A Comment on **Climate Derivatives** for the Climate-Related Market Risk Subcommittee of the Market Risk Advisory Committee of the U.S. Commodity Futures Trading Commission

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The problem: Climate change and uncertainty

As climate change becomes more severe, nearly every long-term financial entity[1] exposed to climate hazards will be forced into group *A* (Adapter), proactively adapting to climate change, or group *B* (Backer), absorbing impacts. Both groups face obstacles that could be addressed by collaborating through financial technology.

The amount of proactive adaptation possible by *A* is limited because of the high uncertainty of climate change.[2] Global climate outcomes depend on countless political, social and environmental factors. Extreme, but scientifically plausible, climate scenarios would be devastating if not proactively addressed, but the potential that an extreme scenario doesn't materialize (and therefore the potential to have undertaken an over-protective project) can raise the cost of capital to prohibitive levels and be politically untenable for government actors.

As a report[3] from Stanford puts it: climate *"uncertainty is new and distinct from risks that engineers routinely consider. It creates challenges for infrastructure planners and engineers unaccustomed to managing such ambiguities. There is a risk of over- or underbuilding, which can, in turn, transfer risks to infrastructure investors.*"

An analysis[4] of climate adaptation options concluded that, for the study area, "*none of the flood protection–barrier strategies is economically attractive (Benefit-Cost Ratios less than 1) under current climate conditions or a low climate change scenario" and that all the strategies were economically attractive in the high climate change scenario.* This is similar to concluding that no pandemic prevention is economically attractive under 2019 conditions, but all the prevention strategies are attractive in 2020.

Research[5] from Goldman Sachs describes the dilemma for cities: *"Urban adaptation could drive one of the largest infrastructure build-outs in history. [...] Given the scale of the task, urban adaptation will likely need to draw on innovative sources of financing. [...] Cities won't want to over-commit to specific climate scenarios. For example, building a seawall to withstand today's "worst-case" 10-foot storm surge won't be of much use if in two decades the surge turns out to be 15 feet. Considering that climate projections have been repeatedly revised to show increasingly severe outcomes, this is a real concern. Taking an investment approach might suggest that it makes sense instead to "wait and see," allowing time for new information to emerge before making any major investments. While this approach makes sense in many contexts, the case of climate change appears to be different. The most significant effects of climate change are likely to be the result of "tail events," which are inherently unpredictable in*

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[1] Examples of long-term financial entities include: a community such as Battery Park City in lower Manhattan, a transportation group such as the NYC MTA, a homeowner, or a mortgage lender.

[2] For example: Haasnoot et al. (2019) Generic adaptation pathways for coastal archetypes under uncertain sea-level rise: "*Adaptation to coastal flood risk is hampered by high uncertainty in the rate and magnitude of sea-level rise. Subsequently, adaptation decisions carry strong risks of under- or over-investment, and could lead to costly retrofitting or unnecessary high margins.*"

[3] Ready For Tomorrow: Seven Strategies For Climate-Resilient Infrastructure.

[4] Evaluating flood resilience strategies for coastal megacities. *Science*, *344*(6183), 473-475.

[5] Taking the Heat: Making cities resilient to climate change.

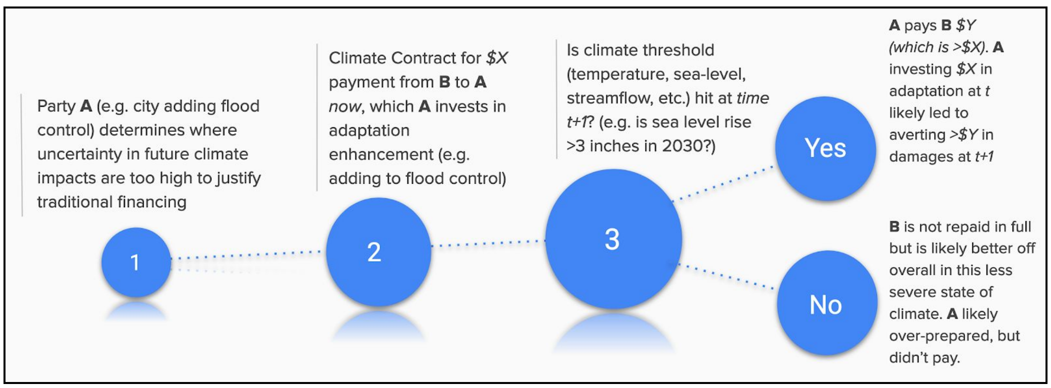
both their timing and their severity. Waiting won't necessarily generate more information about these idiosyncratic events. Waiting may instead mean that cities run out of time to prevent severe damages."

Some entities are better positioned to move into Group *A* and reduce their physical risk now; while others will determine that reducing their financial risk without immediately reducing their physical risk is more feasible, and move into Group *B*.[6]

Currently, most *B* entities are unable to effectively hedge against the risk of potential climate outcomes because only the largest, most sophisticated institutions can issue a catastrophe bond or other long-term insurance mechanism, given the high transaction costs relative to the small amount they would like to insure.[7] Furthermore, regardless of the sophistication of an institution, an insurance product payout would likely provide a lower rate of expected return than a triggered climate contract, and therefore serve as a less effective hedge.

The solution: Swapping risks

Party *A* invests for proactive climate adaptation, funded by *B*[8] hedging financial risk of climate-induced losses. *B* provides $X at Time 1 to *A*, who invests in adaptation that provides adequate protection expected to reduce losses by more than *Y times $X* by Time 2 in scenarios above a predetermined climate threshold (under less extreme climate scenarios, the adaptation may be over-protective in the contract's timeframe).



If the climate threshold is reached before the contract expires, *A* pays *B* with a return of Y on the initial $X. *A* investing to physically reduce risk was specifically designed to avert losses greater than the amount paid back, therefore *A* will likely be better off than if they did not participate.[9] In addition to averting damage, adaptation measures will reduce *A*'s cost of capital

[6] A financial "entity" could be in group *A* and group *B* at different time scales and geographies.
[7] There will be many more *B* parties than *A* parties, i.e. a lot of entities would like to insure at least a small amount of their climate tail risks, but not as many can build large physical adaptation projects.
[8] which is likely an aggregated group of many *B* entities since one *A* party will usually need more capital than one *B* wants to invest in a given contract.
[9] National Institute of Building Sciences: "*Investing more in resilient design and infrastructure pays off in safeguarding against future property destruction, according to research by the National Institute of Building Sciences. [...] For every $1 spent on flood mitigation, New Jersey is estimated to save $6.56.*" According to The Economic Effects of Climate Change Adaptation Measures, raising foundations provides 6.6% and 14.3% housing price increases in Miami-Dade and NYC, and adaptation for storm surges provides a 15.8% housing price increase in Miami-Dade. So there is direct-loss mitigation value in the event of a threshold crossing and, regardless of risk events, there is asset price appreciation due to the recognition of

for other non-climate projects by increasing their creditworthiness. According to BlackRock, "bonds issued by climate-resilient states and cities are likely to trade at a premium to those of vulnerable ones over time."[10]

B is better off because a return of Y is, in expectation, greater than a return from most investments in this more extreme climate outcome state of the world. Furthermore, *B* is guaranteed payment (and the contract has no default risk) if we back the outcome with a catastrophe bond. The rate of return required by *B* is relatively low because the investment is designed to pay off specifically in states of the world with high marginal utility (in more extreme climate scenarios).[11]

If the climate threshold is not reached, *A* is likely not worse off than they would have been otherwise, because (1) they over-prepared, within the timeline of the contract, but did not pay much for it, (2) the extreme climate outcome did not yet materialize, (3) they're prepared for a future increase in climate change that may still occur over a longer time period, and (4) there are likely co-benefits to the adaptation. *B* paid upfront without repayment but is likely overall better off in this state of the world because (1) the extreme climate outcome did not yet materialize and (2) their climate risk was hedged enough during the ensuing period that they were able to continue operating and borrowing at lower rates.

We would price contracts[12] for multiple climate-related variables (temperature and sea-level, and potentially precipitation and drought) at multiple time scales (e.g. 10 and 15 years) to fund adaptation projects reducing local risks to global climate thresholds (e.g. 6 inches of sea-level rise).

According to Morgan Stanley, "Climate resilience is fast becoming an investment imperative in real assets."[13] Owners of real assets (infrastructure, buildings, land) would greatly benefit from Climate Contracts because real assets have (1) long investment holding period horizons (often decades), (2) exposure to climate hazards, and (3) currently no method to hedge long-term climate change risk or fund climate adaptation designed for more uncertain potential climate scenarios.

The surface area of this problem-solution space is incredibly large. Let's zoom in on sea-level rise (SLR) and local infrastructure in the U.S.

Cities and sea-level rise

There is scientific consensus that the global mean sea level has been rising and will continue to rise, but significant uncertainty regarding the extent and timeframe. 30% of the population in the U.S. lives in counties adjacent to the sea.[14] In Florida, 10% of the population is located less than 1.5 meters above sea level. A 40-fold increase is expected in severe flooding along the U.S. coastline by 2050.[15]

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that resilience. Estimating global damages from sea level rise with the Coastal Impact and Adaptation Model: "*there is large potential for coastal adaptation to reduce the expected impacts of SLR compared to the alternative of no adaptation, lowering global net present costs through 2100 by a factor of seven*."

[10] Getting physical: scenario analysis for assessing climate-related risks.

[11] Climate Change and Long-run Discount rates: Evidence from real estate.

[12] Bloch et al. (2012) apply the logic of pricing credit derivative products to pricing climate derivatives of this nature by replacing the survival probabilities and default time densities of credit derivatives with the first-passage (of a climate threshold) complementary distributions and first-passage time density.

[13] Weathering the Storm: Integrating Climate Resilience Into Real Assets Investing.

[14] Coastline County Population Continues to Grow Despite three costly hurricanes in the Atlantic and Gulf; The Effect of Rising Sea Levels on Coastal Homes.

[15] Amplification of flood frequencies with local sea level rise and emerging flood regimes.

$30 - $50 trillion will be spent on infrastructure globally in the next ten years[16] and trillions of dollars worth of existing infrastructure is at risk due to climate change. Similar to how local and state governments issue debt to fund infrastructure projects, they could issue Climate Contracts to fund adaptation of infrastructure. Raising debt will become more difficult post-Covid-19: "*Never before have U.S. municipalities been hit so hard or so quickly or in so many different ways as they are right now by the coronavirus pandemic. [...] which will result in steeper borrowing costs.*"[17] Therefore, financing adaptation through Climate Contracts is even more critical.

Up to 85% of local governments' revenue in the U.S. is generated from property taxes.[18] With 6.9 feet of SLR, 120 municipalities in the U.S. would risk losing at least 20% of their current property tax base, and 30 municipalities could lose at least 50% of their property tax base.[19] Future property tax revenue generated, that otherwise would be lower without adaptation measures, would be a solid backing to underwrite Climate Contracts as *A* parties.

In addition to entities that are more likely to retrofit infrastructure later rather than adapt now,[20] *B* parties to Contracts for sea-level rise would also include U.S. regional banks that own concentrated portfolios of mortgages on at-risk properties;[21] pensions, endowments, sovereign wealth funds, and private investment firms that own coastal real assets; and owners of the $130 billion of U.S. institutional real estate that's in areas in the top 10% for exposure to sea-level rise.[22] More broadly, *B*s are either (1) entities that own similar real assets as *A*s but are not in a position to make physical adaptations in the near-term, or (2) entities that may end up serving as a financial backstop to *A*s, e.g. state and federal governments and insurance companies. Both types of *B*s have similar time horizons and climate variable threshold exposures as *A*s.

Recommendation for the Subcommittee

I recommend that the Subcommittee support and provide guidance on forthcoming efforts to develop Climate Contracts as a widely deployed financial product that allows participants to effectively hedge against climate risk. If Climate Contracts are eventually traded in a relatively liquid marketplace, listed prices on specific contracts (e.g. SLR at 3 inches in 2030) would provide powerful signals for climate risk, globally guiding public policy and planning.

I welcome the opportunity to continue to engage with the Subcommittee on this matter.

Regards,

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[16] Mckinsey: Confronting climate risk.

[17] From Houston to New York, America's Muni Finances Are in Tatters.

[18] As a percentage of local own source revenues (i.e., excluding transfers from state and federal governments) property taxes constitute 85% of local revenue inside Connecticut.

[19] Underwater: Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate.

[20] As noted in Bloch et al. (2012), it's more cost effective to build new infrastructure to higher standards than retrofit existing infrastructure. Infrastructure projects in the planning phase can be built to defend against more extreme climate change through modest upfront expenditures. In doing so, **they're implicitly buying out-of-the-money options on more extreme climate change. These upfront expenditures allow them to generate cash flows under extreme climate change. They can monetize those future cash flows by entering into a Climate Contract.** For *existing infrastructure*, since retrofitting is more expensive, it may make more sense to delay a decision to adapt, and instead buy protection to finance a future retrofit.

[21] McKinsey: "local and regional banks that own concentrated portfolios of mortgages on coastal properties may find themselves especially vulnerable to near-term climate events." Freddie Mac finds that SLR could "destroy billions of dollars in property," with impacts greater than "the housing crisis and Great Recession."

[22] Futureproofing Real Estate from Climate Risks: New Research from ULI in Partnership with Heitman.