How to use historical data to model climate risk adjusted LGD

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Introduction

Loss Given Default (LGD) is usually predicted based on historical data, such as customer behaviour, macroeconomic variables and historical recoveries, using modelling techniques like beta, censored or other regression models. Incorporating climate-related variables, such as global temperatures or sea levels, directly into these models as predictors of LGD would be difficult to justify. This is because the theoretical foundation has not been established or the empirical evidence has not yet existed. Consequently, direct use of climate-related variables in the existing LGD modelling framework would be challenged.

To overcome these challenges, we propose a two-stage model. The first stage involves borrowing approaches used in natural sciences to estimate the **climate change impact** on adverse climate 'events' such as: flooding, severe drought, hurricanes, etc. Stage two leverages traditional statistical models used to estimate the direct **financial impact** of adverse climate events in local area and damage functions used to quantify the **macroeconomic impact** of climate change. The proposed two-stage modelling approach provides a feasible method of quantifying the impact of climate change on LGD using historical data which would not be possible to use in one single, direct model.

Stage 1: Historical modelling in climatology and meteorology

Stage 1 requires estimating how the likelihood and severity of adverse climate events change because of a rise of climate-related variables, such as a global temperature rise. This relationship has been addressed extensively by existing meteorological and climate science literature. A handful of examples of how climatologists have used historical data to estimate how the frequency and severity of adverse climate events are likely to grow over time is provided below:

- **Flooding**: Marsooli et al. (2020) predict an increase in localised flooding under the IPCC RCP 8.5[1] climate change scenario caused mainly by sea level rise.
- **Extreme drought**: Kim et al. (2020) leverage research from the Australian Agriculture and the Resource Economics Bureau which estimate a 36% decline in cereal crop yields in Australia due to extreme drought under RCP 8.5 climate change scenario.
- **Wildfires**: Dupuy et al. (2020) conduct an extensive review of multiple studies to predict a relative increase in mean seasonal fire danger ranged between 2 and 4% per decade in the Mediterranean regions of Europe.

To help illustrate the advantage of climatological models we focus on the example of the relationship between hurricanes and climate change.

Knutson et al. (2020) conducts an extensive literary review of a large number of climatology authors assessing of the impact of climate change on the severity and frequency of tropical cyclones (TCs). Based on an assumption of a 2°C increase in topical temperatures, we can infer three key findings from this study:

1. Climate change increases expected precipitation from TCs, with an average projected increase of 14%.
2. There is broad consensus that climate change increases TC intensity, with projected increases in surface wind speeds ranging from 1% to 10%.
3. There is no clear impact of climate change on the overall frequency of tropical cyclones, with model results ranging from −28% to +22%. However, there is clear evidence supporting an increase in the frequency of the most severe TCs (categories 4 and 5[2]), with a median projection of a 13% increase in frequency.

Stage 2: Statistical simulation of direct financial impact

Due to the complexity, lack of experience and additional resource requirements, banks might be reluctant to develop robust climatology and meteorology models by themselves. Nevertheless, they can leverage from the estimation results of the existing models, construct their own statistical distributions of adverse climate events and analyse their financial impact.

That would require to first construct statistical distributions of the likelihood and severity of the adverse climate events based on local historical data. Then, the historical distributions can be adjusted by applying the estimation results from stage 1 and project the future distributions. A damage curve can then be applied with considerations of the nature of the adverse climate-event to quantify the future losses. Based on the adjusted distributions and damage curve specification, Monte Carlo simulations are then run to predict the direct

[1] The Representative Concentration Pathways (RCPs) describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. RCP 8.5 is the scenario with very high GHG emissions.

[2] The categorisation of tropical cyclones here is based on Saffir-Simpson Hurricane Wind Scale where category I refers to lower severity of tropical cyclones and category IV refers to higher severity.

financial impact. Banks can translate the simulated direct financial impact (e.g., damage losses of properties, constructions) to their haircut models, counterparties' financial statements and operational risk models to measure the impact of traditional risk types such as LGD in credit risk and operational risk. With local historical data being used, this approach can assure that local-specific climate phenomena are captured with a certain degree of interpretability of the results.

Conclusion

Using historical data to model climate risk is often obscure but it is not impossible. Overcoming the challenge of lack of historical data and limited empirical evidence between climate change and traditional credit risk measures, such as the LGD, may require to replace traditional modelling techniques with multi-step approaches that often rely or leverage from results of the existing literature. With the increasing public awareness of storing more climate related data, we are convinced that in the future modelling climate risk will take a standardised and simplified form.

Our next article will be discussing how to use historical data to model climate risk adjusted Probability of Default (PD).

References

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