ECONOMICS – WORKING PAPERS 2021/03

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the EIB scoring model

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EIB Working Paper 2021/03
May 2021

Authors
Matteo Ferrazzi, Fotios Kalantzis and Sanne Zwart (European Investment Bank)

This is a publication of the EIB Economics Department

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economics@eib.org
www.eib.org/economics

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Published by the European Investment Bank.
Printed on FSC® Paper.

pdf: QH-BK-21-003-EN-N ISBN 978-92-861-5034-0 ISSN 2599-736X DOI 10.2867/854649

Abstract:

The EIB Climate Risk Country Scores provide a comprehensive assessment of the climate change risks faced by more than 180 countries. The two sets of scores for physical and transition risks aggregate exposures to various risk factors, taking into account the adaptation and mitigation capacity of each country. The scores confirm that climate risk is a relevant challenge for all countries. However, low-income economies are more vulnerable to physical risk — in particular to acute events, rising sea levels and excessive heat — and in parallel have lower ability to mitigate the challenges posed by the energy transition to a net zero-carbon future and hence financial and technical support deem crucial. High-income economies, which consume a large share of the world's resources and generate significant emissions, generally face higher risks from the transition to a low-carbon future. Countries more dependent on fossil fuel revenues are also among the most exposed to transition risk.

Understanding the relative climate risks faced by countries has various practical applications. First, the scores directly support the management of climate risks at the country level, as well as helping to understand the environmental and policy conditions faced by firms in each country. Second, the assessment of physical and transition risks at country level can help to identify mitigation and adaptation priorities and related financing needs. Taken together, a better understanding of the risks and the consequent adaptation and mitigation needs will help to ensure that opportunities to enhance climate resilience are not missed.

1 Introduction

Climate change is now visible everywhere, and its effects will only intensify in the years to come. The year 2020 rivalled 2016 as the warmest year ever on record, confirming a persistent trend of increasing temperatures. The rise in sea levels is accelerating, ice sheets at the poles have shrunk markedly, and weather events previously considered extreme are now occurring regularly. On a positive note, awareness of the unfolding climate crisis has also increased considerably and last year saw renewed momentum, with many countries bringing forward their carbon emission targets. However, even when the Paris Agreement succeeds to limit global warming to well below two degrees Celsius in the long term, a temperature rise in the coming years is already "locked in," as the effects of the decarbonisation of the economy will only kick in after a while.

The climate emergency exposes societies to large-scale events outside their control. Both the severity and frequency of natural disasters are increasing, and examples abound. Whether it is droughts in Sub-Saharan Africa, wildfires in America and Australia, extreme heat episodes in South Asia, or floods in Europe, no part of the globe appears immune to the consequences of climate change and the significant losses it is causing to the environment, wildlife as well as human lives and livelihoods. While the impact of natural disasters can be easily observed, other effects of the climate crisis are more gradual. Changes in temperature, precipitation and sea levels are building up slowly but steadily over time, albeit with potential detrimental effects.

At the same time, the required transition to a low or zero-carbon economy is surrounded by uncertainty. Phasing out fossil fuels will take decades. Many aspects of the transition, such as its speed, future policies and the impact on prices and assets, pose risks for companies. Uncertainty is already affecting investor decisions, particularly in the energy sector but increasingly spreading to other sectors as well.

A better understanding of all the risks posed by climate change is needed to contain the fallout. The environment, and consequently infrastructure and the entire economy (especially agriculture and activities exposed to the heat) face direct physical risks, which also depend greatly on their location. Transition risk is related to the energy conversion, which affects the entire economy. For businesses, the repercussions go beyond profitability, as supply lines, demand and ultimately even business models could be at stake. Banks are also exposed to climate risks, directly and indirectly via their exposure to firms and individuals, which can affect the safety and soundness of various financial institutions and ultimately the stability of banking systems. Governments are exposed too, as they partly have to sustain the cost of the transition and at the same time may need to provide support measures for affected households and economic sectors, and rebuild infrastructure or make it more resilient.

When dealing with climate risk, the country dimension is of particular importance. The impact of climate risk may appear at first glance as very localised, affecting a single location or a single company (or even only one of its business lines). This is evident especially in the case of acute events (for instance, a river flooding a village, a landslide affecting a hotel, etc.). However, the ability to react to such events — which is not only the ex-ante ability to adapt and mitigate, but also the capacity to adjust and restart a business, modify the strategy and the business model, develop new technologies, receive support from the public authorities, etc. — is closely linked to the country. The ability of a country to cope with the climate challenge is thus one of the main drivers for firms' ability to cope with it as well.

In the financial sector, risk management frameworks have been adjusted to increasingly account for the impacts of climate change. These improvements mainly stem from moral suasion by regulators and other stakeholders and in anticipation of future requirements. More recently, however, binding regulation has been rolled out. For instance, the EU taxonomy, a classification system specifying when an investment can be considered as environmentally sustainable, came into force in July 2020, followed in

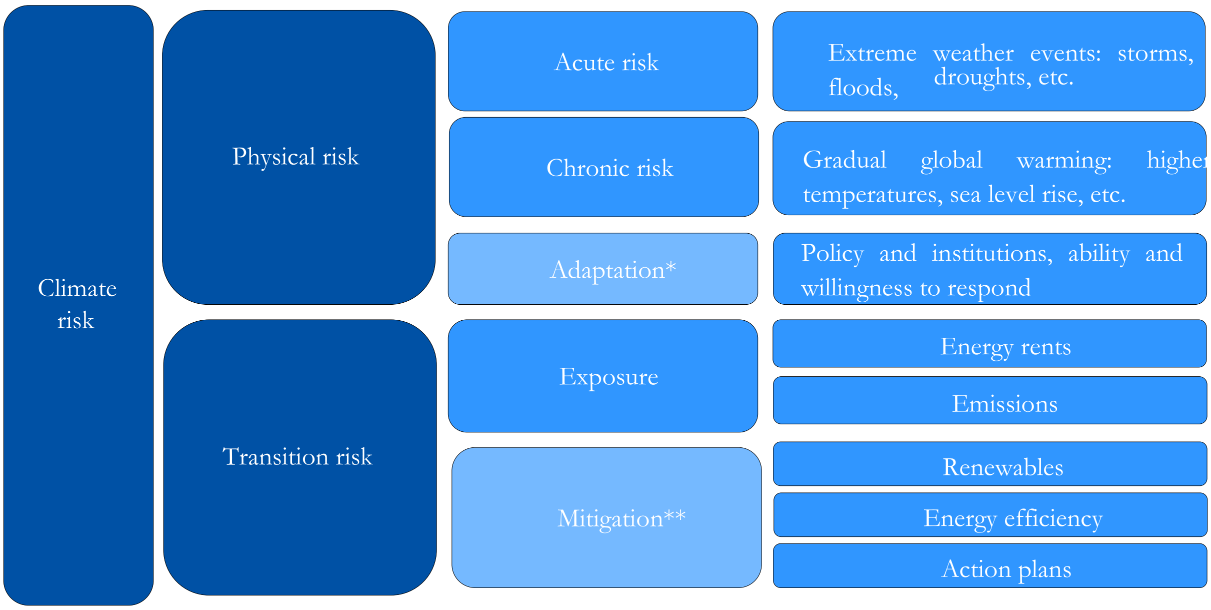
November by the European Central Bank (ECB) guidelines on how banks should prudently manage and transparently disclose climate change risks.

As the EU climate bank and a major provider of green finance in Europe and around the world, the European Investment Bank (EIB) is adjusting all of its practices, including risk management, to abide by best practices and regulations. The climate angle is now an integral part of the EIB's strategy, processes and disclosures. A climate risk assessment is conducted for corporates, financial institutions and other types of counterparts. Risks for individual companies or projects very much depend on their specific features, but many of these risks are common to all companies in the country, either directly through being exposed to the same hazards or being affected by similar national regulations, or indirectly through, for example, potentially lower demand. The model for evaluating climate risk at the country level has been developed by the EIB in-house and is discussed in this note.

2 Climate risk at the country level

Despite the climate crisis being a global phenomenon, the ways in which countries are exposed differ greatly. Countries in the Caribbean, Pacific Islands and other areas could be hit more often and more violently by hurricanes. Temperature increases and changes in precipitation patterns pose risks for countries dependent on agriculture. Across the globe, countries bordering the sea tend to have major urban agglomerations near the coast, which are threatened by the sea level rise. Fossil fuel-exporting countries could see significant drops in demand in the long term, reducing their tax revenues. The need to reduce greenhouse gas emissions also poses risks to advanced countries and other high emitters. Given this wide range of risks, it is useful to classify them (see Figure 1).

Figure 1: Overview of risks stemming from climate change



***Adaptation**: ability to reduce vulnerability to the effects of climate change, alleviate the effects and moderate damage. It includes economic stability and institutional capacity.*
****Mitigation:** actions to reduce greenhouse gas emissions.*

Physical risk covers the direct effect of climate change on assets and productivity. It can be acute if caused by extreme weather events and hazards such as floods, landslides, extreme temperatures, storms and hurricanes, droughts or wildfires. Physical risk is chronic if related to a more gradual effect of global warming, so to longer-term shifts in climate patterns, for instance rising sea levels. Another example of chronic risk is related to higher temperatures, which could lead to lower crop yields and lower labour productivity.

Governments (and in a similar way, corporates and individuals) have the possibility to adapt, at least partially, to the effects of physical risks. The adaptation capacity of a country is an important element for the risk assessment, as shown in Figure 1. It reflects the ability to adjust to climate change by moderating potential damage and coping with the remaining consequences. Some countries are better equipped, politically and economically: countries boasting economic and political stability, strong institutional capacity, strong fiscal capacity and the technical capability to put in place the necessary measures can offset, at least partially, climate risks and protect themselves from exposure to physical risk.

Transition risk refers to the climate risk resulting from mitigation policies as economies move towards a greener, less polluting society. Such policies, stemming from deals like the Paris Agreement in 2015, lead to changes in the energy system and have impacts throughout the economy. For example, firms involved in fossil fuels and those with a high emission intensity could face large shifts in asset values or higher costs of doing business. Although firms in other sectors will be less affected, the entire economy will have to adjust. Climate policies are the main driver of the related risks, as they formalise the need to adjust and prescribe the speed of the transition. These policies will result in potential changes in technologies, shifts in consumer preferences and reputational implications (and possibly even litigation) if climate action is considered inadequate.

While adaptation addresses the impacts of climate change, mitigation attends to its causes. It refers to specific actions to reduce greenhouse gas emissions such as increasing renewable energy capacity and energy efficiency. The Paris Agreement requires each participating country to define nationally determined contributions (NDCs) with specific domestic mitigation measures and objectives. The mitigation component also includes "climate opportunities" related to technologies and products with increasing demand in a decarbonising world (for example, renewable energy, substitutes of plastic, advanced waste management, or carbon capture technologies).

Physical and transition risks may appear rather distinct and unrelated in the short term, but they are closely linked in the long term. Physical risk is already visible, with many of the effects irreversible and growing over time. On the other hand, transition risk can increase easily, for example due to a sudden change in regulation. Similarly, an individual country may be significantly exposed to climate hazards but not to transition risk (or vice versa). At the global level, however, a rapid transition reduces physical risk in the long term but increases the transition risk in the short term. On the other hand, a business-as-usual scenario may not generate transition risk, but will increase physical damage in the future due to more profound climate change.

3 Climate risk assessment: a review of the literature

Climate risk and ways to assess it have attracted increasing attention in recent years, in particular following the Paris Agreement in 2015. Firms, banks, investors, governments and public institutions are demanding more information to gradually prepare for the possible consequences of climate change and the transition to a low-carbon economy. Broadly speaking, the literature follows three approaches: modelling, scenario analysis and (index-based) ratings.

Sophisticated macroeconomic models aim to evaluate the macro impacts of climate change, including integrated assessment models (IAMs) that integrate the science of climate change and the policies addressing greenhouse gas emissions. The most popular IAM model is the DICE model developed by Nobel laureate W. D. Nordhaus (Nordhaus, 1992; Nordhaus, 2000). This approach, which has evolved over time, is based on a Ramsey-Cass-Koopmans neoclassical model of economic growth, combined with a climate module and feedback effects. In this framework, economic growth generates greenhouse gas emissions, which in turn raise temperatures and modify consumption patterns, production and welfare. In particular, damage due to temperature increases reduces output, and additional costs follow from reducing emissions. The DICE model does this by adding to the neoclassical models the so-called "natural capital," an additional type of capital stock, with emission-reducing measures modelled as "investments" that raise the quantity of natural capital, and greenhouse gas emissions as negative flows of natural capital. Such models look at a long-term perspective, and cannot be calibrated for short-term needs. Moreover, they are very sensitive to some assumptions (the discount rate to be applied or the utility function, for instance).

Given the difficulties in projecting future emissions and other factors that influence climate change, some institutions have developed scenario analyses to sketch plausible and consistent representations of the future under different policies and circumstances (TCFD, 2017). Such scenarios look at the possible long-term impacts of climate change, as the time horizon is normally 60-80 years from now. They describe a path of development which may lead to particular outcomes, but they are neither forecasts nor predictions. The most relevant among these scenario analyses are those developed by the International Energy Agency (IEA) to assess different policy outcomes, and by the IPCC (the Intergovernmental Panel on Climate Change created by the United Nations) to consider greenhouse gas concentrations and demonstrate the consequent temperature rises (TCFD, 2017). Among the various IEA scenarios, the "Current Policies Scenario" is projected to generate warming of 6°C, the "Paris Agreement Scenario" limits warming to 2.6°C, and the "Energy Technology Perspectives" provides a scenario analysis of lower-carbon technology development and deployment in various sectors, cutting CO_2 emissions by almost 60% by 2050. The latter would limit warming to 2°C. The IPCC uses the emission scenarios (Representative Concentration Pathways, RCPs) to estimate average global temperature increases by the year 2100. The worst-case scenario for IPCC ("Business as usual" scenario, RCP 8.5) would generate a rise in temperature of 4°C. More benign scenarios, with emissions halved by 2050 ("Aggressive mitigation" scenario, RCP 2.6) would entail a rise in temperatures below 2°C.

In addition to modelling and scenario analysis, index-based ratings have become quite popular over the past few years. A number of institutions have developed ESG (Environmental, Social and Governance) scores for corporations and financial institutions, and more recently sovereigns. The ESG scores, which combine three main sustainability criteria — Environmental[1], Social and Governance (Berg, Koelbel and Rigobon, 2019) — are mainly built to guide investors in their investment choices and are becoming increasingly prominent in the assessment of corporate and financial institution risk. Sovereign creditworthiness can no longer ignore ESG considerations either. Until recently, sovereign rating methodologies have included only a limited number of ESG factors so far (typically governance indicators and institutional strength only), while the most recent rating methodologies consider social (demographics, education, health, housing, poverty, inequality, etc.) and environmental risks as well. Rating agencies typically apply qualitative judgments for ESG scores and also for the way they are incorporated in sovereign ratings, even if based on quantitative information. Some of them have acquired specialised ESG agencies in recent years to strengthen their expertise and knowledge on ESG assessment.

Only a very limited number of institutions have developed "country climate ratings," i.e. indicators which can be used to identify the relevance of climate risk at country level. Some climate-related indicators are proposed by the following institutions:

- **The University of Notre Dame** has developed the Notre Dame Global Adaptation Initiative Index (ND-GAIN; Chen et al., 2015), covering a broad set of countries. The index is built on a large set of equally weighted variables and does not take transition risk into account. Being one of the more widely used climate indices for countries, it is discussed in more detail in the Annex.

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[1] The environmental component is a broader concept than climate risk (physical and transition risk), as it also includes other factors such as water consumption, waste management, energy management, air and water pollution, and natural capital.

- **HSBC** has developed a "Fragile Planet" approach (Paun et al., 2018) covering 67 countries. This is discussed in the Annex in more detail. It is mainly designed to serve the needs of financial investors willing to take climate risk into account in their investment decisions. It is built on four main subcomponents (acute risk, chronic risk, energy transition and potential to respond), with an equal 25% weight for each of them.
- **Moody's** has not regularly or systematically quantified the climate impact on countries nor ranked countries along such dimensions in the past (Moody's, 2016; Moody's, 2018). In a one-off exercise estimating climate scores at country level (Moody's, 2016), it relied largely on ND-GAIN for physical risk to compute an "exposure component." This accounts for ND-GAIN indices, the role of agriculture in the economy, the number of natural disasters and the damage. It also comprises the adaptation and mitigation component (GDP per capita, debt as a percentage of GDP, fiscal deficit, etc.), but it does not include transition risk. More recently, the agency provided a physical risk assessment (Moody's, 2021). Moreover, Moody's rating committees incorporate ESG discussion for sovereigns. When the ESG impact (based on qualitative and quantitative judgments) is material, ESG is discussed in credit rating announcements. (Other **rating agencies**, despite including ESG considerations at country level, do not issue climate risk scores or ratings.)
- **Germanwatch** has developed a Global Climate Risk Index (Eckstein, Künzel, Schäfer, 2021), which exclusively considers extreme weather events.
- **The World Energy Council** assesses energy policies (World Energy Council, 2021) and issues, in cooperation with Oliver Wyman, the Energy Trilemma Index, ranking 128 countries in terms of their energy systems (energy security, energy equity and environmental sustainability).
- **Yale University**, using 32 performance indicators, calculates an Environmental Performance Index (Wendling, Emerson, de Sherbinin, Esty, 2020), ranking 180 countries based on their ability to establish environmental policy targets, without distinguishing physical and transition risk.
- **RobecoSAM** issues comprehensive ESG country scores using 40 indicators. The environmental component has a 20% weight in the overall score and is a meta-index, leveraging on ND-GAIN scores, the Germanwatch Global Climate Risk Index, the World Energy Council Energy Trilemma Index and other indicators (RobecoSAM, 2021).
- **The World Economic Forum** has developed an Energy Transition Index (ETI), which ranks 115 countries across 40 indicators based on the current performance of their energy system, and their readiness for the energy transition.

4 Methodology and model for EIB Climate Risk Country Scores

The EIB has developed a set of country scores in-house aimed at assessing the exposure of individual countries to physical and transition risks. The scores are used in the context of a risk management tool to map the exposure of the EIB portfolio to climate risk. The methodological choices reflect the constraints of the problem: the vast country coverage, the need to assess both physical and transition risk, the assessment of the weights (avoiding merely applying an equal-weight approach), and the willingness to obtain transparent scores leveraged on a parsimonious model (rather than a combination of indices generated by other institutions). EIB Climate Risk Country Scores cover 184 countries and include both physical and transition risks that could materialise over the next five to ten years. The scores are leveraged on a select number of components that were identified as the most relevant (avoiding any redundancy of variables), and aggregate the relevant subcomponents in a rigorous way (avoiding arbitrary weights).

An important feature of our methodology is the aggregation of the variables to obtain the two scores (physical risk and transition risk) and hence rank countries. Several scores/indices use equal weights when aggregating the underlying variables. Although appealing, this seemingly innocuous aggregation reflects a strong assumption (i.e. all variables are equally important), and essentially reflects the fact that the weights have not been rigorously determined by means of statistical analysis (examples: HSBC assigns a

25% weight to each of the four components; ND-GAIN uses 36 equally weighted variables to determine the physical risk component). To overcome this problem, the EIB Climate Risk Country Score Model for Physical Risk translates climate impacts in GDP terms. This has two advantages: (i) we use the same metrics to measure all impacts (we translate them all into the same dimension prior to aggregation); (ii) we can directly infer their relative importance/weight for each country and compare the relative magnitude of each risk component both within and across countries. The conversion in GDP terms for physical risk also means the various risk components can be easily quantified and evaluated, and helps to compare countries. The EIB Climate Risk Country Score Model for Transition Risk aggregates the subcomponents based on a statistical methodology, as described in the following section.

For both physical and transition risk dimensions, the methodological approach first identifies the relevant dimensions of climate risks and then combines these dimensions to get an overall score in each of the two categories. However, the approach used to estimate the physical component of the EIB Climate Risk Country Scores model partially differs in some aspects from the approach used for the transition risk component, for a number of reasons:

- Transition risk and physical risk, while closely related, are very different in nature: transition risk is mainly policy driven; it can affect countries in a very different way compared to physical risk (oil exporters, big polluters versus poorer and smaller countries, islands exposed to water). Unlike physical risk, which is similar for all economic operators in a given geographical location, transition risk can affect firms and governments in different ways. High transition risk for a single company can be detrimental, impacting its business, while it can be positive overall for the sovereign.
- Physical risk is easier to quantify in monetary terms than transition risk, as physical risk by definition relates to losses that can be evaluated in financial terms and hence be expressed in terms of GDP impact. As discussed more extensively below, this is key for aggregating and weighting the different components of physical risk scores. On the contrary, the weights for the components of transition risk had to be assessed in a different way.
- There are more data available for energy-related variables, which are the main components of transition risk. More than one source covers a large amount of countries. On the other hand, the availability of data on physical risk — especially chronic risk — is particularly challenging.

Several challenges complicate the construction of Climate Country Scores. Besides the lack of industry standards (there is no widely accepted methodology or definition on this topic), they are related to:

1. Choosing the right variables and their number for each of the above-mentioned categories of risk, balancing complexity and comprehensiveness. Adding additional variables does not necessarily add information per se, as in some cases accumulating numerous indicators may dilute the role of other more relevant variables.
2. Aggregating variables to obtain a score using a methodology that typically involves predetermined weights.
3. Choosing the appropriate metric to make all variables comparable such that they can be aggregated.

The physical risk component is estimated by adding damage, costs and losses in terms of GDP, giving a measure of the total (yearly) burden a country would need to sustain to offset the climate change-related impacts. Using GDP as a common metric also enables the various components to be aggregated by summing the GDP impacts of each component, thus avoiding the need to determine a specific weight for each component beforehand.

The quantification of GDP impacts is carried out by leveraging on the results of empirical studies and academic literature connecting climate events with their economic impacts (Feyen et al., 2019; NGFS, 2020; Roson and Sartori, 2016), typically in terms of GDP impact (or monetary impact which is then transformed into a percentage of GDP). For each category, the model estimates the impacts of physical climate risk in terms of GDP. The sum of all categories provides a measure (in GDP terms) of the total burden a country would need to sustain to offset all climate change-related impacts. An alternative interpretation is that this approach generalises a weighted aggregation of the components by allowing for country-specific weights: instead of deriving a single weight based on the entire sample of countries, the country-specific weights depend on the component's impact for a specific country, taking into account its development, region and/or other main features.

As shown in Figure 1, the physical risk components in our model are the following:

- **Acute risk**: capturing the risks generated from extreme weather events, including hydrological risks (floods and landslides), meteorological risks (extreme temperatures, fog and storms) and climatological risks (droughts, wildfires, glacial lake outburst). (Bamber et al., 2019; IPCC, 2019).
- **Chronic risk**: capturing the risks stemming from gradual, longer-term shifts in climate patterns, which are based, in turn, on the following components[2]:
    - **Impact on food and agriculture**, taking into account the reliance of an economy on agriculture (i.e. the role of agriculture in each economy) and the impact of climate change on crop yields (Chen et al., 2015; FAO, 2017; Feyen et al., 2019; Moody's, 2019);
    - **Impact on sea levels** (the melting of glaciers and ice sheets is the dominant source of sea level rise), based on academic studies regarding the economic costs of being exposed to higher waters, depending on the amount of the population and land exposed to the sea (Bamber et al., 2019; Diaz, 2016; IPCC, 2019; Moody's, 2020);
    - **Impact on required infrastructure quality**: similarly to the direct impact of acute risk (i.e. damage) on infrastructure, chronic risk puts infrastructure (roads, ports, telecommunications, etc.) under higher strains, and could thus require upgrades of existing structures, increasing construction and maintenance costs. The effect of chronic climate risk on infrastructure cannot be directly estimated, hence we use the estimated need to adapt, which can be summed up to the other costs generated by climate change (World Bank, 2016);
    - **Impact of heat on productivity**, as temperatures beyond a certain threshold negatively affect labour productivity of outdoor activity, where outdoor activity is defined as the sum of agriculture, construction and mining as a percentage of GDP (McKinsey, 2020).
- **The adaptation capacity** of individual countries accounts for the financial capacity to adapt to climate change (represented by fiscal revenues and the sovereign rating) and for the capacity to do so effectively (leveraging on World Bank Governance Indicators and the United Nations Human Development Index). The adaptation capacity indicates the share of the risks that can be mitigated, reducing the vulnerability to climate impacts. In the EIB Climate Risk Country Scores model, the ability to adapt is calculated as a ratio between 0% and 100%, and capped to a maximum level of adaptation of 90% with the possibility to adapt for a maximum of 3% of GDP.

The objective of the transition risk assessment is to provide a view on the future decarbonisation of each economy and its associated risks. To do so, the transition risk comprehensively covers the various dimensions of the energy transition, by including the full range of information and indicators necessary to assess the impact of the transition to a low or carbon-neutral economy on the value of each country's assets. In this assessment, three are key for identifying the factors that have a material impact on countries' economic performance: the geography-specific carbon indicators (reflecting risks), their relation

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[2] Climate change and in particular higher temperatures may also have an impact on three additional categories that are not considered in the model: (1) health and the spread of diseases (many diseases thrives in warmer climates); (2) surface water (higher temperatures creating water stress); and (3) tourism. Such effects are not taken into account in the current methodology, as economic literature on such topics is still not detailed enough (i.e. limited country coverage), not recent enough or not usable for assessing the potential impact on GDP. Regarding tourism, the aggregate global economic impact of a climate change-induced change in tourism demand was concluded to be quite small (United Nations, 2008), but the impact on tourism may harshly affect some countries that rely significantly on the sector.

to the global climate ambition and the speed of adjustment, and finally the commitment of each country to this global plan as part of its adaptive capacity in the context of the transition.

The geography-specific carbon indicators are not only related to carbon-intensive sectors, but also to the carbon footprint of the whole economy. To this end, the assessment gives an overview of both the role of producers of energy goods and services in the economy and that of sectors that are highly reliant on energy or producing energy-intensive goods. To get a better understanding of the drivers of countries' overall greenhouse gas emissions, two more indicators are taken into account based on the Kaya identity (Kaya, 1990) that represent mitigation efforts, as follows:

$$CO_2/Pop = (GDP/Pop) \cdot (E/GDP) \cdot (CO_2/E) \quad (1)$$

where CO_2 emissions per capita (CO_2/Pop) are expressed as a function of GDP per capita (GDP/Pop), energy intensity (E/GDP) and carbon intensity (CO_2/E), in which the variable Pop indicates the population, and E is the primary energy consumption. Simply put, equation (1) shows that the carbon footprint is related to the energy intensity of the economic output (E/GDP) and the carbon intensity of the energy supply (CO_2/E). Therefore, countries that would like to mitigate transition climate change risks must introduce policies related to the energy intensity of GDP (typically involving improvements in energy efficiency) and policies that relate to the carbon intensity of energy supply (typically focusing on the promotion of low-carbon or zero-carbon sources of energy such as renewables). This allows the assessment to identify several country risk profiles.

In the existing geography-specific carbon indicators, risks are assessed under two climate-related transition scenarios. These scenarios represent different levels of ambition (e.g. 2°C or 1.5°C global warming) and views on how the objective will be achieved based on the IPCC (2019) analysis. We assume that more ambitious scenarios will lead to more disruptive changes and create more sudden, abrupt impacts on carbon-intensive economies, which means a higher transition risk for them. The year 2030 was chosen as an important milestone in the global decarbonisation process and the remaining global carbon budget was taken as a benchmark for penalising less optimal behaviours. For the current analysis, the 2°C global warming scenario was considered the most probable scenario for the globe.

While existing carbon-related indicators and scenarios can broadly provide a comprehensive picture of transition risks, other levels of information are relevant as well. For example, the nationally determined contribution plans (NDCs) communicate the planned transition of each country/region and its adaptive capacity in the context of the transition. To this end, the transition risk assessment from the NDCs took into account whether countries have unconditional plans (targets that are not conditional upon additional financing or support from other states or institutions), conditional plans, or no plans at all, favouring countries with unconditional plans. Although the NDCs are subject to the credibility of each country or region, they are considered a critical indicator that links carbon-related data with the most recent country announcements on climate action.

The main advantage of the chosen methodology and the underlying indicator is that it ensures a fair and comprehensive assessment and different levels of risk based on the global warming scenario assumed. This is achieved by evaluating the current state and the policy effectiveness of each country over the past five years, as well as its distance to the optimal pathway for reaching the 2°C or the 1.5°C scenarios (as mentioned above the 2°C scenario was used for estimating the transition risk scores). By combining the three time dimensions (past, current and future), the assessment neither generously rewards countries that have started their decarbonisation process earlier and managed to reduce emissions from a much higher level than they would have done otherwise, nor penalises countries that still have a high level of emission intensity if only this dimension was accounted for risks. This also applies to countries that have a low level of emission intensity which vastly increases as part of their catching-up with more advanced economies. The latter case is in line with Article 4 of the Paris Agreement (non-Annex I countries, which are mostly developing economies), which recognises that "peaking [of greenhouse gas emissions] will take longer for developing country."

The transition risk components of the Climate Risk Country Scores are the following:

- **The exposure component**, consisting of two dimensions:
    - **Greenhouse gas emissions performance**, which takes into account the past and current performance and the distance of each country from the global optimal greenhouse gas emissions level per capita in line with the Paris Agreement;
    - **Revenues stemming from fossil fuel exports** that are expected to decline due to stricter climate policies in the future and changes in consumer preferences.

- **The mitigation component**, consisting of three dimensions:
    - **The deployment of renewables** in final energy consumption (affecting the carbon intensity), after taking into account the current and past performance related to the level of renewables penetration to ensure fairness;
    - **Energy efficiency** improvements, after evaluating countries based on past, current and optimal performance in the net-zero carbon future;
    - **The level of commitment of countries** to contributing to the global climate challenge based on their nationally determined contribution plans, which indicate efforts to reduce national emissions and adapt to the impacts of climate change.

Our score is the outcome of an indicator that combines all the above dimensions. The methodology of the composite indicator builds upon the one proposed in the *Handbook on Constructing Composite Indicators* published by the Joint Research Centre of the European Commission (JRC, 2008). This handbook provides a logical process for selecting the most relevant indicators and examines a variety of issues that should be taken into consideration. According to this, the transition scores were calculated after bringing the indicators to a common scale, allowing for partial compensation among each other and selecting the appropriate weights[3] of the various climate risk dimensions based on the literature and econometric analysis.

Like most other rating models, the EIB Climate Risk Country Scores are the outcome of a solid quantitative methodology, which may then be complemented by potential expert adjustments — "overrides" — of country experts from the EIB Economics Department. Taking into account adaptation and mitigation capacity, and following the possible expert adjustments, final scores range from 1 to 5 (1 = very low risk; 2 = low risk; 3 = elevated risk; 4 = high risk; 5 = very high risk), but can easily be translated into different and more granular scales.

5 Climate risk data

The EIB Climate Risk Country Scores model has been built using an ample variety of sources. In general, climate risk data are not easily available for a large number of countries and the availability of data differs significantly for physical and transition risk. Some sources — such as the International Energy Agency (IEA) and US Energy Information Administration (EIA) — cover a broad spectrum of countries in terms of energy data (energy consumption, greenhouse gas emissions, renewables production, etc.), which can be used to estimate transition risk. The availability of data on physical risk, especially chronic risk, is

[3] The weights were estimated based on a constrained multivariate analysis that used the geometric mean of the selected dimensions as a benchmark (which allows for partial compensation among sub-indicators). According to its results, the following weights were selected for the five dimensions: emissions (40%), fossil fuel rents (10%), renewables (15%), energy efficiency (25%) and climate ambition (10%).

particularly limited. Moreover, while a rich set of climate data is accessible (temperatures, wind, rains, etc.), their estimated impact on the economic activity of each country is not.

The acute component of the physical risk scores is measured with data sourced (and later transformed as impact on GDP) from EM-DAT, the Emergency Events Database. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) of the Université Catholique de Louvain. The database is compiled from various sources, including United Nations agencies, non-governmental organisations, insurance companies, research institutes and press agencies. The dataset takes into account disasters conforming to at least one of the following criteria: 100 or more people affected; ten or more people dead; declaration of a state of emergency; a call for international assistance. Damages are expressed in USD, but are not always reported in full (the dataset does not always record all the economic losses associated with each event), especially in the case of emerging markets (the dataset often provides some information about the event — deaths and people injured, affected or made homeless — but not the amount of the damage). Events can be grouped into three main categories:

- Hydrological: floods and landslides
- Meteorological: extreme temperatures, fog and storms
- Climatological: droughts, wildfires, glacial lake outburst

Geophysical events (earthquakes and volcanoes), technological events (industrial accidents) and biological events (from epidemics, insects or animals) are recorded in EM-DAT but excluded from the scores as they are not directly associated with climate change. Scores are hence built calculating the monetary damage as a percentage of GDP[4], summing the hydrological, meteorological and climatological components and considering the latest ten-year average.

The chronic risk component of the EIB Climate Risk Country Scores comprises four subcomponents. None of these are readily available in any structured dataset covering the large number of countries where the EIB is active. Therefore, we had to derive each of the four components, leveraging on existing economic literature to estimate the impact of global warming (Figure 1). The fewer agricultural crops subcomponent is derived, for instance, from estimates of the FAO (2017). This study takes into account various emerging regions (not single countries). The impact of higher levels of seawater has been sourced for each country from a specific study of Diaz (2016). The infrastructure component (the need to upgrade infrastructure) is derived from a World Bank (2016) study, which provides regional estimates for certain regions (East Asia Pacific, Latin America and the Caribbean, South Asia and Sub-Saharan Africa). The impact of heat on productivity has been calculated starting from a time series of monthly average temperatures (from the World Bank). These are mapped with the relationship between the change in temperatures and the respective change in productivity, replicating estimates developed by McKinsey (2020). World Bank data (from World Development indicators) complement these indicators to take into account the role of the different sectors in the economy (agriculture, manufacturing, services, construction and mining as a percentage of GDP), the exposure to seawater ("Population living in areas where elevation is below 5 metres, % of total population"; "Land area where elevation is below 5 metres, % of total land area") and the quality of infrastructure ("Logistics performance index: Quality of trade and transport-related infrastructure").

[4] Gross domestic product (GDP) in nominal terms is sourced from the International Monetary Fund World Economic Outlook dataset.

Table 1: Physical risk components

Dimension	Sub-dimension	Variable used	Unit	Source
Physical risk: acute	Hydrological (floods and landslides), meteorological (extreme temperatures and storms) and climatological (droughts and wildfires) impacts	Damage	% of GDP	EM-DAT
Physical risk: chronic	Fewer crops	Agriculture	% of GDP	WDI
		Production loss	% of GDP	FAO (2017)
	Impact of higher level of seawater	GDP impact	% of total population	Diaz (2016)
		Population living in areas where elevation is below 5 metres	% of total population	WDI
		Land area where elevation is below 5 metres	% of total land area	WDI
	Need to upgrade infrastructure	Adaptation gap	% of GDP	World Bank (2016)
		Quality of infrastructure	Index	WDI
	Impact of heat on productivity	Labour productivity	%	McKinsey (2020)
		Monthly average temperatures	Degrees Celsius	World Bank
Adaptation capacity	Economic ability to respond	Fiscal revenues	% of GDP	IMF
		EIB internal sovereign rating	Rating scale	EIB/ECON
	Institutional ability and governance	Governance indicators	Index	WB
		Human Development Index	Index	UN

The transition risk scores result from the combination of ten different indicators compiled for the period 2010-2017 (see Table 2). The aim is to develop a consistent, credible and quantifiable indicator set that covers all transition risk dimensions and can be applied to a broad selection of countries to identify trends and draw general conclusions.

In particular, data on fossil fuel rents (as a percentage of GDP) were collected by the World Bank. According to the World Bank methodology, the estimates of fossil and solid fuel rents are calculated as the difference between the price of a commodity and the average cost of producing it. This is done by estimating the world price of units of specific commodities and subtracting estimates of average unit costs of extraction or harvesting costs (including a normal return on capital). These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of GDP. In our analysis, a higher indicator will imply higher transition risks.

All energy and climate-related indicators were collected from the Energy Information Administration (EIA). This data source was favoured over the alternative of the International Energy Administration (IEA) as it provides data for 174 countries compared to 134 for the IEA. These (174) countries cover all continents, represent more than 96% of the world's population, and almost 100% and 92% of the world's greenhouse gas emissions and energy consumption, respectively. For the remaining 12 countries for which we could not find data, a score was allocated based on their regional average and expert judgments.

The assessment takes into account the level of CO_2 emissions and energy consumption (representing the degree of energy efficiency), either per person or in terms of GDP depending on the degree of correlation among different indicators. Energy consumption is calculated as the sum of the gross inland consumption of the five sources of energy: solid fuels, oil, gas, nuclear and renewable sources. GDP is at constant prices to avoid the impact of inflation, with a base year of 2010. These indicators identify the extent to which there is a decoupling between energy consumption or greenhouse gas emissions and economic growth or the number of people over time. Relative decoupling occurs when energy consumption or greenhouse gas emissions grow, albeit more slowly than the economy (i.e. GDP) or population. Absolute decoupling occurs when energy consumption or greenhouse gas emissions are stable or fall while GDP or the population increase. Absolute decoupling is likely to alleviate the environmental pressures from energy production and consumption. To that end, higher indicators will imply higher transition risks.

The emission and energy intensity indicators were complemented by the share of renewables in the gross inland energy consumption (as a percentage of total energy consumption). Gross final renewable energy consumption is the amount of renewable energy consumed for electricity, heating and cooling, and transport for a calendar year. The share of renewable consumption provides a broad indication of progress towards reducing the impact of energy consumption on the environment, since energy from renewable sources generally has a lower environmental impact per energy unit on a life-cycle basis than energy sourced from fossil fuels. Increasing the share of renewables in energy consumption will help countries to reduce greenhouse gas emissions from power generation, which accounts for two-thirds of CO_2 emissions globally. To that end, a higher indicator will imply lower transition risks. In other words, this indicator will work in the opposite direction than those of the previous two.

Finally, data on nationally determined contributions[5] (NDCs) were collected by the World Resources Institute (Climate Watch platform). According to these data, an indicator that classifies countries into four categories was developed. Countries with lower ambition levels will receive a higher score, i.e. countries that have not set a climate target for reducing greenhouse gas emissions. The most ambitious countries are considered to be those with only unconditional targets. In addition to this, information from the United Nations report and the IEA's sustainable scenario analysis for the remaining global greenhouse gas emission budget and global energy consumption under the 2˚C and 1.5˚C scenarios were taken into account.

[5] According to Article 4.9 of the Paris Agreement, countries around the world agreed to submit detailed plans to reduce greenhouse gas emissions domestically and make efforts to stabilise the increase in global temperatures well below 2°C, and preferably below 1.5°C (United Nations, 2015).

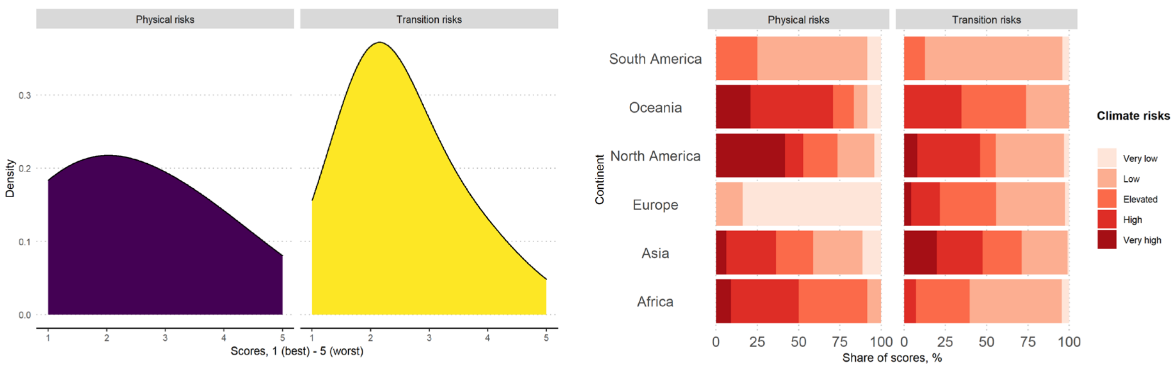
Table 2: Transition risk components

Dimension	Sub-dimension	Variable used	Unit	Source
Exposure	Revenues	Oil, gas and coal rents	% of GDP	WB
	Costs	Current greenhouse gas emissions per capita	MMtonnes CO_2/capita	EIA
		Past greenhouse gas emissions per capita	Annual average change over the past five years (%)	EIA
		Future greenhouse gas emissions per capita	Gap from the 2030 global average (MMtonnes CO_2/capita)	EIA, UN
Mitigation	Energy efficiency	Current energy consumption per GDP	quad BTU/GDP	EIA
		Past energy consumption per capita	Annual average change over the past five years (%)	EIA
		Future energy consumption per capita	Gap from the 2030 global average (quad BTU/capita)	EIA, IEA, UN
	Renewables	Current renewables production in primary energy consumption	% of renewable production in primary energy consumption	EIA
		Past renewables production change	Annual average change over the past five years (%), weighted by the share of annual renewable production in primary energy consumption	EIA
	Climate ambition	Commitments to mitigate greenhouse gas emissions	0-1	CAIT/NDCs

6 Model results

EIB Climate Risk Country Scores assess physical and transition risks for 184 countries[6]. The distribution of both risk scores is right-skewed. This means that most countries are located in the low/medium risk categories, with a few exceptions that are distributed along a long right tail of higher risks. This tail is longer for the distribution physical risk scores than the transition risk scores.

Figure 2: Density plots of climate country scores and share of scores per continent



Note: North America is composed of North America and the Caribbean.

[6] For the scores, please contact the authors.

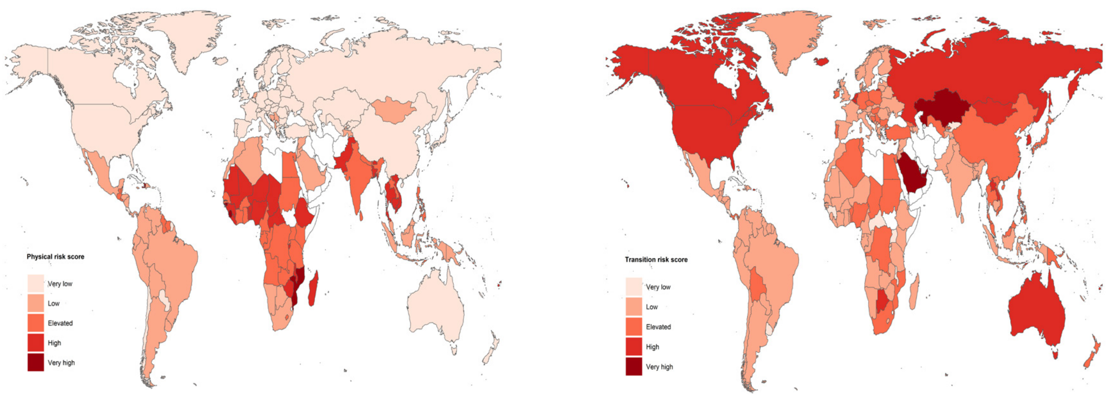
Looking at physical risks, emerging and developing economies, and those exposed to rising sea levels and/or heat are the most vulnerable, with scores ranging from 3-5. Specifically, the Caribbean and Pacific regions face the highest risk due to their exposure to acute risk (hurricanes and tornadoes for instance) and to high levels of seawater going forward. Sub-Saharan African countries are also exposed to significant physical climate risk, especially the chronic component (fewer agricultural crops and lower productivity due to heat, elevated need to upgrade infrastructure). The Middle East and North Africa are mostly exposed to physical chronic risk, implying a gradual impact of climate change on these countries.

Physical climate risk is very relevant for European countries: the acute risk component alone generated damages of more than EUR 60 billion in EU countries between 2010 and 2019, according to EM-DAT. In relative terms (and compared to the size of their economies), however, they are less exposed than other parts of the world. More generally, most advanced countries are less subject to weather events and at the same time have a greater ability to put in place adaptation measures. Having strong institutions, better fiscal capacity and the ability to put in place protective measures tends to protect them from being exposed to the full impact of climate change.

Turning to the transition risk scores, advanced countries are more exposed to the risks stemming from the transition to a net-zero carbon future environment. Generally, fossil fuel-producing countries, advanced countries and those that do not see the transition to a net-zero emissions future as an opportunity (as reflected by renewables deployment and energy efficiency improvements) are the most exposed to transition risk, hence having scores ranging from 3-5. Across continents, Asia, together with Oceania and North America, appear to be the most exposed to transition risks, while Europe, South America and Africa are the least exposed. South American countries are relatively homogenous, with scores close to 2 (low). Oceania, North America and Asia are the most heterogeneous groups.

Focusing on cross-country comparisons, the assessment shows that developing countries are on average less exposed to transition risks. Countries and sovereigns, including Uruguay, Saint Vincent, Costa Rica and Burundi, are the best performers. All these countries present low risk indicators and even their worst ones still outperform those from many other countries. On the other end, Bahrain, the United Arab Emirates, Saudi Arabia, Qatar and Trinidad and Tobago all scored higher than other fossil fuel-producing countries. None of these countries have enough low risk indicators to compensate for the high risk ones. Overall, the scores per subcomponent of the composite indicator reveal that there are countries in the sample with divergent decarbonisation paths, reflecting regional and national climate policy objectives.

Figure 3: Physical (left) and transition (right) risk country scores in the world



7 Conclusions

The European Investment Bank (EIB), the climate bank of the European Union and leading provider of climate finance worldwide, has developed in-house Climate Risk Country Scores as part of its climate risk management framework. The choice to develop these ratings in-house reflects the lack of standards regarding definitions and a modelling approach, and the limited public availability of "country climate ratings" for a wide range of countries. More specifically, two complementary sub-scores, covering more than 180 countries, have been developed: a physical risk score and a transition risk score.

The physical risk score includes the risk of natural disasters (acute risk) as well as more gradual changes (chronic risk), both calculated as the sum of damage, costs and losses as a share of a country's GDP. The adaptation component, which takes into account the ability and willingness of the country to respond to climate risk (i.e. fiscal space, stability, governance and level of development) can partially offset the impact. The impact net of adaptation provides a measure of the average (yearly) burden a country incurs due to climate change-related impacts.

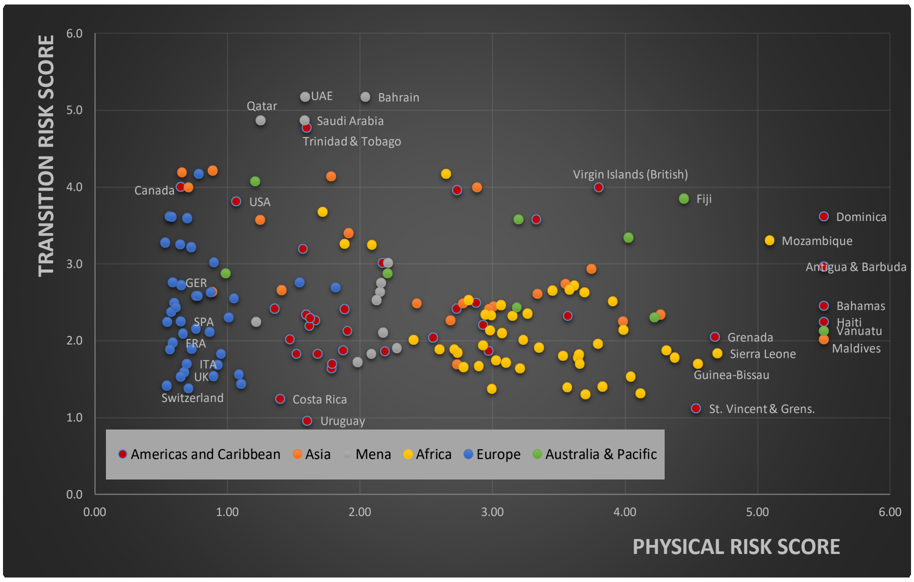
The transition risk score takes into account the exposure of a country to risks stemming from the transition to a low or net-zero carbon future, including total greenhouse gas emissions, and the revenues deriving from fossil fuels. These risks are then adjusted in line with countries' climate strategies, comprising the deployment of renewable energy, energy efficiency improvements and the level of climate ambition as indicated in their nationally determined contribution plans. The transition risk is strictly related to the climate policies which have been put in place to help countries achieve carbon neutrality, in line with the Paris Agreement goals. These climate policies affect the cost of doing business and the returns on domestic assets, increasing the likelihood of carbon-intensive assets becoming stranded.

The Climate Risk Country Scores model uses a number of publicly available sources and various statistical methods, and builds on recent literature. The model scores are complemented by potential expert adjustments ("overrides") by the country economists of the EIB Economics Department to take into account a variety of additional "soft" information not incorporated in the model. Final scores range from 1 to 5 (1 = very low risk; 5 = very high risk). The EIB Climate Risk Country Scores model is flexible and allows for future additions of supplementary modules. It is hence expected to be adapted and fine-tuned in the future, in line with the future availability of better climate data and academic literature on the economic impact of climate change.

The results of the EIB Climate Risk Country Scores model show that climate risk — both physical and transition risk — is a relevant challenge for advanced and emerging countries alike, as no country is immune from their effects. As underlined in section 6, emerging and developing economies, and those exposed to rising sea levels or heat are the most vulnerable to physical risk. At the same time, advanced economies are less exposed (compared to the size of their economies) and have a higher ability to reduce their vulnerability thanks to their economic strength and institutional capacity. However, advanced countries, which consume a large share of world resources and generate significant emissions, generally face higher risks from the transition to a low-carbon economy. The most exposed to transition risk are those with a high dependence on fossil fuel exports and revenues (some Middle Eastern countries for instance, but also countries in Africa and Latin America), and those with low renewables deployment and low energy efficiency improvements.

In general, the highest burden is faced by emerging and developing countries as they are significantly exposed to physical risk, and have lower ability to mitigate the challenges posed by the energy transition. Moreover, developing countries are expected to face even higher transition risks in the near future, if catching up with developed economies entails higher greenhouse gas emissions. A number of low-income and developing countries have — with more intensity than others — the double challenge of having to face high physical risk and high transition risk (Figure 4).

Figure 4: Climate Scores — physical risk (horizontal axis) and transition risk (vertical axis)



Note: Scores range potentially from 0.5 to 5.5; higher scores denote higher risk. Source: EIB

The Country Risk Climate Scores have various practical applications. First, they support risk management, contributing to the assessment of countries (as part of sovereign rating considerations) and to the assessment of counterparts. Knowing the risks each country is facing due to climate change helps to identify the risks borne by the counterparts of that country (corporations, municipalities, households, etc.) and thus enables financial institutions and other players to minimise the potential negative consequences of such risks. At the EIB, the Climate Risk Country Scores will serve as a country anchor for the Climate Risk Screening Tool that is used to assess climate risk for all counterparts (see Annex 8.2 for further details on the tool). Second, the assessment of risks at country level helps to identify mitigation and adaptation priorities and the related most pressing financing needs. Overall, better recognising climate risk — and the consequent (financial and non-financial) need for adaptation and mitigation — ensures that opportunities to enhance climate resilience are not missed. Future refinements, reflecting new insights and better data quality, will further enhance the quality of the model and its assessments.

8 Annex

8.1 Country scores of HSBC and ND-GAIN

HSBC Fragile Planet

HSBC Fragile Planet (2018 edition) is a climate risk indicator covering 67 countries. It is mainly designed to serve the needs of financial investors willing to take climate risk into account in their investment decisions. The HSBC Climate Index (Paun et al., 2018) takes into account the "physical impacts" (i.e. chronic risk, with 25% weight), the "sensitivity to extreme events" (i.e. acute risk, 25% weight), the "energy transition" (25%, which includes the relevance of commodity exports in each country) and the "potential to respond" (25% weight, with variables related to the development of the country and the quality of institutions, such as GDP per capita, debt-to-GDP ratio, rule of law, Corruption Perception Index, etc.).

The HSBC Fragile Planet methodology has two main editions (2018 and 2019) which differ significantly: the 2019 edition no longer incorporates physical risk, while it does include "climate opportunities" (corporate climate revenues, for instance). The 2019 edition uses different weights: 35% for energy transition, 30% for policy and institutions and 35% for climate opportunities. The HSBC methodology constitutes a good starting point for any analysis on climate scores but also has certain drawbacks (see table below), especially related to the limited country coverage, the role of physical and transition risk and how the different dimensions are weighted.

University of Notre Dame Global Adaptation Index (ND-GAIN)

The ND-GAIN Global Adaptation Index (Chen et al., 2015) covers 192 countries and is made up of two main components: vulnerability (i.e. physical risk, including adaptive capacity) and readiness (including social, economic and governance indicators such as Doing Business, corruption, regulatory quality, political stability, etc.), while it does not take into account transition risk. The ND-GAIN index is made up of a large number of indicators (45 indicators — 36 for vulnerability and nine for readiness) with equal weights. The relevance of each single indicator is hence rather low.

Table 3: Characteristics of HSBC Fragile Planet (2018) and ND-GAIN (2015)

HSBC Fragile Planet (2018)	ND-GAIN (2015)
• Well-established methodology • Ability to catch "climate opportunities" (corporate climate revenues in 2019 edition, with 35% weight) • Simple (uses a limited number of factors) • Focus is on comparable scores for financial market investors • 67 countries covered • Identical weightings: 25% for each component • Limited number of chronic risks covered; only reliance on fossil fuels is taken into account for transition risk • Methodology is evolving and changing significantly over time. The change in methodology for the 2019 edition excludes physical risk, adding climate opportunities	• Reliable and state-of-the-art indicator, widely used in the industry • Country coverage: 192 countries • Long-term horizons are considered for various indicators (sensitive to long-term climate models) • Extensive (over 74 variables are considered, but this complicates understanding the main sources of risk) • Variables are equally weighted (for instance, the population living under five metres above sea level has the same weight as paved roads, electricity access or medical staff in calculating physical risk) • Transition risk is not considered and is mainly illustrated by "readiness," i.e. the level of development of the country

8.2 The EIB Climate Risk Screening Tool

The Climate Risk Country Scores serve as country anchor scores for the EIB Climate Risk Screening Tool. The Climate Risk Screening Tool is a counterparty-level assessment methodology developed at the EIB to assess the sensitivity of its counterparties to both physical and transition risks in a consistent manner, with the objective of providing transparency over the portfolio's exposure to climate risk. The EIB assessment pursues the following approach:

- Initial scores take into account the countries (i.e. the EIB Climate Risk Country Scores) and sectors of operations of a counterparty. These initial scores serve as the starting point for the counterparty's climate risk assessment. They are derived from a Group internal physical and transition risk assessment of countries and sectors.
- Adjustments to the initial scores are performed to account for the heterogeneity of counterparties within an industry sector or a region. These adjustments are based on the counterparty's specific vulnerability to physical hazards and, when relevant, on industry-specific quantitative transition risk indicators.
- The combination of the initial score and the adjustments results in a separate "Inherent Risk Score" for physical and transition risk.
- The adaptation and mitigation capacity assessment captures the counterparty's ability to withstand climate hazards and adapt its business model to the requirements of a lower-carbon economy.
- The final scores for each counterpart — with separate scores for physical and transition risk — result from the combination of the "Inherent Risk Score" and the adaptation and mitigation capacity. This is the main outcome of the model, with scores ranging from 1 (lowest risk) to 5 (highest risk).

While the underlying assessment logic is consistent across all credit segments, tailored versions are applied to cover all counterparty types across EIB portfolios, applying to corporates, financial institutions, public sector entities, sub-sovereign public authorities, project finance and (indirect) equity. The output of the Climate Risk Screening Tool is used to assess and monitor climate risk across the EIB Group's portfolio and to report to the EIB Group's governing bodies. The roll-out of the Screening Tool started in July 2020 across the existing lending and investment portfolios. The coverage of the tool is expanding to treasury and derivatives portfolios as well as to new operations. A climate risk assessment will be performed for all new counterparties at appraisal stage, and updated on a yearly basis as part of the annual counterparty review process.

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Assessing climate change risks at the country level:

the EIB scoring model

European Investment Bank
The EU bank

Economics Department
economics@eib.org
www.eib.org/economics

European Investment Bank
98-100, boulevard Konrad Adenauer
L-2950 Luxembourg
+352 4379-22000
www.eib.org – info@eib.org

PDF: ISBN 978-92-861-5034-0