acceptability more efficiently and at a lower cost*
  - *Using sentiment as a proxy for the level of public acceptance*

- **Sentiment analysis** involves classifying the polarity (i.e., positive, neutral, or negative) of a given text at the at the document-, sentence-, or feature/aspect-level

- There are two main approaches to Sentiment Analysis:
  - *Lexicographic approach: involves dictionaries or phrases with their corresponding polarity valence*
  - *Statistical approach: involves constructing statistical models that 'learn' the polarity of the text passage*

- *We are following the lexicographic approach (first phase)*

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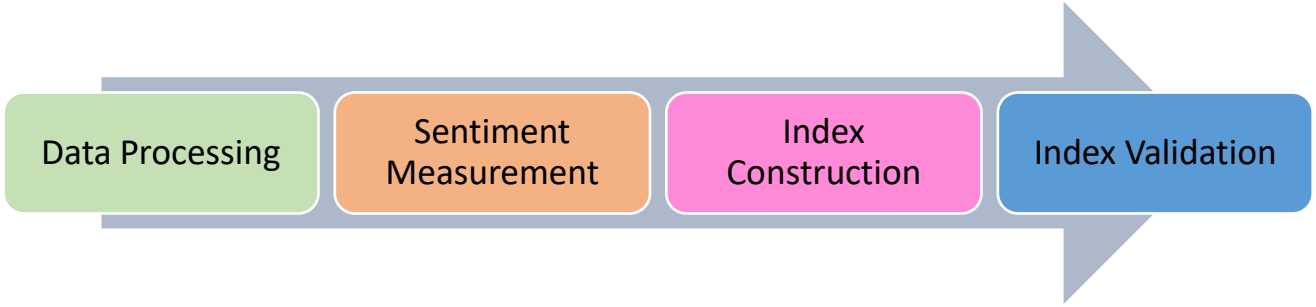
Sentiment Analysis process



- ✓ The analysis uses 25 years of article news in English
  - *UK, AUS, CAN, NZ, and USA*
  - *now expanding to other languages*
  - *The analysis only includes news articles including ESG related topics*

- ✓ Sentiment Analysis can be applied to all asset-types
  - *preliminary results for windfarms*
  - *preliminary results include sentiment indices from 2005 onwards*

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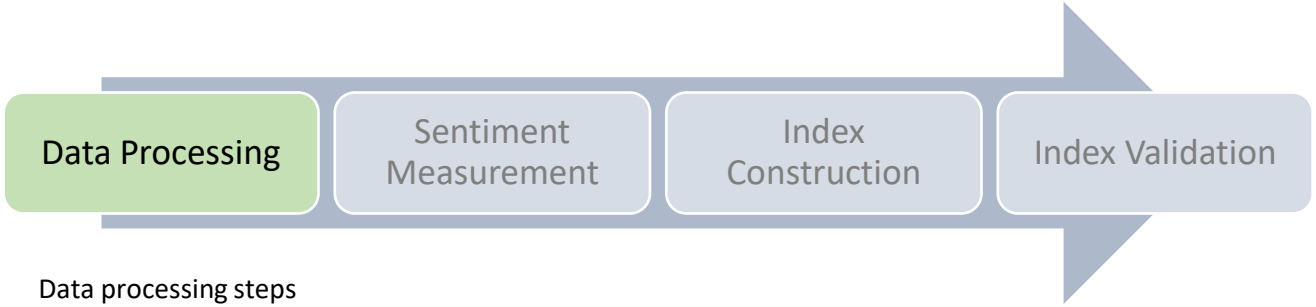
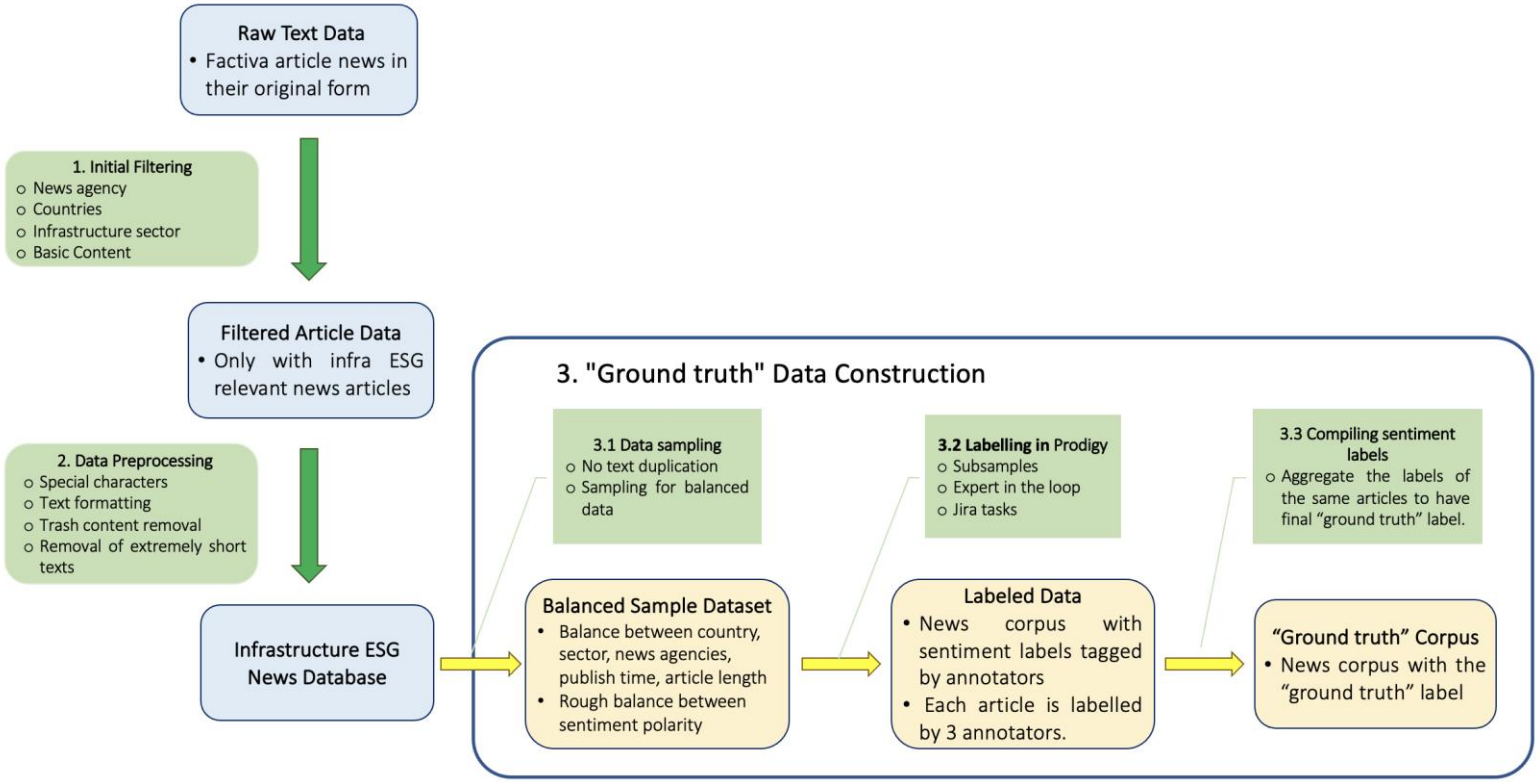
Sentiment Analysis process: Data processing



Data processing steps



A "**ground truth**" dataset is critical to validate Sentiment Analysis results

1. Text for annotation is sampled from the news database
   - *The sample must be balanced over multiple aspects (e.g. countries, news sources, publication years, article length)*

2. Human annotators read and label article news as either positive, neutral or negative
   - *3 or more annotators per news article*

3. Article news where annotators agree on their implicit sentiment become part of a "ground truth" dataset

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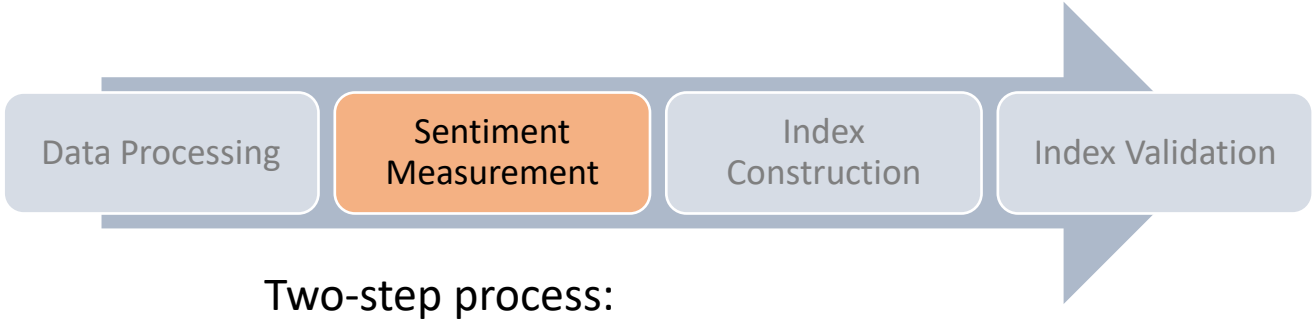
Sentiment Analysis process: Sentiment measurement



Two-step process:

1. Follow the Shapiro, Hale, Sudhof, and Wilson (2020) approach
   - *Measure the sentiment of a set of text based on the sentiment of the words contained therein*
   - *Use current sentiment lexicons containing sentiment words and negation rules to develop a model*
   - *Compute the sentiment scores of the words in the articles*
   - *Compute the article sentiment scores by averaging words' scores*
   - *Keep article scores for comparison with results from step 2, and to create the sentiment index*

2. Develop a Machine Learning model to measure the sentiment of news articles
   - *Use sentiment-labeled text data to build a model that "learns" how sentiment is expressed*
   - *Once the model is created, estimate the sentiment (S(a)) of each news article in the ESG news database*
   - *Compare the results from the Machine Learning model with the results from the lexicon approach (step 1)*

- *For the initial development, we follow step 1*

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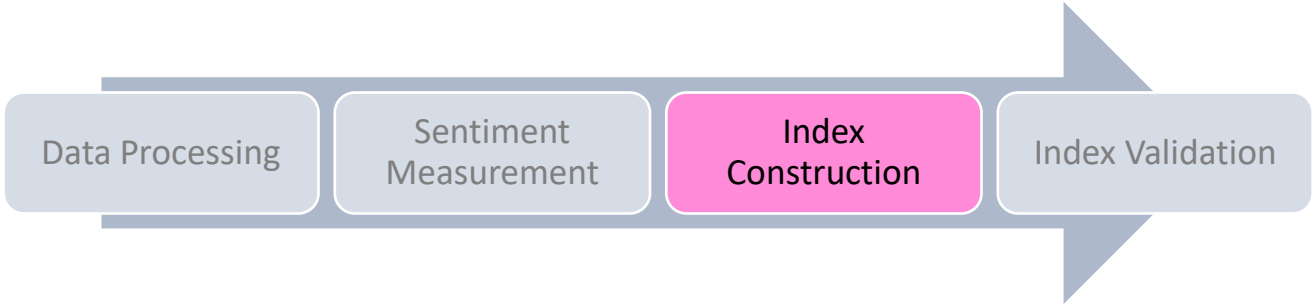
Sentiment Analysis process: Index construction



Following (Shapiro, Sudhof, & Wilson, 2022) to create the index of social acceptability

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

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 indicators reflecting the article's idiosyncratic character*
- *Employ newspaper systematic fixed effects controls for different public voices in our sample over time*

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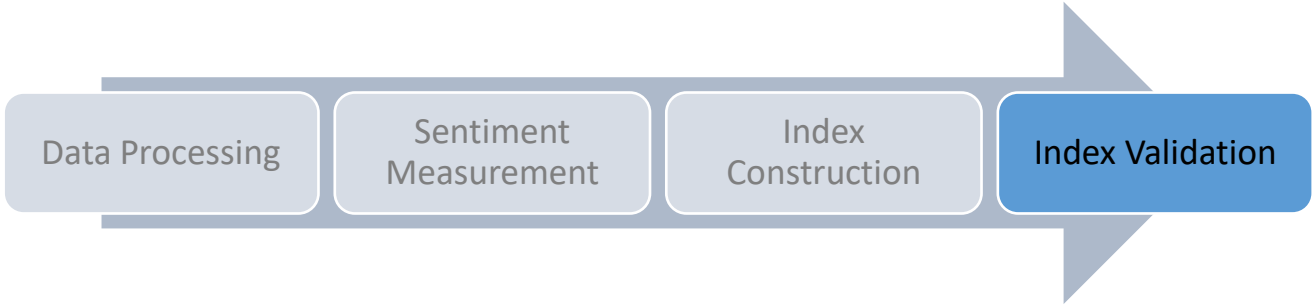
Sentiment Analysis process: Index Validation



- Compare the index results with other data sources
- Aim to identify if the index is measuring what it is intended to
- These include:
  - *Opinion polls or surveys (e.g. UK government BEIS surveys)* *https://www.gov.uk/government/collections/public-attitudes-tracking-survey*
- Non-survey data, such as the number of projects awarded

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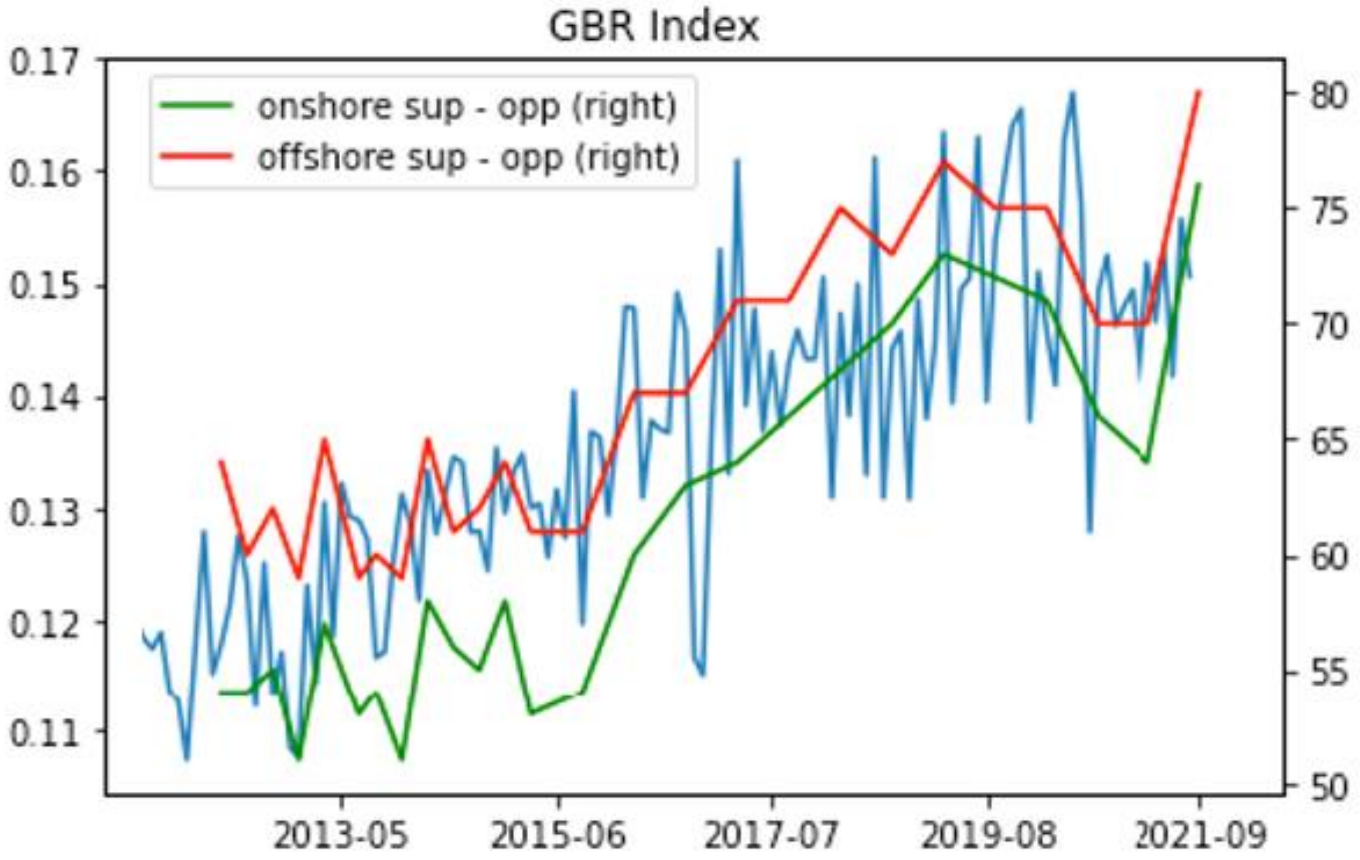
Social acceptability risks: Results for windfarms

- Data from UK BEIS Public Attitudes Tracker Survey (red, green lines)
- Blue line – EDHEC sentiment index



EDHECinfra sentiment index correlates with the sentiment assessment by UK BEIS Public Attitudes tracker Survey

- Sentiment indices are less expensive and can be scaled up globally across several sectors

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Social acceptability risks: Use cases

1) Industry Analysis
   - *To analyse the acceptability of different infrastructure asset-types*

2) Project Analysis
   - *Monitor the social acceptability of specific infrastructure projects*
   - *Identification of issues, that can be addressed early to ensure social acceptance of projects*

3) Infrastructure Performance Analysis
   - *There is some evidence of the relationship between social acceptability and asset prices*
   - *Further analyses on the financial/economic effects of high/low social acceptability (e.g. investment returns, revenues, profits, cancellation, distress risks)*

By analyzing the social acceptability of projects:

- ✓ The identification and management of social issues can be proactive, not reactive
- ✓ Resulting in projects can proceeding with greater acceptance
- ✓ A reduction in protests and disharmony
- ✓ Reducing the costs involved in producing and managing infrastructure
- ✓ Providing strong complementary information to infrastructure investment evaluation
- ✓ Predicting and quantifying the investment risks through extra non-financial dimensions

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Conclusions

- ✓ Risk management is the main driver of the demand for ESG data
  - *Information about ESG risks is not priced nor reflected in market prices*
  - *Regulatory reporting will become the main driver of the demand for ESG data*
- ✓ Investors are mainly concerned about climate impact and physical risks
  - *Social acceptability risks is another pressing concern*
- ✓ There is not enough ESG information for risk management
- ✓ However, it is possible to produce the information investors need (Green Infra's goal)
  - *Our approach to assessing climate impact, physical risks, and social acceptability risks is scalable to all sectors*
  - *Our early results already show that there are assets way more exposed than others (e.g., MIA airport is a high-emitter highly-exposed to physical risks asset)*
- ✓ These metrics will allow investors to correctly benchmark assets and make better comparisons/decisions in terms of ESG risks

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Feedback and discussion: ESG risk management strategies

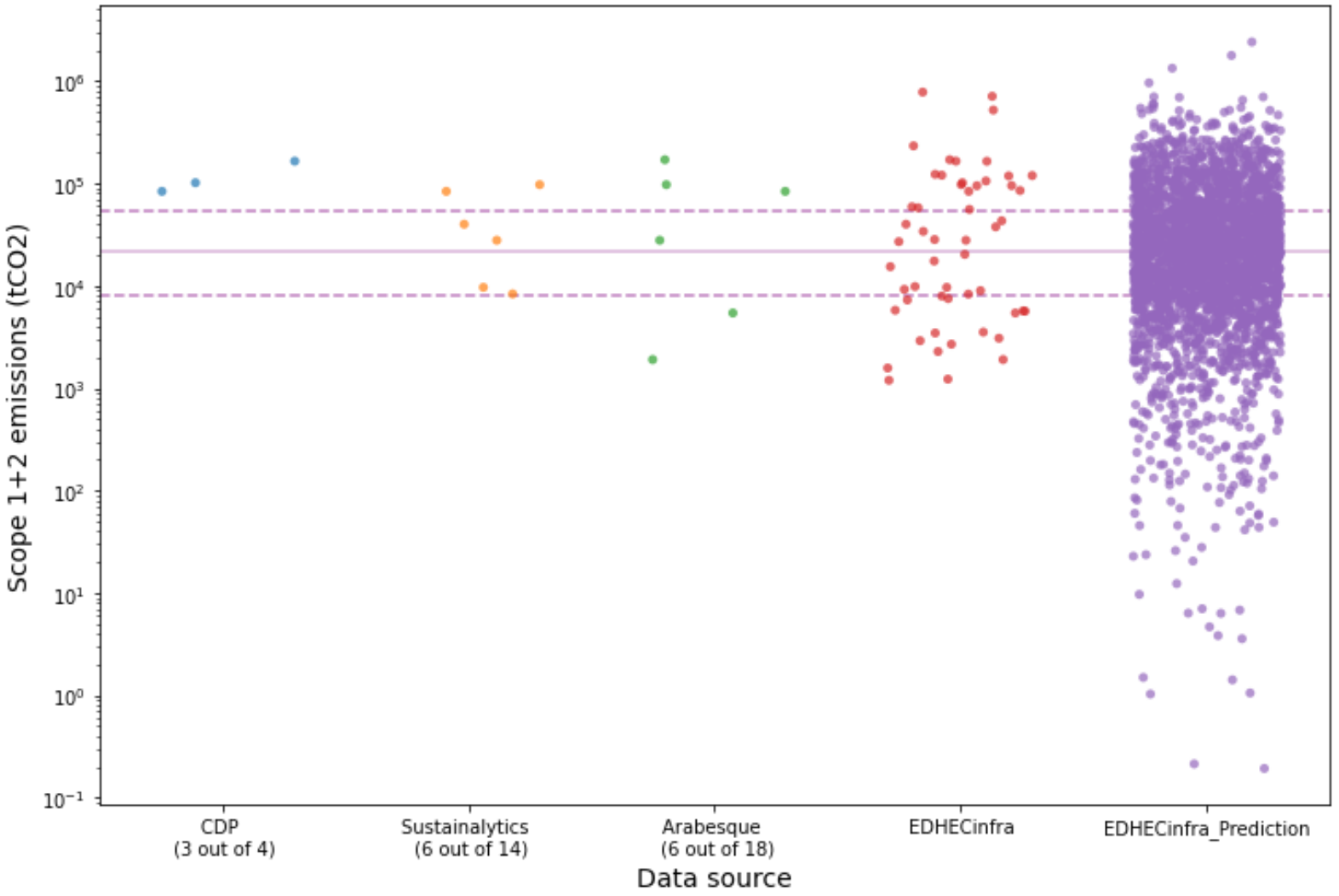
- Carbon tax is arguably the most important transition risk
  - *Carbon taxes affect all companies at the same time (systematic risk –no diversifiable)*
  - *The financial impact of a carbon tax depend on how much asset/companies emit*
  - *Having a precise measurement of carbon emissions is critical*
- Physical risks are location dependent
  - *Physical risks do not affect all companies at the same time (idiosyncratic risk –but hard to diversify)*
  - *Investors and companies can transfer the risks via insurances or mitigate the risks (e.g., building resilience)*
- Social acceptability risks is time and location dependent
  - *However, it could expose a company/asset to company, industry, and market (e.g., investing in country X) social acceptability risks*
  - *Investors and companies can implement actions to improve public and local communities' acceptance, but are limited if they need to address generalized rejection towards the whole industry or market*

Thank you

Datasets **comparison**

- We can plot our predictions (with quartiles) along our model dataset.
- We can also compare predictions with other datasets when we have the same airports real values.

(excluding airport groups and airports not in our model dataset)



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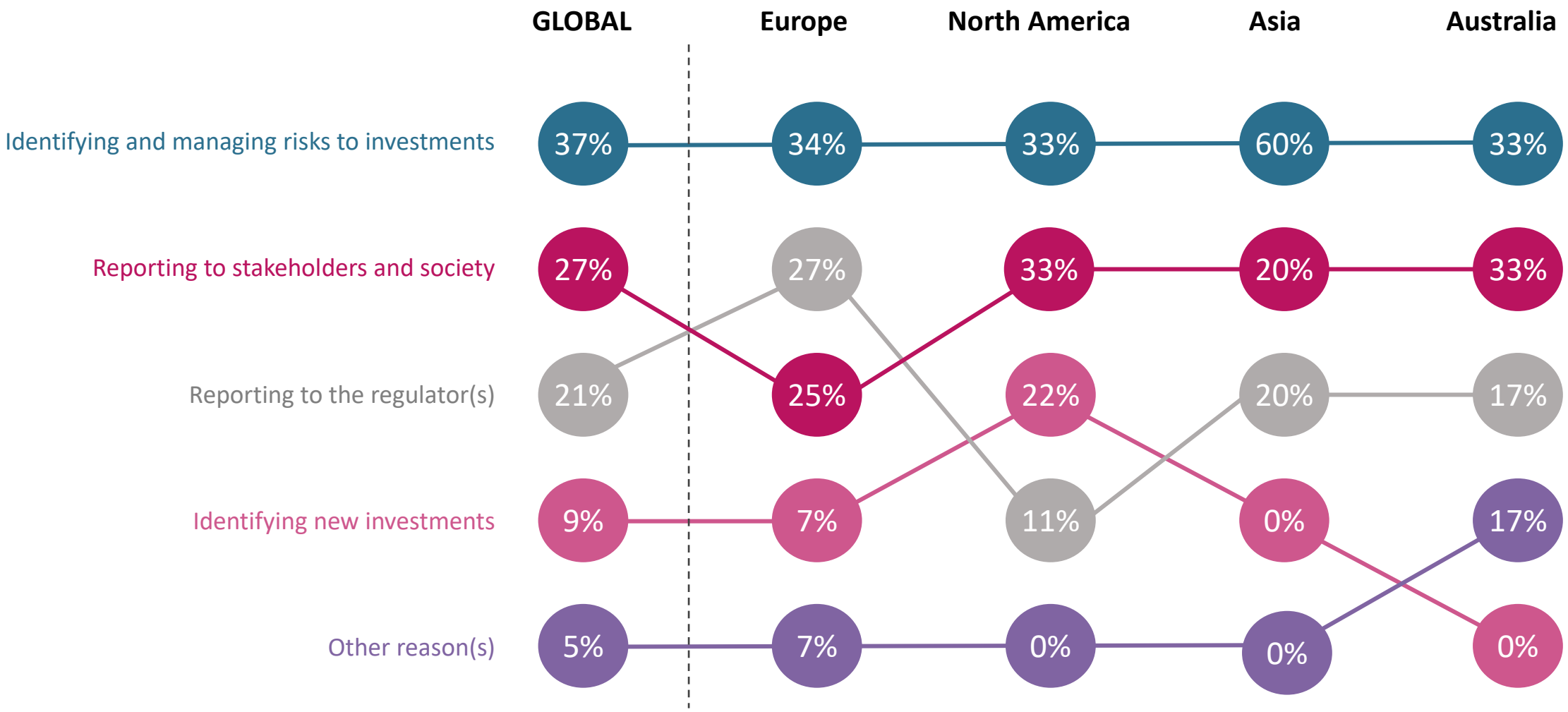
Risk management is the main driver of the demand for ESG data



Findings

- Scope 1 emissions have significant dependence on:
  - local’s climate temperature and its variations,
  - terminals surface.
  => confirmation of the literature (on a larger sample).

- Scope 2 emissions may depend on more parameters, involving more airport charateristics and being harder to estimate.

- Scope 1+2 regressions is closer to the scope 1 emissions fit.

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Estimation of scope 3 emissions: Challenges

Scope 3 models

- Cruise emissions (model 1)
  - proper identification of aircrafts,
  - great circle distance estimates,
  - distance to CO2 conversion
- LTO emissions (model)
  - identification of aircrafts,
  - Estimate improvement with schedule time data.

Aggregation

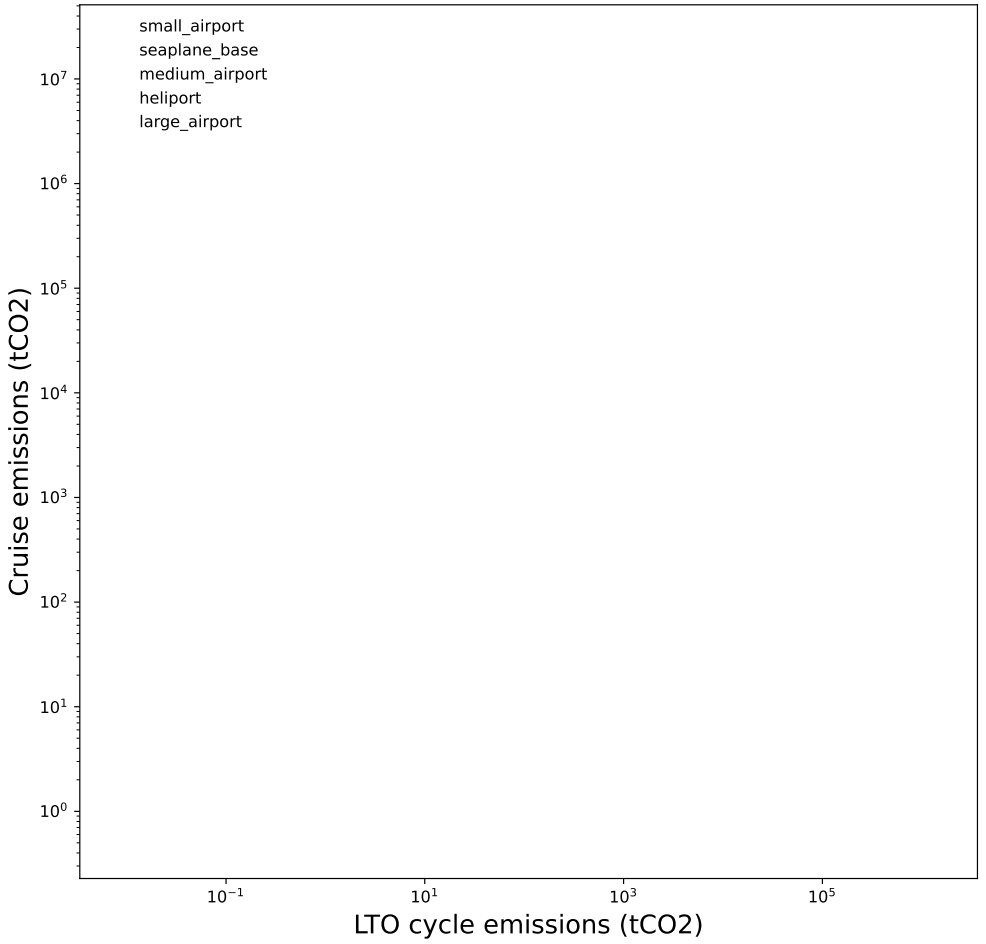
- Airport:
  - by departing airport for cruise emissions,
  - separation departing vs. arrival for LTO emissions
- Frequency:
  - Yearly,
  - Quarterly

S3 estimates (not-prediction) were made for 8000+ airports

Results

Ratio LTO / Cruise emissions:

- Large Airports:
  0.15 +/- 0.09
- Medium Airports:
  0.19 +/- 0.13
- Small Airports:
  0.24 +/- 0.34



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Conclusions

- Airports are under growing exposure to transition risk.
- Only few report real emissions publicly. Hence, global estimates of scope 1, 2, 3 emissions are lacking.
- We developed a statistical method for scope 1 and 2, with encouraging results, allowing predictions for 1.5k – 3.5k airports. It will be further improved with more regressors and more data.
- We developed a predictive method for scope 3 emissions from cruise and LTO cycle based on flight schedule data, for 8k+ airports. The results are already robust, but other improvements are planned.

Next steps

- Methods will be refined and extended as improvements can be added into the models.
- We can palliate the lack of reporting through these estimates.
- Investors can use this data to compare airport emissions and integrate this ESG component in their decisions.
- The method for scope 1 and 2 emissions will be applied to more infrastructure types.
- A similar approach will be applied for scope 3 emissions of the transport sector (e.g. ports).

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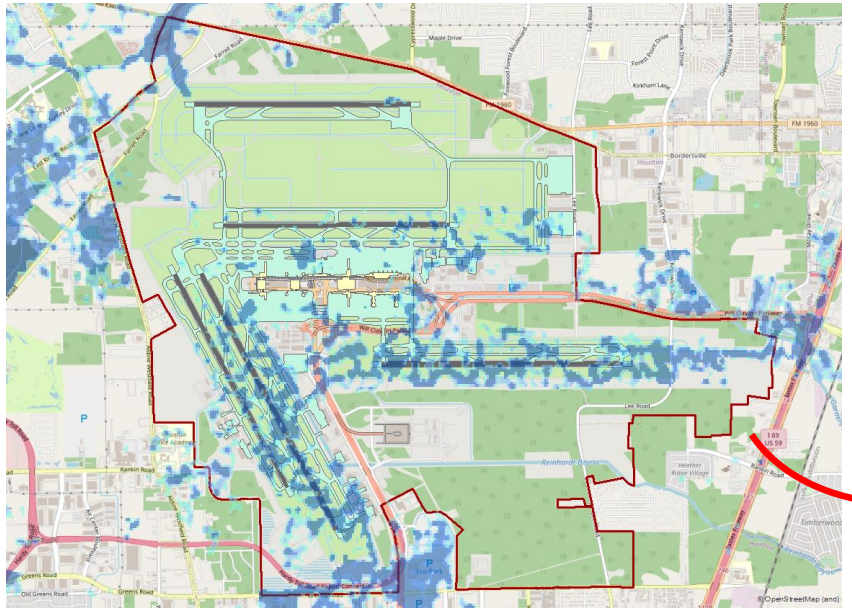
Physical risks: Assets' exposure to flood risk

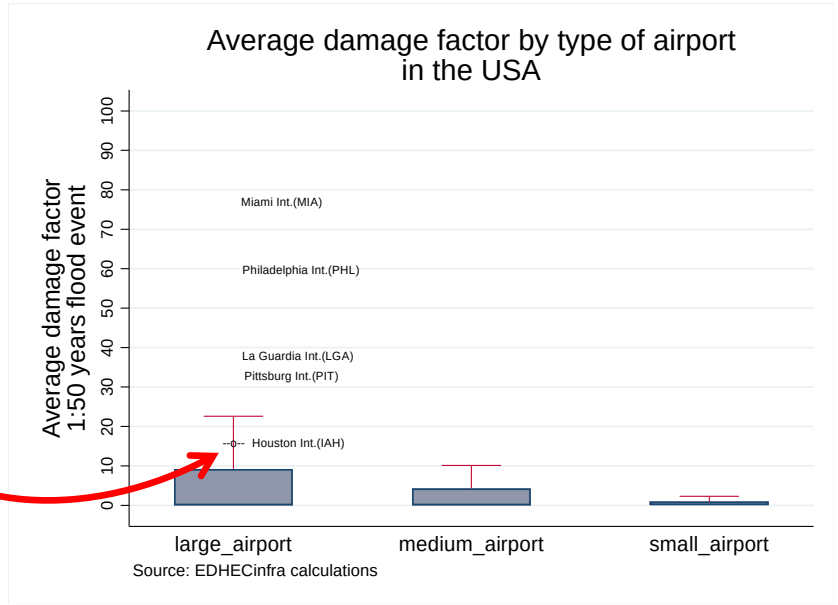
Combination of asset identification + hazard models + damage functions to estimate exposure to physical risks

- More than 100k assets have been identified, including 46k polygons for airports, solar farms, and windfarms
- More than 5 types of hazard models (e.g., flooding, sea-level rise, storm, heat stress, earthquake)
- Damage functions for 21 asset-types

Damage functions for ~500 airports in USA

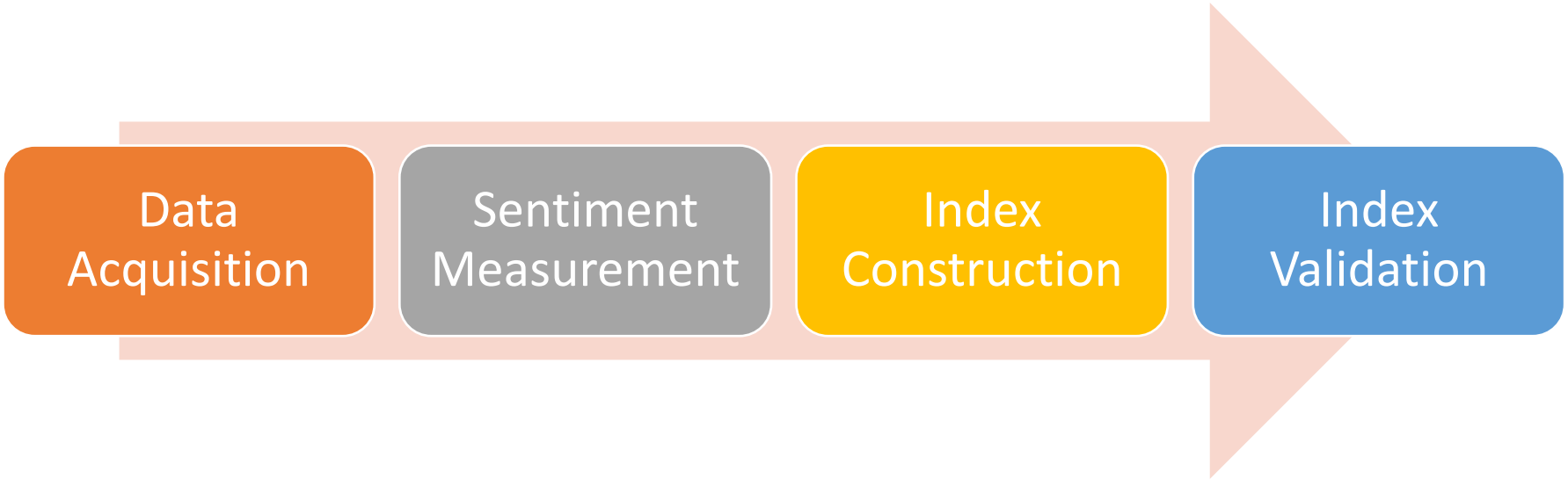
Houston Int. Airport (IAH)





Approach

- 4 major steps towards to the social acceptability indices



Data Acquisition

- We adopt the Dow Jones' Factiva as the major news source
- We extract the news articles from the raw data source with the following criteria :
  - **Industrial sector:** initially focused on renewables, but expanding focus to other industrial sectors
  - **Countries:** Only focused on UK, Australia, Canada, New Zealand and the United States. We will extend to the non-English speaking countries by using the articles with other languages.
  - **News agencies:** Same events can be reported by multiple news agencies, but the news agencies could have different influences of the public. Ensure we include both the international major news agencies and local news agencies
  - **Content:** We only include the news articles containing ESG related topics. These are identified by the EDHECinfra Infrastructure Taxonomy and Exposure Profile for each infrastructure sector. A topic classifier to identify the articles containing this ESG news was built, employing topic modelling techniques.

References

- Alcorn, G. (31 May, 2015). *East West Link: the case for and against Melbourne's $6.8bn road*. Retrieved from The Guardian: https://www.theguardian.com/australia-news/2014/oct/10/-sp-east-west-link-18km-road-election-flashpoint
- Algaba, A., Ardia, D., Bluteau, K., Borms, S., & Boudt, K. (2020). ECONOMETRICS MEETS SENTIMENT: AN OVERVIEW OF METHODOLOGY AND APPLICATIONS. *Journal of Economic Surveys, 34*(3), 512-547.
- Berinsky, A. J. (2017). Measuring public opinion with surveys. *Annual review of political science, 20*, 309-329.
- Da, Zhi, Joseph Engelberg, and Pengjie Gao (2015). The sum of all FEARS investor sentiment and asset prices. *The Review of Financial Studies* 28.1 (2015): 1-32
- Plimmer, G., & Pickard, J. (17 May, 2022). *HS2 protests set to cost high-speed UK rail line up to £200mn.* Retrieved from The Financial Times: https://www.ft.com/content/f7c10368-5702-4f19-8b9f-0f1c209da7d7
- Shapiro, A. H., Sudhof, M., & Wilson, D. J. (2022). Measuring News Sentiment. *Journal of Econometrics*(228), 221-243.
- Victoria Auditor Generals Office. (2015). *East West Link Project.* Melbourne: Victoria Auditor Generals Office. Retrieved 31 May, 2022, from https://www.audit.vic.gov.au/report/east-west-link-project?section=