



# Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness

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In this paper we bridge the gap between climate science and real-world financial indicators, focusing on a metric that is eminently familiar to financial decision makers: the sovereign credit rating. By linking climate science with economic models and real-world best practice in sovereign ratings, we simulate the effect of climate change on sovereign credit ratings for 108 countries under three different warming scenarios.

Sovereign ratings are reported using a 20-notch scale, where AAA is 'prime high grade' and anything below BBB- is considered 'speculative' (or informally, 'junk'). We convert this into a numerical scale and use a machine learning model to predict creditworthiness, training it on ratings issued by S&P (one of the largest credit ratings agencies) from 2015-2020. Next, we combine climate economic models and S&P's own natural disaster risk assessments to develop a set of climate-adjusted data. We use these to simulate the effect of climate change on sovereign ratings. Finally, we calculate the additional cost of corporate and sovereign debt due to climate-induced sovereign downgrades.

We focus on sovereign ratings because they are already used in a range of financial decision-making contexts (e.g. under Basel II rules, ratings directly affect the capital requirements of banks and insurance companies). They cover over US\$ 66 trillion in sovereign debt, acting as 'gatekeepers' to global financial markets. Sovereign downgrades increase the cost of both public and corporate debt, influencing overall economic performance and significantly affecting fiscal sustainability.



We document three key empirical findings. First, in contrast to much of the climate-economics literature, we find material impacts of climate change as early as 2030. In one realistic scenario, we find that 63 sovereigns suffer climate-induced downgrades of approximately 1.02 notches by 2030, rising to 80 sovereigns facing an average downgrade of 2.48 notches by 2100. The most affected nations include Chile, China, Slovakia, Malaysia, Mexico, India, Peru and Canada. More importantly, our results show that virtually all countries, whether rich or poor, hot or cold, will suffer downgrades if the current trajectory of carbon emissions is maintained.

Second, our data strongly suggests that stringent climate policy consistent with the Paris Climate Agreement will result in minimal impacts of climate on ratings – with an average downgrade of just 0.65 notches by 2100.

Third, we calculate the additional costs to sovereign debt – best interpreted as increases in annual interest payments due to climate-induced sovereign downgrades – in our sample to be between US\$ 22–33 billion under a low emissions scenario known as RCP2.6, rising to US\$ 137–205 billion under RCP 8.5. These translate to additional annual costs of servicing corporate debt ranging from US\$ 7.2–12.6 billion to US\$ 35.8–62.6 billion in each case.

There are caveats. There are no scientifically credible quantitative estimates of how climate change will impact social and political factors, so these are excluded from our model. Thus, our findings should be considered as conservative. Moreover, our results should be understood as scenario-based simulations rather than predictions. We do not comment on the relative probabilities of any given warming scenario playing out in practice.

The key take-home message is that existing climate science and economics are capable of supporting credible, decision-ready green finance indicators. Governments issue ever-longer dated bonds, of which life insurance companies and pension funds are eager buyers, thus enabling them to match their own long-term liabilities. Therefore, investors should consider the long-term creditworthiness of sovereign issuers. Currently there is no reliable yardstick for assessing sovereign creditworthiness beyond the current decade and this research fills this gap. Based on the methodology applied here future research could focus on developing ultra-long ratings not only for sovereigns but also for other issuers including corporates.

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