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### The true costs of climate change

Climate risk combines the characteristics of a black swan event - hard to predict, highly disruptive - with the inevitability of a systemic shift that we all know will happen. Mark Carney called this tension between the ineluctability of climate change and the limited ability of financial markets to anticipate and integrate long-term factors the “Tragedy of the Horizon.”

Climate risk is also defined by dynamic uncertainty: the future will be what we make of it, through our collective policy and economic decisions. Yet some of the changes underway may not be reversible, bringing another layer of uncertainty. Melting ice sheet and sea level rise, for example, may already be beyond the reach of policy intervention, while scientists are still working to understand the physics of the processes underway. The physical changes, combined with broader environmental pressures - unsustainable natural resources consumption, water stress, biodiversity loss, and their ripple effects -- point to existential threats to human societies that our financial system does not yet know how to fully process.

These characteristics of climate change will mold the shape and features of risk assessment tools. Maps become an essential asset, as climate risk is fundamentally geospatial. To assess their risk, lenders and investors need to understand the spatial distribution of their portfolio - a challenge for many institutions. Climate risk assessments should be forward-looking and as granular as the science will allow; yet that granularity may still not be enough to inform investments and risk mitigation as global climate models perform best at the regional scale.

Pervasive and multifaceted, climate risk should be mainstreamed and integrated into established risk management tools and models. To bridge the knowledge gap between disciplines, there will need to be collaboration between economists, financial modelers and climate scientists. Financial institutions should embrace the complexity of climate impacts on economies and financial systems and be ready to work with a range of models to understand impacts across asset classes, sectors and geographies. They also need to recognize and understand the assumptions, limitations, and uncertainties of the models.

Early efforts to assess climate risks in bank and investment portfolios shed light on the progress and limitations of the exercise. With adequate

location and sector data, financial institutions can readily identify core exposure in their portfolios. While the costs of transition risk are fairly well understood, the costs of physical risk are grossly underestimated due to data limitations, raising the specter of potentially flawed decision making. The discrepancy comes from a lack of historical data on economic and financial weather-related losses, as well as the limitations of climate models in predicting non-linear changes, and the difficulty of modeling second and third order impacts on human and ecological systems. Addressing these fundamental data and modeling limitations is a critical to incorporating the true costs of climate change in financial and economic decisions.