Yield Book
An LSEG Business

Analytics Insights

Climate and Sustainable Investment

Assessing physical climate risks on Agency CMBS

Impacts on prepayment speeds, valuation and forecasted scenarios

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Introduction

In this study, we evaluated the impact of physical climate hazards, notably inland and coastal flooding, on the prepayment speeds of Agency CMBS securities. We found significantly lower prepayment speeds for loans vulnerable to heightened flood risks. This disparity became even more pronounced in pricing when the adjustments were integrated into prepayment and valuation models. Such observations highlight that it's imperative to embed climate-related risks within the framework of Agency CMBS investment decision-making.

Our approach utilized historical and forward-looking climate projections provided by our data vendor partner Sust Global, combined with Yield Book's Agency CMBS loan-level database and industry-leading prepayment models to provide estimates for climate-adjusted valuations for three different industry-standard climate scenarios reflecting selected Shared Socio-economic Pathways (SSPs) and Representative Concentration Pathways (RCPs) combinations: Strong Mitigation (SSP1-RCP26), Middle of the Road (SSP2-RCP45), and High Emissions (SSP5-RCP85).

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Executive summary

Physical climate risks are significantly impacting commercial real estate (CRE) properties across the US, as well as the issuers, investors, and loan borrowers in the CMBS markets where loans backed by the CRE properties are pooled together to create securitizations with tranches (classes/bonds) of cash flows at different seniorities and average lives. GSEs are holding an estimated $6trn in debt without pricing flood risk in their guarantee fees[1], and the last two years have seen many large home insurers withdraw from key states exposed to physical climate risks to limit losses, particularly with respect to flooding, wildfires and hurricanes. The resulting socio-economic impact on borrowers has been widespread, with a rise of 21% in home insurance costs to US homeowners since 2015, and increased difficulty in obtaining mortgages and reliance on state insurers of last resort.[2]

The resulting impact on CMBS holdings has not been fully understood to date, with a lack of robust physical climate models to assess the future influence of potential climate disasters on underlying collateral, and, combining these forward-looking scenarios with prepayment and default models to quantify the potential price effect at a security level.

In this paper, we introduced a methodology to identify geographic areas susceptible to elevated climate risks and evaluate prepayment trends across distinct vintage cohorts. Our analysis revealed that loans originated from regions characterized by high flood risks consistently exhibited decelerated prepayment speeds across all principal Agency CMBS products, including GNPL, FNDUS, Freddie K, and SB. Furthermore, we advocate for a robust approach to seamlessly incorporate climate risk determinants into Yield Book's prepayment models. This integration facilitates the determination of climate adjusted CPRs, WALs, OAS, and consequently, the subsequent implications for the pricing of Agency CMBS securities.

[1] *Mortgage Finance and Climate Change: Securitization Dynamics in the Aftermath of Natural Disasters*, NBER (2021)

[2] *Insurers withdraw from riskiest areas as threats from climate change grow*, NBER (2023)

Physical Climate Risk Models

Our approach utilizes historical climate data and forward-looking projections provided by our partner Sust Global, combined with Yield Book's Agency CMBS loan-level database and industry-leading prepayment models. In this section we provide further detail into these elements, and an overview of how these are combined.

Global Climate Models

Climate Scenarios

There are many potential future scenarios for climate change that have been modelled. Practically, the amount of data generated for each location could reach 10,000 datapoints given the various inputs/options. As the understanding of this topic is nascent within finance with storage and interpretation of big datasets potentially posing an issue for clients, we have provided three well-known scenarios, namely Strong Mitigation (SSP1-RCP26), Middle of the Road (SSP2-RCP45), and High Emissions (SSP5-RCP85).5, to generally represent low, medium, and high risk to climate change.

Climate Hazards

Various physical climate hazards have been separately modelled by climate scientists globally over decades under different SSP-RCP scenarios, with their publicly available outputs typically comprising location and time-specific risks to the given peril. The climate hazards in this report include the below 4 perils which are impactful to property value and prepayments.

- **Flooding:** Inland and coastal flooding is expressed as the probability of the asset to floods, provided at a resolution of 1km; 5% is considered high here, particularly where that occurs over multiple years. Inputs include elevation of the property, river routes, global temperature, and rainfall patterns[3,4].

- **Wildfire:** Future risk to wildfire is expressed as the annual probability of wildfire at an asset location within 300m of the asset. This model combines global, high-resolution historic fire observations from a multi-decadal satellite record with historical data on a variety of factors that contribute to fire risk, including precipitation, temperature, topography, land cover, ignition sources, and ecology for future climate-induced risk probability projections.

- **Sea Level Rise:** This model captures the risk to storm surges and coastal flooding, a key physical risk from hurricanes, as well as a general rise from melting icecaps. Assumptions also include the expected global temperature rise and the associated expansion of water, and the distance of the asset to the nearest coast (>5km is shown as zero risk). Further development includes increasing the geospatial resolution, incorporating altitude of the asset, and expanding the impact of sea level rise to water cycles, and inland and coastal flooding[5]. It should be noted that the precision and recall of the projected flood risk models are at 99% and 39% respectively, indicating a very low rate of false positives and thus confidence in prediction of a flood, where high risk is indicated.

- **Hurricanes:** Observed hurricane data from the NOAA and other ocean observational datasets is compared to modelled tracking data for each scenario, and then benchmarked against observed Category 3+ storms in regions of known high impact such as Bangladesh,

[3] Dottori, F. et al, *Increased human and economic losses from river flooding with anthropogenic warming*, 2018

[4] Hirabayashi, Y. et al, *Global flood risk under climate change*, 2013

[5] Payne, A.J. et al, *Future sea level change under CMIP5 and CMIP6 scenarios from the Greenland and Antarctic ice sheets*, 2021

Gulf of Mexico, and China. The output is a metric [0,1] indicating the severity of a given event at a given location.

Table 1: Physical Climate Hazard summary

Peril	Description	Unit
Flooding	Indicates the projected flood likelihood; calculation makes use of a suite of flood hazard maps for both inland and coastal floods	Probability
Wildfire	Combines projections from Burned Area Fraction and the Keetch-Byram Drought Index Susceptibility Score (KBDI); interpreted as the probability of wildfire occurring around the asset location	Probability
Sea level rise	Expressed relative to a baseline period	Change
Hurricane	Projected likelihood of hurricanes (Category 1 and above)	Probability

Risk and Exposure Terminology

Throughout this report, there are references to climate *risk* and *exposure*, two different concepts. *Risk* represents the actual physical characteristics at a certain location, while *exposure* refers to the dollar amount of the outstanding balance of commercial real estate loans underlying the CMBS securities.

The underlying climate risk data employed in this paper matches the level of location information available at the asset level, which is generally address but, in some cases, ZIP code. Thus, we have used the ZIP code across the analyzed securities to ensure consistency.

CMBS Risk to Physical Climate Hazards

A metric for physical climate risk has been delineated, drawing upon climate risk data for geo-coordinated locations associated with CMBS exposure. Utilizing this metric, we discerned areas characterized by heightened climate risks. An exhaustive prepayment analysis for Agency CMBS loans was subsequently undertaken to ascertain the influence of climate risk on prepayment velocities.

Constructing a CMBS-specific climate risk metric

A comprehensive risk metric, termed the YB CMBS Climate Risk Metric (*YBCC Metric*), has been formulated. This metric encapsulated the predominant climate risks, integrating present-day severity, contemporary trends, and historical averages:

- $Score_{severity}$ = *latest severity of risk event*
- $Score_{trend}$ = *change in severity for most recent periods*
- $Score_{avg}$ = *historical average severity measure*
- $YBCC\ Metrice_{risk} = \beta_{severity}\ ^{*}Score_{severity} + \beta_{trend}\ ^{*}Score_{trend} + \beta_{avg}\ ^{*}Score_{avg}$

where risk = cyclone, flood and wildfire, β_{*} is the corresponding weight.

The *YBCC* metric spans from 0 to 1, where 0 signifies minimal climate risk and 1 represents the maximal risk.

As of August 2023, there are 54K active loans backing CMBS securities with a total $1,122 bn exposure, including $392 bn in Agency CMBS (CMBS securitizations guaranteed by government agencies including Ginnie Mae, Fannie Mae, and Freddie Mac) and $730 bn in non-Agency CMBS (private label CMBS securities) (Exhibit 1).

Exhibit 1: CMBS Exposure Summary

CMBS Type	# of Loans	# of Deals	Total Balance ($bn)
Agency CMBS	26,514	589	392
Non-Agency CMBS	27,268	1,297	730
Total	53,782	1,886	1,122

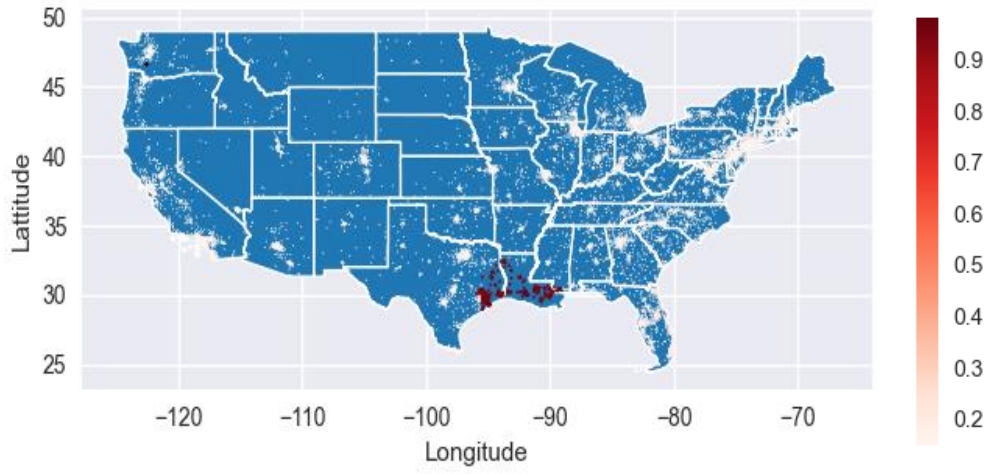
Source: Trepp, Yield Book (Sep 2023)

In the subsequent sections, we will present the geographical distribution of CMBS exposure, juxtaposed with the YBCC metric for various climate risks. Each dot denotes CMBS exposure, while the coloration signifies the value of the corresponding YBCC metric.

Cyclone

The historical cyclone dataset encompasses Category 3, 4, and 5 cyclones detected within a 241km radius of the geo-coordinates of commercial real estate properties backing CMBS loans (i.e., CMBS properties), spanning from January 2010 to December 2020. The YBCC metric reveals a pronounced concentration of cyclone risk within the regions of Louisiana and East Texas.

Exhibit 2: YBCC Metric Distribution for Cyclone

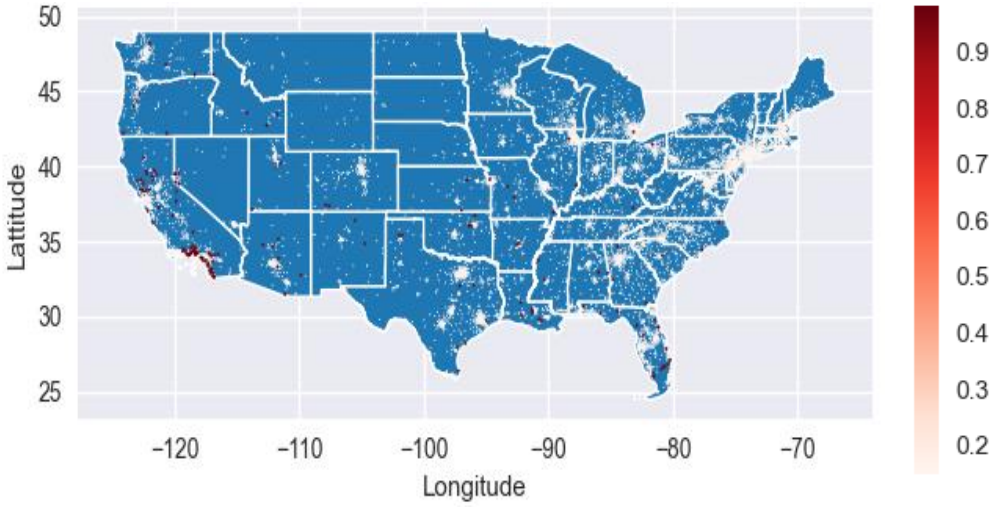


Source: Sust Global, Yield Book (Sep 2023)

Wildfire

The wildfire dataset is comprised of an annual series of satellite-detected wildfires within a 1km proximity to CMBS properties, covering the period from 2001 to 2021. The YBCC metric delineates a heightened concentration in California, supplemented by intermittent occurrences across various states.

Exhibit 3: YBCC Metric Distribution for Wildfire



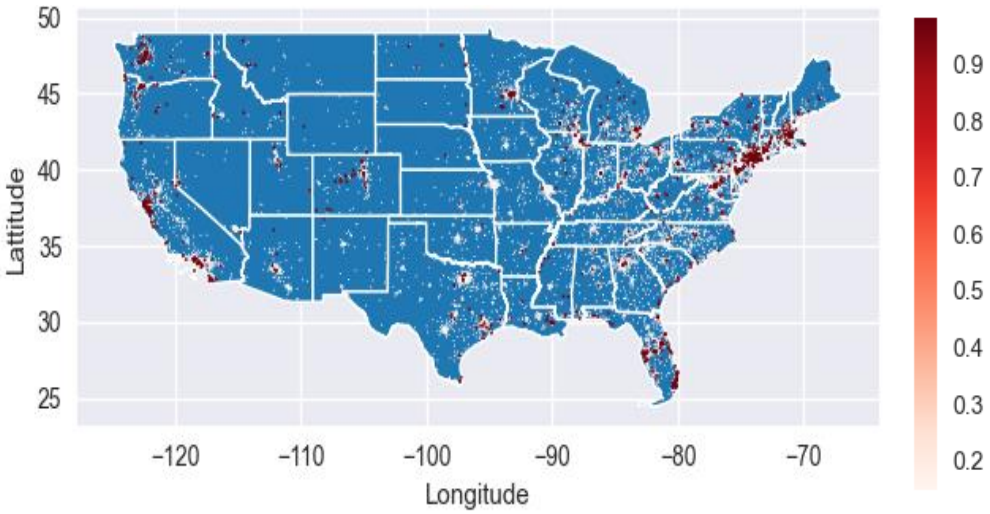
Source: Sust Global, Yield Book (Sep 2023)

Flood

The flood dataset encompasses an annual series of observed inland and coastal floods situated within a 1km vicinity of CMBS properties, spanning the years 2012 to 2021. The YBCC metric

highlights a pronounced concentration in the Northeast, Florida, Washington, and the Californian coast.

Exhibit 4: YBCC Metric Distribution for Flood



Source: Sust Global, Yield Book (Sep 2023)

To identify high flood risk areas, we first computed CMBS exposure weighted average YBCC flood metric based on geo-coordinates of the underlying properties, followed by aggregation of the data to the zip code level. Zip codes falling within the top 25th percentile were designated as high flood risk regions, with the remainder classified as low flood risk areas.

It's pertinent to note that the underlying properties of Agency CMBS securities in our research are exclusively supported by multifamily properties (vs. non-Agency CMBS which covers various property sectors such as office, retail, hotel, multifamily, and industrial). Given that a minimal number of these properties are in regions vulnerable to severe climate hazards such as cyclones and wildfires, the sample size is diminutive and, consequently, not statistically significant for this analysis. On the other hand, a considerable number of multifamily properties are situated in zones prone to high flood risk, rendering this study predominantly focused on the repercussions of flood risk for Agency CMBS

In the next section, we compare the actual prepayment speeds for Agency CMBS pools in high and low flood risk areas.

Prepayment analysis

In the realm of Agency CMBS, prepayment refers to the action of paying off a commercial mortgage loan prior to its maturity date. Prepayment activities or speeds are commonly gauged using CPR, an annualized measure that denotes the fraction of loan principal anticipated to be paid ahead of schedule, primarily due to loan refinancing, property sales, or foreclosures.

Commercial mortgages tied to Agency CMBS securities typically feature a prepayment protection provision, frequently termed "call protection" to inhibit prepayment behaviour. This signifies that should an Agency CMBS loan be prepaid before its maturity some kind of penalties are typically

incurred for loan borrowers. The form of prepayment penalty structures varies across products, and an exhaustive discussion on these structures exceeds the boundaries of this document.

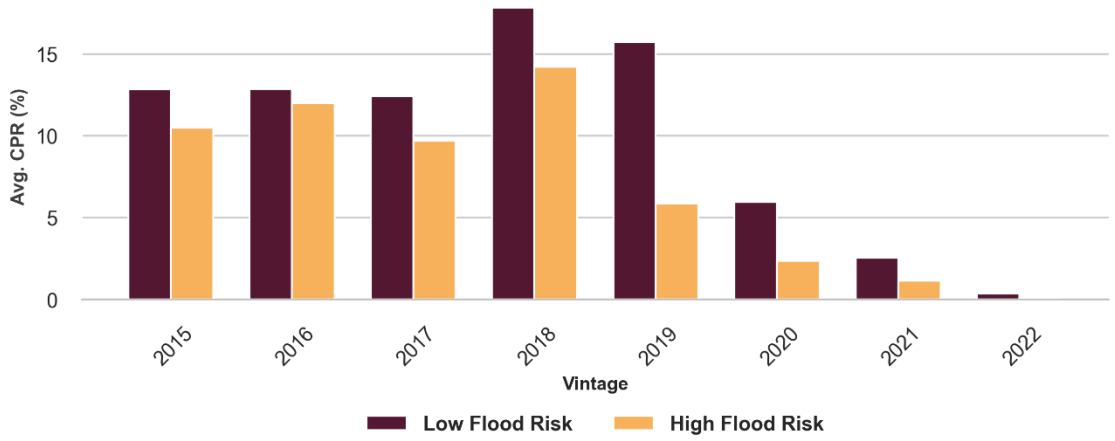
It's worth noting that both the prepayment speeds and the associated penalties influence the cash flow dynamics. Slow prepayment speeds lead to diminished prepayment penalty collected. This, however, also results in an increase in cumulative coupon payments over time due to the extension of the loan life. Conversely, faster prepayment speeds result in inverse effects. The repercussions of both the penalty premium and the coupon payment on the comprehensive cash flow — and consequently on valuation — are contingent upon several determinants: the unique prepayment penalty framework linked to the security, its coupon rate, the remaining life to maturity, the prevailing interest rate landscape, etc.

Consequently, a profound grasp of prepayment speeds pertaining to Agency CMBS securities is indispensable for a rigorous evaluation of loan cash flow and security price. In the following sections, we will dive into the comparison of prepayment activities of various Agency CMBS products to analyse the influence of flood risks, including Ginnie Mae Project Loans (GNPL), Fannie Mae Delegated Underwriting and Servicing (FN DUS), and Freddie Mac Multifamily (Freddie MF).

GNPL

For GNPL loans located in areas characterized by high flood risk (average YBCC metric of 0.82), the observed prepayment speeds (lifetime average CPR) were markedly slower by 3.1 CPR on average in comparison to those in regions with low flood risk (with average YBCC metric of 0.21). This discrepancy was most pronounced for some of the recent vintages, including 2018, 2019 and 2020 (Exhibit 5 & 6).

Exhibit 5: GNPL Actual Prepayment Speeds (Low Flood Risk vs. High Flood Risk)



Source: GNMA, Yield Book (Sep 2023)

Exhibit 6: Summary of GNPL

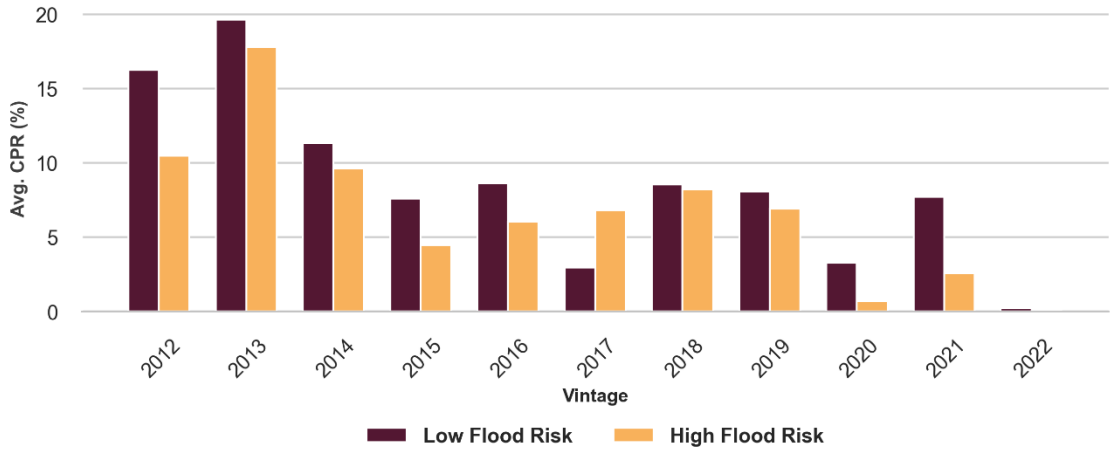
Risk Area	# of Loans	Total Exposure ($bn)	Lifetime Avg. CPR	Avg. YBCC Metric
Low Flood Risk	15,955	88.0	10.0	0.21
High Flood Risk	2,126	8.7	6.9	0.82

Source: GNMA, Yield Book (Sep 2023)

FN DUS

Analogous trends were discovered for FN DUS loans. Notably, the variance was more pronounced for floating-rate FN DUS loans with the prepayment speeds in high flood risk areas exceeding those in low flood risk regions by an average of 1.8 CPR (Exhibit 7 & 8), but relatively subdued for fixed-rate loans with average 0.8 CPR lower in high flood risk areas than in areas with low flood risk (Exhibit 9 & 10).

Exhibit 7: DUS Floating Rate Actual Prepayment Speeds (Low Flood Risk vs. High Flood Risk)



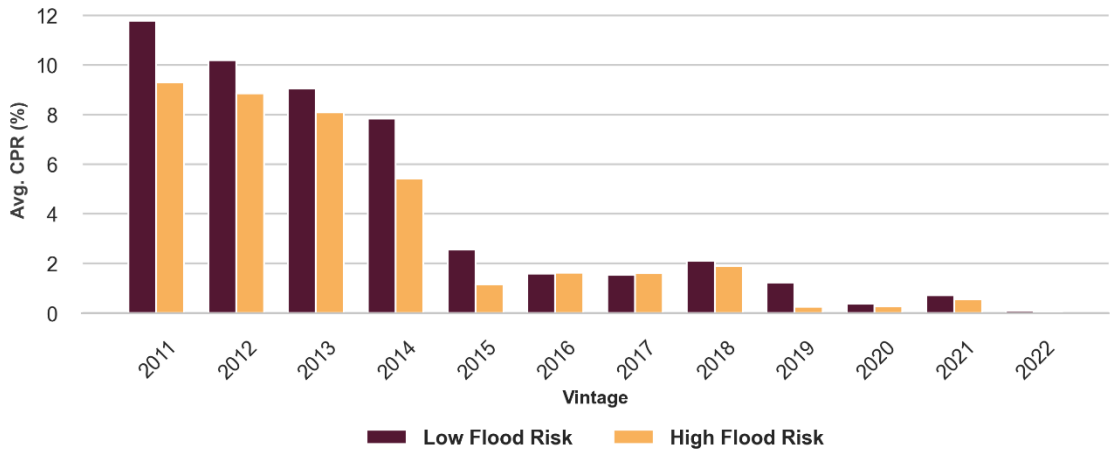
Source: FNMA, Yield Book (Sep 2023)

Exhibit 8: Summary of Floating Rate DUS

Risk Area	# of Loans	Total Exposure ($bn)	Avg. CPR	Avg. YBCC Metric
Low Flood Risk	2,837	309.2	8.5	0.21
High Flood Risk	353	29.0	6.7	0.83

Source: FNMA, Yield Book (Sep 2023)

Exhibit 9: DUS Fixed Rate Actual Prepayment Speeds (Low Flood Risk vs. High Flood Risk)



Source: FNMA, Yield Book (Sep 2023)

Exhibit 10: Summary of Fixed Rate DUS

Risk Area	# of Loans	Total Exposure ($bn)	Avg. CPR	Avg. YBCC Metric
Low Flood Risk	29,412	900.3	4.1	0.22
High Flood Risk	3,285	90.5	3.3	0.78

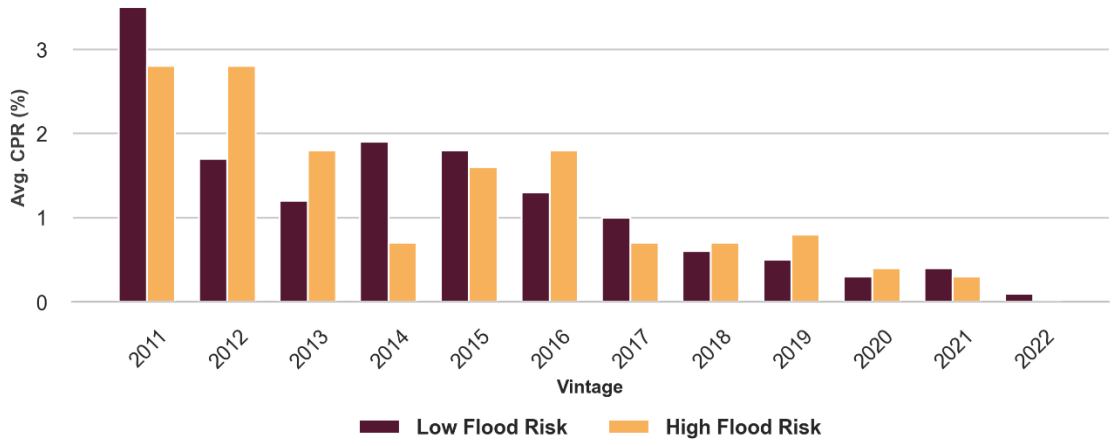
Source: FNMA, Yield Book (Sep 2023)

Freddie MF

Within Freddie MF, Freddie K and SB represent two primary multifamily lending programs. Flood risk also causes divergence by product and associated coupon type.

For Freddie K fixed-rate loans, which predominantly feature robust call protection, the overall prepayment speeds remained considerably subdued. Consequently, no discernible pattern emerged in relation to the impact of climate risk on these fixed-rate loans. (Exhibit 11 & 12).

Exhibit 11: Freddie K Fixed Rate Actual Prepayment Speeds (Low Flood Risk vs. High Flood Risk)



Source: FHLMC, Yield Book (Sep 2023)

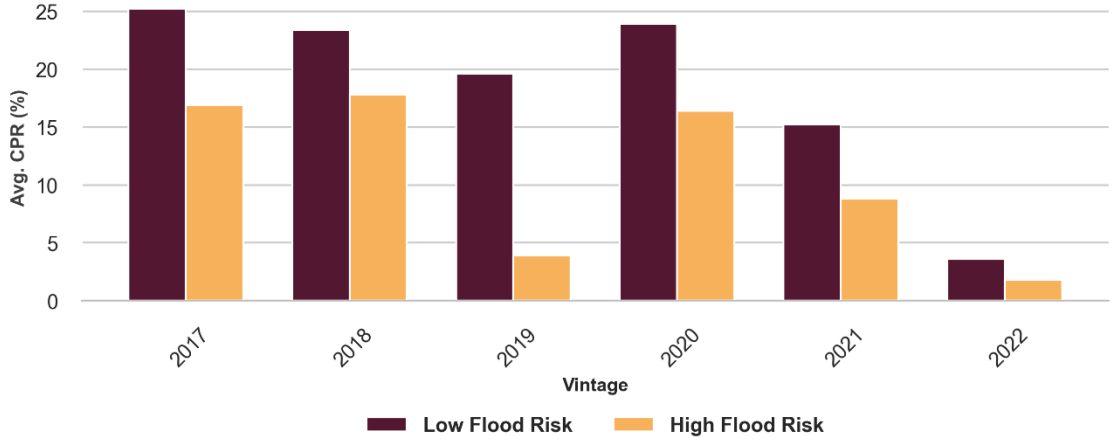
Exhibit 12: Summary of Fixed Rate Freddie K

Risk Area	# of Loans	Total Exposure ($bn)	Avg. CPR	Avg. YBCC Metric
Low Flood Risk	13,659	207.6	1.2	0.11
High Flood Risk	1,860	31.7	1.2	0.81

Source: FHLMC, Yield Book (Sep 2023)

Freddie K floating-rate loans exhibit significantly higher prepayment activities due to weak prepayment protection. As presented in Exhibit 9, the prepayment speeds for floating-rate loans in high flood risk regions were slower by 8.4 CPR on average (Exhibit 13 & 14).

Exhibit 13: Freddie K Floating Rate Actual Prepayment Speeds (Low Flood Risk vs. High Flood Risk)



Source: FHLMC, Yield Book (Sep 2023)

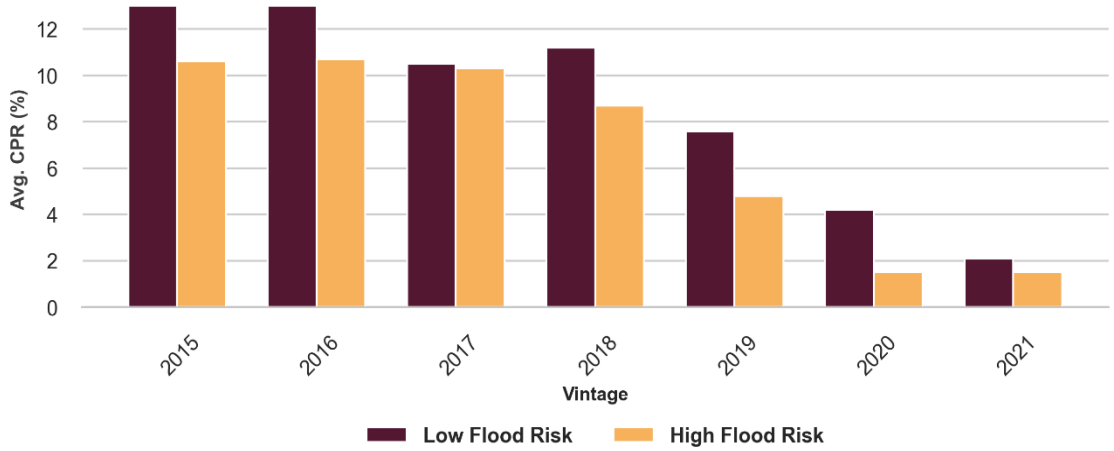
Exhibit 14: Summary of Floating Rate Freddie K

Risk Area	# of Loans	Total Exposure ($bn)	Avg. CPR	Avg. YBCC Metric
Low Flood Risk	4,539	56.3	22.1	0.15
High Flood Risk	557	11.9	13.7	0.54

Source: FHLMC, Yield Book (Sep 2023)

Freddie SB fixed-rate loans offer less strict prepayment protection compared to Freddie K fixed-rate loans. Across various vintages, as illustrated in Exhibit 15 & 16, the prepayment speeds were consistently slower in regions characterized by high flood risk (1.6 CPR differential on average comparing to low flood risk regions).

Exhibit 15: Freddie SB Fixed Rate Actual Prepayment Speeds (Low Flood Risk vs. High Flood Risk)



Source: FHLMC, Yield Book (Sep 2023)

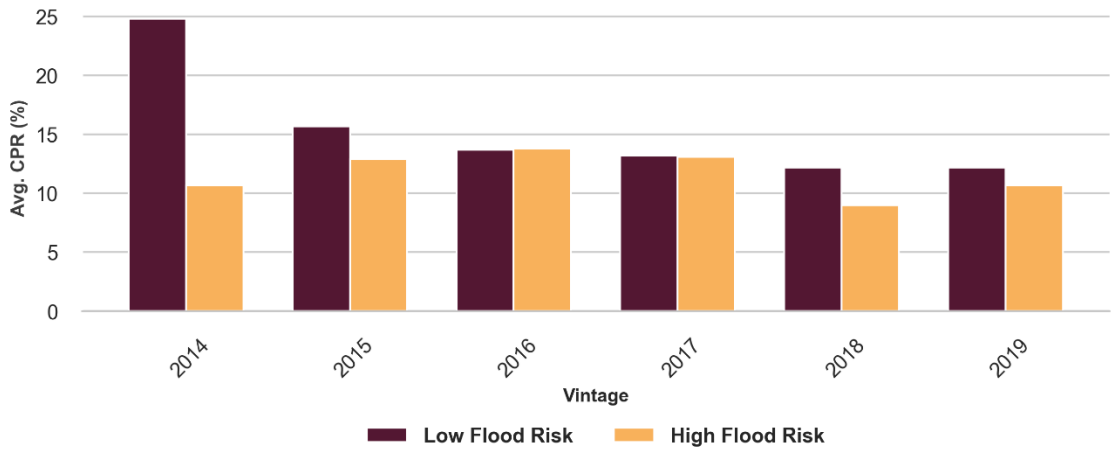
Exhibit 16: Summary of Fixed Rate Freddie SB

Risk Area	# of Loans	Total Exposure ($bn)	Avg. CPR	Avg. YBCC Metric
Low Flood Risk	5,716	9.3	9.8	0.14
High Flood Risk	1,002	1.9	8.1	0.91

Source: FHLMC, Yield Book (Sep 2023)

Similar to Freddie K floating-rate loans, Freddie SB adjustable-rate (ARM)[6] loans are subject to lax prepayment protection, resulting in faster prepayment speeds. As delineated in Exhibit 17 & 18, the prepayment speeds in regions marked by high flood risk are mostly slower across the various vintages and on average the prepayment speeds are about 1.4 CPR faster in low flood risk areas.

Exhibit 17: Freddie SB Floating Rate Actual Prepayment Speeds



Source: FHLMC, Yield Book (Sep 2023)

Exhibit 18: Summary of ARM Freddie SB

Risk Area	# of Loans	Total Exposure ($bn)	Avg. CPR	Avg. YBCC Metric
Low Flood Risk	6,691	10.1	11.4	0.11
High Flood Risk	1,521	2.6	10.0	0.82

Source: FHLMC, Yield Book (Sep 2023)

[6] *SB deals are usually backed by fixed rate, floating rate, and hybrid rate, i.e., paying fixed rate for certain periods and then paying floating rate coupon. ARM includes both floating rate and hybrid loans.*

Possible Explanation of Flood Risk Impact on Prepayment Speed

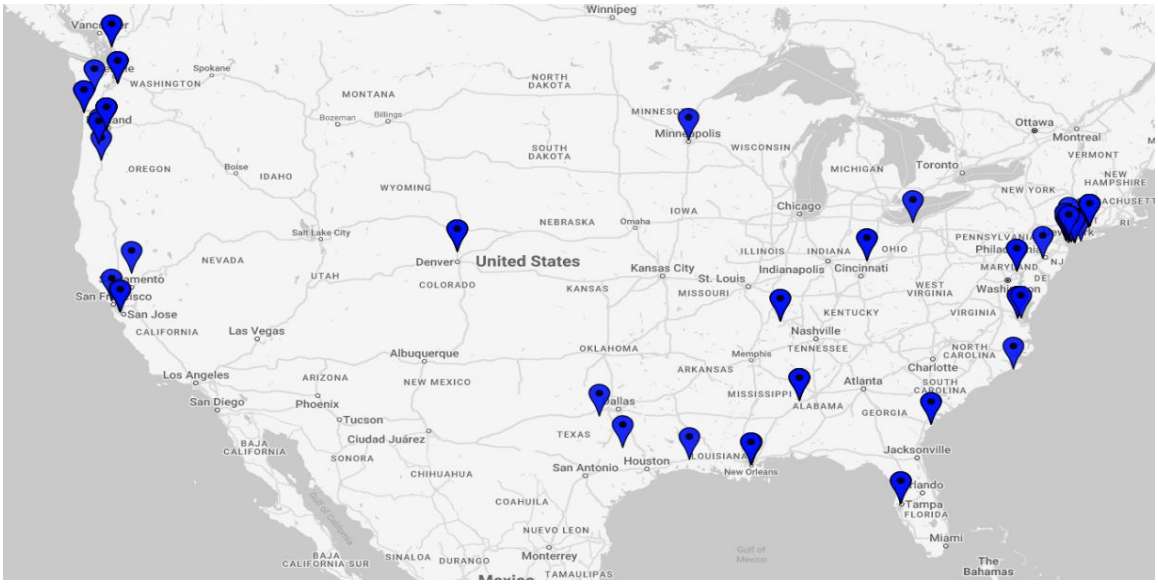
One may assume, intuitively, that involuntary prepayment speed may rise post a major flood event as loan borrowers of properties damaged by a severe flood will either file an insurance claim or default (if without flood insurance), causing the overall prepayment speed to tick up (contrary to our observation that prepayment speeds are lower in the high flood risk areas). However, there hasn't been sufficient historical data to prove this is the case. In fact, involuntary prepayment of Agency CMBS loans is usually a very small fraction of the overall prepayment and can hardly move the needle on the overall prepayment speed

The reason prepayment speeds tend to be slower in high-flood risk regions might have to do with the fact that properties located in those regions are naturally less attractive to renters with lower occupancy rate and lower rent, resulting in poorer operating financials (e.g., lower DSCRs and Debt Yields), and hence harder to meet refinance criteria set by lenders. More importantly, the cap rate demanded by investors for this type of properties will be higher due to the perceived risk, leading to depressed property valuation and higher LTVs - making a sale transaction less likely and refinancing more difficult (whether to take advantage of lower rate or for payoff upon maturity).

Impact of Flood Risk on Agency CMBS Security Valuations

In an effort to quantify the pricing impact on Agency CMBS securities stemming from climate risk, we selected 100 FN DUS securities (pools) backed by properties located in high flood risk areas across the country (Exhibit 19).

Exhibit 19: Distribution of underlying properties across the US



Source: Yield Book (Sep 2023)

Based on the prepayment analysis in the previous section, we constructed a collection of CPR adjustment seasoning curves, categorized by product and coupon types. These CPR adjustment curves enabled us to refine the model-projected CPR for collateral located in high flood risk zones, contingent upon loan age and the degree of flood risk severity.

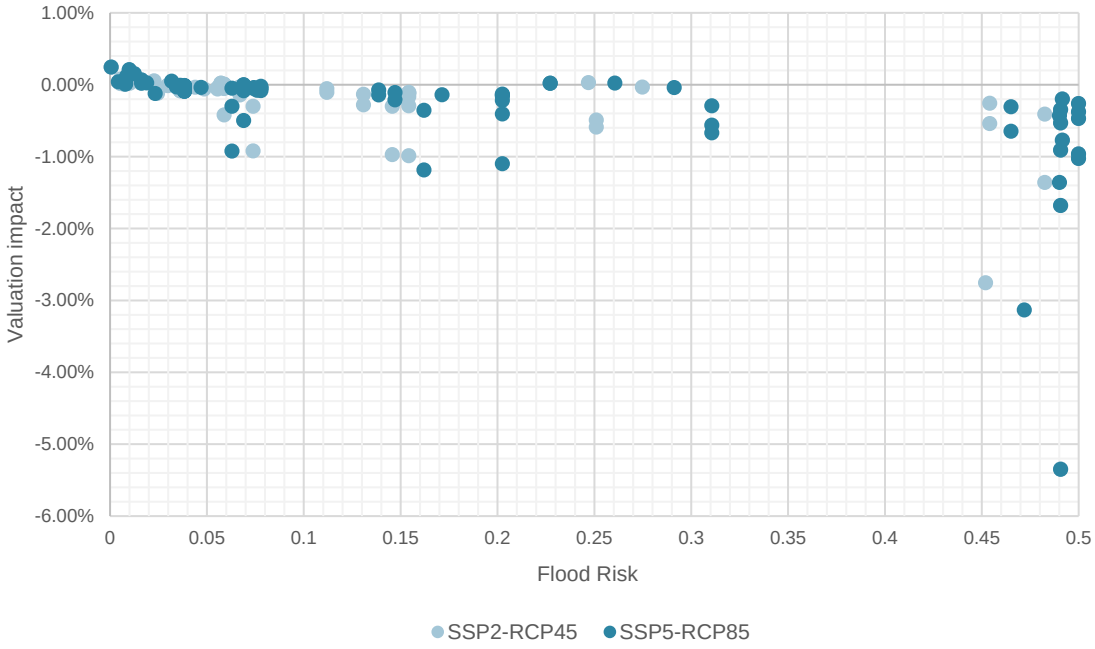
Next, we used YB analytics tool to calculate the OAS of the selected 100 securities based on their latest market price. Then, the CPR adjustment curves were combined with the forward-looking flood risk projections supplied by Sust Global to adjust YB prepayment model projected CPR for these securities. The OAS together with the flood risk adjusted CPR vectors were then used to calculate the climate risk-adjusted price.

Note that Sust Global has two[7] distinct climate scenarios for flood risk projections - SSP2-RCP45 and SSP5-RCP85. We utilized both for the evaluation exercise.

Our findings indicated that, when adjusted for flood risk, the prices for the majority of the securities were consistently lower than their respective market prices, with variations ranging between -5.22% and +0.24%. The difference between the scenarios when contrasting SSP2-RCP45 with the more severe climate scenario, SSP5-RCP85, is illustrated in Exhibit 20. Notably, there's a correlation of -56.4% between the Sust Global inland and coastal flood risk metric and the pricing impact across the evaluated securities. This relationship aligned with intuition: the intensity of the climate scenario directly influenced the degree of CPR adjustment, subsequently affecting the pricing impact.

[7] *For most climate risks, Sust Global provides three distinct scenarios, SSP1-RCP26, SSP2-RCP45, and SSP5-RCP85. For flood risk, only two distinct scenarios are available, and SSP1-RCP26 is effectively the same as SSP2-RCP45.*

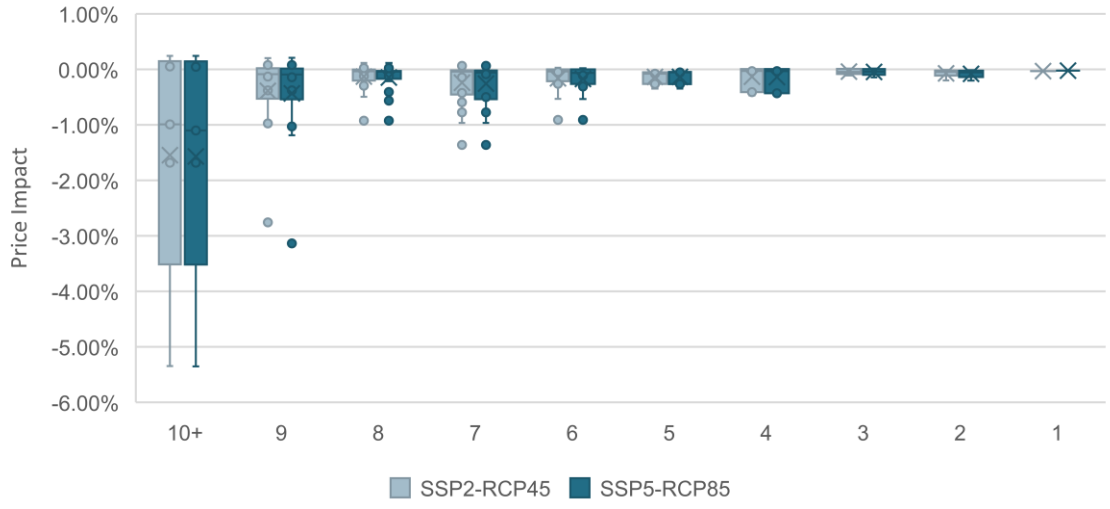
Exhibit 20: Valuation Impact by Climate Scenarios



Source: Yield Book (Sep 2023)

Subsequent patterns emerged in our analysis, with Exhibit 21 showing the most pronounced valuation disparities in securities with a higher WAM. This outcome aligned with expectations, given the extended timeframe in which speeds can undergo variations. The valuation effects are consistent across all scenarios. However, the more severe climate scenario manifested a slightly bigger price impact, which was in line with anticipated outcomes.

Exhibit 21: Valuation impact by Weighted Average Maturity (WAM)



Source: Yield Book (Sep 2023)

It's worth noting that the current economic conditions have resulted in subdued prepayment speeds for the majority of agency CMBS products. This context naturally curtails the scope for notable variations in speed. Should we transition to an environment where CPR rises significantly, we anticipate a considerably more profound effect on climate risk-adjusted evaluation.

Conclusion

Through this study, we have demonstrated the importance of incorporating physical climate risk data in the valuation and risk assessment for Agency CMBS. Specifically, there exist meaningful risks associated with inland and coastal flooding that remain understudied and potentially unaccounted for in CMBS security pricing.

The prepayment analysis for multiple agency CMBS products has revealed the significant impact of flood risk to the prepayment speeds.

We found the market might have been over pricing some Agency CMBS securities with properties concentrated in high flood risk areas: for selected FN DUS pools backed properties in areas with elevated flood risks—as indicated by our composite climate risk metric—the climate risk-adjusted prices were mostly lower than the prevailing market prices, with the difference reaching up to 5% when adjusting CPR projection by Sust Global' s anticipated flood risk metrics.

About Yield Book

Yield Book is a trusted and authoritative source for fixed income analytics that enables market makers and institutional investors to perform complex analysis of their portfolios, benchmarks, trading decisions, historical performance, and risk. Yield Book products offer analytical insight into an extensive range of financial products in the fixed income space including governments, agencies, corporates, high yield, emerging markets, mortgages, ABS, CMBS, CMOs, CLOs, and derivatives. The platform utilizes dedicated centralized servers that help ensure reliable, prompt data delivery. Yield Book forms part of London Stock Exchange Group's Data and Analytics Division.

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