Credit worthiness and portfolio stress testing in a hotter world transitioning to Net-Zero: Development of a global and multisectoral climate stress test model for export credit agencies and steps towards improvement and validation

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Abstract

Climate change presents an increasing material risk to the financial system, driven by more frequent extreme weather events and the ongoing technological and regulatory transition towards a low-carbon economy. These evolving uncertainties challenge conventional credit rating methodologies, underscoring the need for innovative approaches to stress testing investment portfolios.

This paper outlines UK Export Finance's (UKEF's) development of a scorecard-based climate stress test model, designed to project sovereign and corporate credit ratings under a range of physical and transition risk scenarios. The model design choice responds to the need of further understanding the influence of risk channels on ratings and to facilitate sensitivity analysis across these channels. Given UKEF's idiosyncratic, heterogeneous, and globally complex portfolio—spanning multiple sectors and geographies—the model needed to accommodate both global sovereign credit assessments and sector-specific impacts across regions. As an Export Credit Agency (ECA), UKEF required a framework capable of capturing the diverse climate-related risks inherent in its transactions.

Our findings suggest that both physical and transition risks can lead to sovereign downgrades, particularly in countries with hotter climates and economies heavily dependent on fossil fuels. Net-Zero policies are projected to significantly affect credit ratings in sectors such as aviation, chemicals, and fossil fuel-related industries. As climate-related financial risk analysis continues to evolve, fostering collaboration between financial institutions and academia—underpinned by a multidisciplinary approach—will be essential to refine methodologies and support informed decision-making.

Keywords: *globally covering climate stress test model; physical and transition risks; validation; export credit agencies; emerging markets; complex portfolios, climate financial risk*

Disclaimer: The authors would like to emphasise that the results discussed herein, along with their interpretation, represent their own views and do not reflect His Majesty's Government (HMG) policy on the matters addressed in this article.

1. Introduction

Climate risk is a recognised anthropogenic and material threat that has already resulted in widespread adverse economic impacts, costs, and losses. It is expected to further disrupt economic activity, damage assets, and undermine corporate performance and fiscal stability [1, 2].

In response, most sovereigns are implementing decarbonisation policies across various economic sectors to mitigate climate change and adaptation policies to reduce physical climate risks [3, 4]. These transition policies are anticipated to significantly influence sovereign fiscal health and corporate profitability—both positively and negatively [5, 6]. A key function of the financial sector is to allocate capital efficiently, ensuring investments remain resilient to emerging risks and aligned with the organisation's risk appetite. In this context, stress testing exercises are essential to inform senior decision-makers.

Unlike many historically well-understood risks, climate risk is often described as a "green swan" event: its occurrence is certain, but its timing and precise impacts remain uncertain [7]. Meanwhile, the non-linear nature of climate risk calls for immediate risk management, requiring new approaches to risk assessment. This need led G20 members to establish the Task Force on Climate-Related Financial Disclosures (TCFD) in 2015 [8]. TCFD has since been integrated into the International Financial Reporting Standards (IFRS) [9], prudential frameworks and regulatory regimes [10, 11]. Further advancements in climate risk management are required by supervisory expectations, and it is in financial institutions' commercial interest to price risk appropriately to deliver higher returns than their competitors. This asks for developing climate-related impairment metrics, climate risk appetite thresholds, and climate-informed pricing strategies [12, 13].

Ongoing research aims to translate climate risk into quantifiable metrics that financial institutions and multilateral organisations can use to stress test portfolios and model climate-impacted credit ratings. These efforts focus on assessing sovereign and sectoral vulnerability to physical climate risks [14], as well as the challenges faced by sovereigns and corporates in aligning their economic activities with decarbonisation targets and policies. In this context, results from integrated assessment models and various climate and energy scenarios are being employed to evaluate portfolio resilience and systemic exposure to climate risk [15 -18].

Several financial institutions and credit rating agencies have focused their efforts on scorecard-based methodologies to assess climate risk [19-22]. These approaches incorporate various risk transmission channels to define variables associated with physical and transition risks—such as losses from floods or other extreme weather events, and indicators related to carbon and fossil fuel intensity. The scorecard approach allows institutions to tailor modelling tools to their portfolios and assign weights to risk channels according to their specific circumstances. However, the use of different data sources, weighting schemes, averaging techniques, and ranking methods can complicate the comparability of results. Based on these scorecards, decisions regarding potential credit downgrades or upgrades are typically made using expert judgement or internal decision frameworks [19].

Other research has focused on modelling climate-impacted fiscal and macroeconomic indicators as an intermediate step to assess changes in sovereign credit ratings. For example, Klusak et al. 2021 [23] projected sovereign ratings affected by physical risks using a random forest model, informed by climate-impacted GDP trends from Kahn et al. (2021) [24] and fiscal indicators that account for physical risk exposure. Their methodology extrapolated historical correlations between GDP damage and physical risk under various Representative Concentration Pathway (RCP) scenarios, covering 109 countries through to 2100. In 2024, the Bank of England (BoE) developed an in-house Debt/GDP model to produce inputs for projecting sovereign rating notch changes under physical and transition risk scenarios [25].

The projected Debt/GDP trends were based on climate impacted fiscal revenues and expenditures, accounting for investments in green technologies, changes in fuel duty and fossil fuel production taxes, carbon taxation, and the impact of lower economic growth due to chronic physical risks and acute physical risk driven expenditure. These expenditure and revenue streams were modelled on the basis of data from NGFS (Network for the Greening of the Financial System) Phase III scenarios [26], covering five scenarios in terms of speed and magnitude of physical and transition risks up to 2050 and focussing on a limited number of countries (mostly developed economies). The OECD's 2025 Global Debt Report [27] also examined the impact of transition investments on sovereign debt, considering different decarbonisation pathways and financing assumptions. Similarly, the Office for Budget Responsibility (OBR) analysed the effects of economic damage, decarbonisation investments, and fiscal revenue losses on UK debt trajectories under various scenarios [28]. These studies consistently highlight the potential for significant increases in projected Debt/GDP ratios, which could materially affect sovereign credit ratings—a topic further explored in a companion paper submitted by the authors to this conference ("Increasing fiscal and credit risks for nations in a hotter and net-zero bound world: Global covering modelling framework to project climate impacted fiscal indicators and changes to sovereign ratings ").

Additional modelling tools have been developed to assess the impact of climate-related physical and transition risks on corporate cash flows and asset values via Merton-type models [29] to estimate probabilities of default based on future cash flows and debts. For instance, in the context of NGFS Phase V short-term scenarios [30], changes in default probabilities due to climate risks have been reported for 50 sectors across multiple regions, as well as for major sovereigns from 2025 to 2030. These results were derived by integrating outputs from the GEM-E3 general equilibrium model [31] into the CLIMACRED framework [32], which builds on the concept of Climate Policy Relevant Sectors (CPRS) [6] and links service demand, fuel consumption, production, and emissions trajectories.

Export credit agencies (ECAs)—such as UK Export Finance (UKEF)—typically manage globally diversified portfolios that span a broad range of economic sectors. Due to their mandate, ECAs frequently finance transactions in developing and emerging economies. These regions are generally more exposed to physical climate risks, tend to have lower credit ratings, and face greater uncertainty regarding the implementation of transition policies. Furthermore, climate modelling in these contexts is often less reliable, primarily due to the limited availability of high-quality data needed to support robust projections. In recent years, ECAs have stepped up efforts to decarbonise their project pipelines [33] and are increasingly recognised as key actors in the mobilisation of climate finance. Nevertheless, fossil fuel and other high-carbon exposures still account for approximately 29% of portfolios [33] among ECAs operating under the OECD Arrangement [34]. It is worth also noting that, under the OECD Agreement [34], ECAs may support transactions with maturities of up to 15 years—and up to 22 years for eligible low carbon energy projects. These portfolio characteristics highlight the need for robust modelling tools capable of assessing climate-impacted credit ratings and conducting stress tests with appropriate geographical, sectoral, and temporal coverage.

Given the global and sectoral coverage of UKEF's portfolio, and the associated complexities, the authors adopted a scorecard-based approach—drawing on data from NGFS Phase IV—for the development of the presented climate stress test model, covering both sovereign and corporate exposures. This approach was selected as it enables a clearer understanding of the contribution of various drivers to climate-impacted rating changes, facilitates the use of weights that reflect risk transmission channels across regions and sectors, and supports further analysis of uncertainty in key risk drivers. The presented model is used to assess UKEF's portfolio exposure to both physical and transition climate risks. In addition to detailing the model itself, this paper describes a validation exercise designed to benchmark the expert judgement applied when converting risk scores into sovereign and credit rating notch changes.

In line with UKEF's commitments under the TCFD framework [8, 35], and UK government requirements [36] for the periodic assessment of long-term climate risk exposure, the model is used regularly to stress test UKEF's portfolio. Methodological assumptions, data inputs, and the approach for translating risk scores into rating changes are subject to ongoing review and validation.

This paper aims to contribute to the broader discussion on climate stress testing frameworks, offering insights into result validation and limitations derived from the unprecedented nature of climate financial risks. It places particular emphasis on portfolios with diverse geographical and sectoral exposure, such as those managed by ECAs. Following this introduction, the paper outlines key methodological aspects of UKEF's climate stress test model, presents results from its sovereign and corporate components, and details the validation exercises undertaken. The concluding sections contextualise the findings, focusing on uncertainties and data limitations, and are aimed to highlight the need of further research in the development of global covering climate stress test modelling tools.

The authors would also like to emphasise that the results discussed herein, along with their interpretation, represent their own views and do not reflect His Majesty's Government (HMG) policy on the matters addressed in this article.

2. Methodology

The UKEF climate stress testing model comprises two key subcomponents: a sovereign sub-model and a sectoral sub-model. Both are designed to project climate-related risk scores and resulting climate-adjusted credit ratings across six five-year periods, from the present day through to 2050. The model incorporates scenarios developed under Phase IV of the NGFS framework [26][1], supplemented with data from additional sources such as Climate Analytics [37] and the World Resources Institute's Aqueduct project [38].

2.a. Sovereign Model

The sovereign component of the model covers 209 countries & territories, projecting scores for both physical and transition climate risks and translating them into potential and unmitigated changes in sovereign credit ratings for climate stress testing purposes. Physical risks considered in the model include the impacts of floods, cyclones, heatwaves, wildfires, crop failures, droughts, and water stress. Transition risks relate to the challenges sovereigns may face in meeting or aligning with net-zero targets. In this regard, the model takes into account sovereign GDP growth, the projected development of renewable energy sources, reliance on oil rents, and the assumed ambition and timeframe of emissions reduction commitments. **Table 1** and **Table 2** present the physical and transition risks assessed in the model, respectively, along with their corresponding data sources.

Table 1. *Physical risks considered in UKEF' sovereign climate stress test model, data sources and description*

Variable	Data source	Description
Annual expected damage from river floods	Climate Analytics, (on the basis of NGFS scenarios) [37]	Relative change in annual expected damage from river floods (expressed as % of change against the reference period, 1986-2006).
Annual expected damage from cyclones		Relative change in annual expected damage from cyclones (expressed as % of change against the reference period, 1986-2006).

[1] We have considered the results projected using the REMIND-MagPie model, particularly for the following scenarios: Current Policies, Delayed Transition, Fragmented World, Low Demand, and Net Zero [26].

Labour productivity due to heat waves	Climate Analytics, (on the basis of NGFS scenarios) [37]	Relative change in labour productivity due to heat stress (expressed as % of change against the reference period, 1986-2006).
Land fraction annually exposed to crop failures		Change in land fraction annually exposed to crop failures (expressed as % of change against the reference period, 1986-2006).
Land fraction annually exposed to wildfires		Change in land fraction annually exposed to wildfires (expressed as % of change against the reference period, 1986-2006).
Drought risk index	WRI, Aqueduct project [38]	The drought risk measures where droughts are likely to occur, the population and assets exposed, and the vulnerability of the population and assets to adverse effects.
Water stress		Baseline water stress measures the ratio of total water demand to available renewable surface and groundwater supplies.

Table 2. *Transition risks considered in UKEF' sovereign climate stress test model, data sources and description*

Variable	Data Source	Description
GDP growth rates	NGFS Phase IV [26]	GDP growth rates for developed and developing countries, across scenarios and time horizons.
Carbon taxes as share of GDP		Carbon taxes are estimated as the product of fossil CO_2 emissions and carbon prices. This indicator measures the ratio of Carbon costs and sovereign GDP, across scenarios and time horizons.
Fossil energy cost as share of GDP		Energy costs are quantified as the product of primary fossil prices (for energy vectors) and primary fossil energy consumption. This indicator measures the ratio of Energy costs and sovereign GDP, across scenarios and time horizons.
Shares of renewables as total primary energy consumption		Ratio of primary energy consumption (supplied by renewables) and total country-level primary energy usage – across scenarios and time horizons.
Current Policy Commitment	Net Zero Tracker [3]	Pledges proposed, assumed or legally binding decarbonisation targets
Oil rents as share of GDP	World Bank [39] and NGFS Phase IV [26]	Modelled accounting for current shares of oil rents in GDP, reported by the WB [39], and projections for global oil production [26].

In designing the scorecards, variable selection reflects the main climate physical and transition risk channels identified in previous studies conducted by financial institutions, academic bodies, and credit rating agencies [19–23]. The selection process also ensures non-collinearity and provides globally consistent coverage. Various approaches were considered for defining variable weights. These included statistical techniques based on variance dispersion (e.g. the principal component analysis method), estimates of potential economic damage associated with specific risk perils, expert judgement, and a review of relevant literature—particularly to benchmark weightings assigned by other institutions for comparable risks [19 -21]. These approaches align with best practices recommended by the OECD for the development of composite indicators [40].

For each variable, the corresponding value for a given sovereign was ranked according to scenario type and time horizon. A composite score was then calculated based on the assigned weights for each variable and the relative position of each data point. Total sovereign physical and transition risk scores were also ranked by scenario type and time horizon, with the resulting ranking positions mapped to a maximum downgrade scale. Additionally, score ranges were defined to allow for potential upgrades, particularly in cases where competitive advantages may emerge from the transition to net zero.

Initial maximum downgrade assumptions were based on expert judgement, informed by historical credit downgrades linked to natural catastrophes and supported by literature projecting notch changes due to physical and transition risks [23, 25]. These assumptions were validated through the development of a climate-impacted debt-to-GDP model (see the paper titled "Increasing fiscal and credit risks for nations in a hotter and net-zero bound world: Global covering modelling framework to project climate-impacted fiscal indicators and changes to sovereign ratings"), which provided inputs for a random forest-based credit rating model. The climate-impacted debt-to-GDP figures were constructed using a methodology similar to that of the Bank of England [25], incorporating the effects of physical and transition risks on sovereign fiscal revenues and expenditures. These figures were subsequently used as inputs to an in-house random forest credit rating model, which was employed to project climate-impacted ratings for a sample of countries under scenarios of high physical and transition risk across various time horizons. The maximum observed potential downgrades ranged from one to four notches for physical risks, with most affected countries experiencing downgrades of up two notches. For transition risks, the maximum downgrade observed was three notches, thereby confirming the initial assumptions regarding maximum notch changes.

It is important to note that the projected sovereign notch changes should be interpreted as potential and unmitigated variations in sovereign credit ratings. Due to the way the model was developed, it does not account for fiscal flexibility that sovereigns may currently possess to finance adaptation measures, nor does it consider the potential for economic diversification in oil-producing countries. In our view, the results of this stress testing exercise should be used in conjunction with a broader framework that enables decision-makers to incorporate these mitigating factors—an approach also recommended in the work published by the European Investment Bank (EIB) [19, 41].

2.b Sector Model

The sectoral component of UKEF's climate stress test model examines how the transition to Net Zero could affect 16 economic segments relevant to UKEF's portfolio. These segments include: Aviation; Buildings; Cement Production; Chemical Manufacturing; Steel and Metal Industries; Financial Services and Insurance; Combustion-Based Land and Sea Transport; Electromobility; Geothermal Energy; Hydroelectricity; Nuclear; Solar; Wind; Oil & Gas; Thermal-Based Electricity; and a residual category labelled "Others". These sectors are assessed across 14 global regions: Canada, New Zealand, and Australia; China; Russia and Countries from the Reforming Economies of the Former Soviet Union; European Union and the UK; India; Japan; Lain American and the Caribbean; Middle East, North Africa, Central Asia; Non-EU28 Europe; Other Asia; Sub-Saharan Africa; and the United States of America). This sectoral and regional breakdown encompasses a substantial share of global gross value added and reflects a wide range of decarbonisation policy instruments and geographical challenges.

The model generates scores across various NGFS scenarios [26] and time horizons, based on changes in sectoral gross value added, regional and sector-specific carbon taxation, energy prices, and carbon footprints. It enables comparisons of how transition risks may affect the creditworthiness of different sectors within a region. Conversely, it allows benchmarking of how a specific sector's creditworthiness may vary across regions due to differences in climate mitigation policies or fuel costs. **Table 3** presents the variables considered in the sectoral model.

Table 3. *Variables considered in the corporate component of the UKEF's climate stress model to assess sectoral and regional transition risks*

Variable	Data Source	Description
Evolution of gross value added for the sector, in comparison with the reference year	CBES [42]	Represented as annualised returns derived from sectoral gross value added. Data for the UK has been extrapolated to other geographies.
Evolution of carbon taxation related costs for the sector, in comparison with the reference year	NGFS Phase IV [26]	This accounts for the impact of carbon taxes associated with the different sectors. Estimated as the product of sectoral, regional, and scenario-based fossil CO_2 emissions and carbon prices divided analogous figure for the reference year.
Evolution of energy costs for the sector, in comparison with reference year		This accounts for the impact of energy costs associated with the different sectors. Estimated as the product of sectoral, regional, and scenario-based emissions and carbon prices divided analogous figure for the reference year.
Current Carbon Footprint	NGFS Phase IV [26] and various literature sources for current sectoral Gross Value Added (GVA) across world regions	Current carbon footprint (expressed as emissions per unit of monetary output, for the different sectors across world regions) has been estimated using fossil CO_2 emissions reported by NGFS and different sources for sectoral and regional GVAs.

The variable selection responds to key climate and energy transition related indicators expected to impact on corporate finance stability and resilience, as underlined by previous works [19-23, 30-32]. For each variable, the final scores are ranked to create segmentations, effectively standardising the scores into discrete buckets. These standardised scores are then aggregated to produce a final score for each unique combination of sector, region, scenario, and year. A probit-type model is employed to convert climate risk scores into probabilities of default (PDs). Notch changes are subsequently defined by accounting for the climate-adjusted PDs alongside the S&P 10-year default probability [43]. This approach was adopted given its common use in corporate credit rating modelling [44], particularly in contexts where data is scarce or where further assumptions are not available.

3. Results

This section provides a summary of the key trends observed for climate impacted sovereign and sectoral credit ratings, based on model runs using scenarios from NGFS Phase IV, as well as insights from the conducted validation exercise for benchmarking maximum sovereign downgrades. It is worth noting that these results derive from a stress test exercise, aiming to identify sovereigns and sectors at risk, to prompt further in-depth analysis in terms of possible and relevant mitigants.

3.a. Changes to sovereign credit ratings

Physical and transition risks are expected to affect sovereign credit ratings over the coming years. The most significant downgrades due to physical risks are observed under scenarios such as Current Policies (CP), Delayed Transition (DT), and Fragmented World (FW)[2], which assume more frequent and severe weather events. Within these scenarios, greater impacts are projected over longer time horizons (in this analysis: 2050). Sovereigns in regions such as Africa, the Middle East, Central America, and South-East Asia are expected to face the largest downgrades related to physical risks (**Figure 1**), particularly if adaptation measures are not implemented by their respective governments. Downgrades for some countries in these regions could range between 1.5 and 2 notches under the Current Policies 2050 scenario (risk scores modelled using NGFS Phase IV data). As previously noted, the presented climate stress testing model focuses on unmitigated risks and does not account for potential future adaptation measures that sovereigns may undertake, nor for the fiscal or economic buffers they may possess to support such actions.

The transition to net zero is projected to have the greatest impact on sovereigns whose economies are heavily dependent on fossil fuel rents and whose energy systems exhibit a high reliance on fossil fuels. In this context, the largest potential downgrades (between 2 and 3 notch downgrades) are modelled for sovereigns in the Middle East, and economies with a significant reliance on coal (**Figure 2**). These are observed under scenarios where decarbonisation policies are implemented in an orderly manner, such as the Net Zero and Low Demand scenarios (between 2030 and 2040), as well as in scenarios involving more abrupt decarbonisation policy responses, such as Delayed Transition (between 2035 and 2045). It is important to note that these potential notch changes should be interpreted in the context of sovereigns not diversifying their economies, and they do not account for possible fiscal or economic growth levers that could support such diversification.

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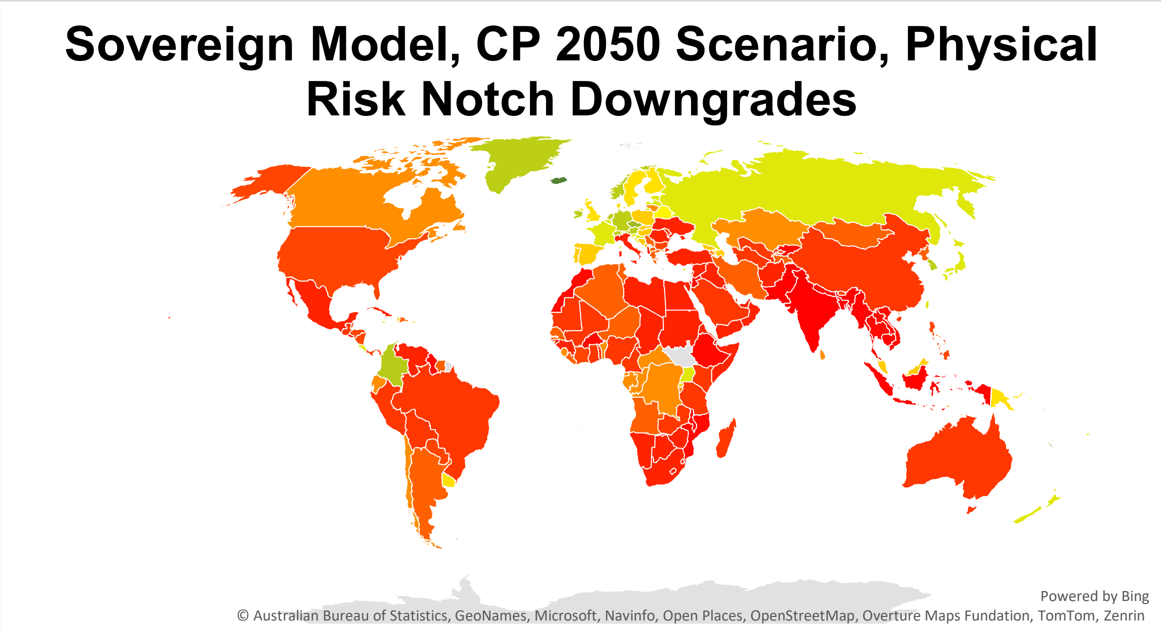
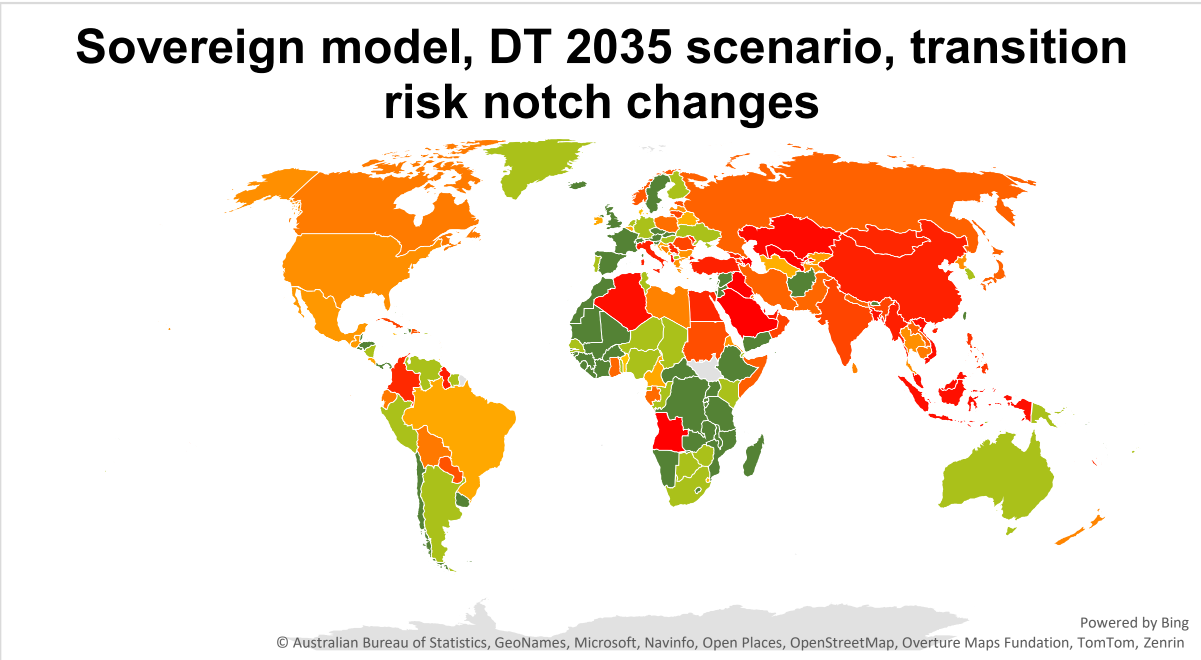
[2] For further details on the scenario narratives, please refer to the NGFS website [26]. In brief, the *Current Policies* scenario reflects high physical risks and low transition risks, as it assumes no additional climate mitigation measures are implemented. The *Delayed Transition* and *Fragmented World* scenarios, by contrast, assume regionally and temporally varied implementation of climate mitigation policies.

Figure 1. *Projected unmitigated changes to sovereign credit ratings under the Current Policies scenario for the 2050-time horizon (considering NGFS Phase IV data). The colour scale ranges from green to red, where green indicates limited impacts on credit risks and red progression towards maximum unmitigated physical risk projected by the developed model. These projections do not account for potential adaptation measures that countries may implement or their economic and fiscal resilience to do so.*



Source: UKEF modelling

Figure 2. *Projected unmitigated changes to sovereign credit ratings under the Delayed Transition scenario for the 2035-time horizon. The colour scale ranges from green to red, where green indicates limited impact in credit risk and red progression towards maximum unmitigated transition risks projected by the developed model. These projections do not account for potential measures sovereigns may take to diversify their economies, nor do they consider the fiscal buffer available to support such changes in economic matrices.*



Source: UKEF modelling

3.b. Sectoral corporate risk scores and credit ratings

Decarbonisation is projected to affect corporate creditworthiness through region- and sector-specific carbon and fuel taxation, as well as current and anticipated levels of technological adoption—based on the assumptions underpinning various NGFS scenarios [26]. Sectors with high carbon intensity are expected to experience the most pronounced credit downgrades within each region and at a global level, particularly under scenarios and timeframes where decarbonisation measures are assumed to be implemented. These include the Low Demand and Net Zero scenarios (2030–2040), and the Delayed Transition scenario (2035–2045), as illustrated in **Table 4** and **Table 5**. It is important to note that individual firms within a given sector may adopt technologies to mitigate transition risks. For example, some may partially replace fossil fuels with low-carbon alternatives or implement carbon capture technologies to reduce exposure to future carbon taxation. However, the scope of this article is to provide a sector-wide overview, rather than to assess firm-level mitigation strategies.

Table 4. *Projected global exposure average climate impacted notch changes across key economic segments, on the basis of the results from the sectoral component of the developed climate stress test model.*

Global exposure average notch change for key economic segments	NZ, 2035	NZ, 2040	DT, 2035
Chemicals	-3	-3	-3
Aviation	-2	-2	-3
Buildings	-2	-2	-2
Oil & Gas	-3	-2	-4
Financial services	-2	-1	-2
Wind power	2	2	2

Source: UKEF modelling

Table 5. *Projected global exposure average climate impacted notch changes across key economic segments, on the basis of the results from the sectoral component of the developed climate stress test model.*

EU27+UK exposure average notch change for key economic segments	NZ, 2035	NZ, 2040	DT, 2035
Chemicals	-2	-2	-2
Aviation	-2	-2	-3
Buildings	-2	-1	-1
Oil & Gas	-2	0	-3
Financial services	-2	-1	-2
Wind power	0	0	0

Source: UKEF modelling

When assessing most sectors across global regions under a given climate mitigation-oriented scenario and time horizon, changes in creditworthiness may reflect the relative challenges each region faces in implementing decarbonisation measures. This assumption is based on the premise that the global economy is *collectively striving* to reduce emissions in these sectors, and that legislation and carbon pricing policies may be applied across all world regions for a given sector. Such trends were observed in scenarios with ambitious decarbonisation targets and short- to medium-term timeframes, such as Net Zero by 2035. For example, if global emissions reduction targets were imposed on key sectors such as chemical manufacturing by 2035, companies operating in developed regions—such as the EU27+UK, where low-carbon technologies are currently more widely adopted within these sectors—would likely be less adversely affected than their counterparts in other regions. This explains the lower potential downgrades observed in comparison with the global UKEF portfolio. In less technologically advanced or economically constrained regions, firms may face greater difficulties in meeting these targets, which could negatively impact their creditworthiness. In the case of low-carbon technologies—particularly those related to wind power—the model focuses on regional potential for wind power development. As a result, regions outside the EU27+UK may exhibit greater potential due to higher wind resource availability, which translates into stronger global creditworthiness performance. In Net Zero scenarios, sectoral creditworthiness tends to remain stable or improve as we move towards 2040.

At both global and European levels, the largest downgrades are observed under Delayed Transition scenarios, which assume abrupt technological and regulatory changes. In the case of high carbon-intensive sectors, better credit performance is also seen within regions that have begun decarbonising early. This reflects the same patterns described above in terms of progress towards climate mitigation targets, aligning with the narrative of the Delayed Transition scenarios.

The authors have compared regional sectoral trends against short-term scenarios released by the NGFS [30], which present adjustments to probability of default (PDs) over a shorter time horizon and use different methodologies, such as valuation-based models. Despite these methodological differences, the trends presented here align in terms of regional directionality for sectoral creditworthiness when compared with the Highway to Paris scenario, which appears most closely aligned with the Net Zero-type scenarios discussed in this article and in the NGFS long-term framework.

3.c. Validation exercises for sovereign downgrades

Maximum downgrade thresholds—derived from expert judgement and a review of the literature on sovereign physical and transition risks—were validated by benchmarking them against climate-impacted ratings projected using a random forest-based forecasting model. This model was inputted with internally developed climate-impacted fiscal indicators, including revenue and expenditure streams, debt-to-GDP ratios, and climate impacted fiscal indicators from the NGFS scenarios [26]. The methodology applied is consistent with that used by the Bank of England [25] and Klusak et al. [23]. Further results from this exercise are presented in the paper entitled "Increasing fiscal and credit risks for nations in a hotter and net-zero bound world: Global covering modelling framework to project climate impacted fiscal indicators and changes to sovereign ratings" also submitted to this conference". The random forest model projected potential sovereign credit rating downgrades of up to three notches under high-transition risk scenarios, compared to a baseline scenario assuming no physical risk impacts and current decarbonisation policies. The most significant downgrades were observed in oil-producing countries, where a marked increase in debt-to-GDP ratios was driven by reduced oil demand in a transitioning global economy. This aligns with the results presented in section 2, both in terms of geographical distribution and magnitude of the notch changes, reflecting the trends as well presented by previous works [19]. For developed economies, both the scorecard model and the random forest model project transition related sovereign downgrades of up to 1 notches, with some nations improving their fiscal or creditworthiness due to transition related competitive advantages, such as potential for renewable energy production.

Regarding physical risks, the internally modelled fiscal indicators used in the random forest model accounted only for chronic impacts, derived from reduced fiscal revenues due to slower economic growth. The random forest model was run using fiscal indicators based on GDP impact data from NGFS Phase IV and Phase V, with the latter incorporating updated damage functions that reflect greater chronic physical damage. Using NGFS Phase IV data, the model projected maximum downgrades of around one notch under scenarios such as Current Policies with a 2050-time horizon. In contrast, when using NGFS Phase V data, the model projected maximum downgrades of up to four notches, with most affected countries experiencing downgrades in the range of up two notches.

Given the inherent challenges in validating credit stress test models—particularly the inability to back-test future scenario narratives—we conclude that benchmarking expert-based downgrade assumptions against projections from traditional credit models, informed by climate-impacted indicators, supports the appropriateness of the downgrade thresholds used in the UKEF climate stress test model.

4. Limitations and future work

Climate financial risk and stress testing is an evolving field, with methodologies still under development and reliant on climate and energy scenarios that are themselves continuously improving. The unprecedented nature of these risks, combined with inconsistent mitigation policies, challenges conventional credit rating approaches. Further complexity arises from the absence of standardised assessment frameworks and the inability to back-test results.

In this paper, a global covering climate stress test score-card based model has been developed, on the basis of the data from NGFS Phase IV scenarios [26], to project climate impacted sovereign and corporate ratings. The author acknowledges limitations in the following domain, leading to future research to overcome the associated challenges:

- *Variable selection and weighting*: The authors have conducted an in-depth literature review and considered risk channels also assed by other financial institutions. However, given the evolving nature of the climate stress test field, more accurate, benchmarked or further disaggregated data could be available in the future. Given the model is part of a Continuous Improvement Process, the considered variables and weights tend to be periodically reviewed to account for the above.

- *Conversion of scores to notch changes*: The authors are conscious of the need to refine methods to convert risk scores to notch changes. A benchmark between assumed expert-judgement and literature-based notch changes and a random-forest credit model was conducted, showing alignment in terms of maximum downgrades. Nevertheless, the authors are of the opinion that this an area of continuous improvement, requiring further research and benchmarking exercises against the work conducted by other financial institutions.

- *It is important to note that the model reflects unmitigated risks.* Countries and corporates can reduce exposure through measures such as economic diversification or climate adaptation strategies. Some models in the literature attempt to incorporate these mitigants based on current conditions or national adaptation plans. In practice, financial institutions and credit ratings agencies appear to use climate stress-test results primarily to identify vulnerable sectors and geographies, then assess existing or potential mitigants before considering rating adjustments [19, 38].

Despite these limitations, it is essential for financial institutions to develop climate stress-testing frameworks to quantify climate risk and allocate capital efficiently, by pricing risks appropriately. Collaboration between financial institutions, academia, and regulators is critical to achieving this.

5. Conclusions

This paper presents a novel global, multi-sector climate stress-testing scorecard-based model designed to project the impact of physical and transition risks on sovereign and corporate credit ratings aiming for a medium and long-term perspective. The proposed modelling framework may be particularly relevant for financial institutions with significant exposure across multiple world regions, such as export credit agencies. The model draws on NGFS Phase IV scenarios and incorporates expert judgement-based assumptions regarding maximum rating notch changes.

Physical risks are projected to have the greatest long-term impact in tropical and subtropical countries, especially those with agriculture-based economies and weaker credit ratings. Transition risks—such as reduced fossil fuel use—are likely to affect oil-producing nations, some of which also face productivity losses due to rising temperatures, leaving them exposed to both physical and transition risks. High-carbon sectors show the largest projected rating downgrades when considering scenarios compatible with net-zero trajectories whilst showing different changes in their credit ratings, based on regional circumstances.

Despite inherent methodological limitations, the model highlights the importance of enhancing efforts to assess climate-related financial risks and to develop robust stress-testing frameworks—particularly for institutions with globally diversified portfolios or significant exposure to climate-sensitive regions and sectors. Future improvements to the modelling tool include developing a more systematic methodology for converting risk scores into notch changes, further incorporating adaptation and transition mitigants to complement model results, reviewing variable weightings, and updating inputs to reflect the latest NGFS scenarios.

Through this work, the authors aim to underscore both the importance and the modelling challenges associated with developing globally comprehensive climate stress-testing models. They stress the need for collaboration between financial and academic institutions in terms of knowledge sharing, validation, and benchmarking exercises.

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