

Flood Risk Exposures and Mortgage Security Market Performance and Risk Sharing

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Disclaimer

The views expressed in this paper are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Philadelphia, Federal Reserve Bank of Kansas City, or the Federal Reserve System.

Motivation

- Real estate is increasingly threatened by flood risk, one of the most costly climate-linked natural disasters
- Trillions of dollars of mortgages and financial instruments are secured by real estate

Research Questions

- Are mortgage performance and mortgage terms correlated with flood risk?
- Does the risk (i.e., subordination) of mortgage-backed securities (MBS) reflect flood risk?

Preview of Findings

- Severe mortgage delinquency increases with flood risk
 - Mortgages in high flood risk areas are up to 1.8 percentage points more likely to default
 - Mortgage interest rates barely respond to flood risk, but LTVs are lower
- Flood risk is correlated with deal-level default shares
 - A 1 point increase in average Flood Factor is associated with a 1.6 percentage point increase in default share of a deal
- Deal subordination increases with flood risk, but not deal spreads
 - A 1 point increase in average Flood Factor is associated with a 2.6 percentage point increase in subordination below AAA and 0.4 percentage point increase in subordination below BBB-

Contribution

- We show that MBS performance and structure reflect underlying natural disaster risk
 - Ouazad and Kahn (2021; 2024) and Gete, Tsouderou, and Wachter (2023) show this for MBS securitization and credit risk transfers
- We estimate how flood risks interact with mortgage performance and mortgage terms
 - Sastry (2022), Gete et al. (2023), Issler et al. (2021), Biswas et al. (2024), Gallagher and Hartley (2017)
- Provide more comprehensive approach on calculating aggregated climate risk exposures within structured finance markets (i.e., MBS) demonstrating a way to measure exposure across hazard types or asset markets

MBS Background

Background on MBS

Mortgages



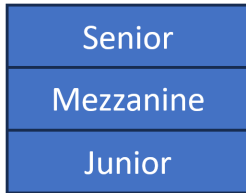
Mortgage
Pool



Risk

Low
↓
High

Mortgage-Backed Security
(divided into “tranches” and
sold at dif. levels of risk)



Expected Return

- **Pool:** A group of mortgage loans
- **Deal:** A group of one or more pools
- **Tranche:** A “slice” of a deal with a particular risk
 - Assigned a CUSIP and sold on the market
 - No direct correspondence between a tranche and a mortgage
- **Subordination:** Percent of a deal that falls beneath a more secure or higher rated tranche (e.g., subordination to AAA or BBB)

- **Subprime:** Mortgages originated with lower credit scores, lower income, and higher DTI
- **Alt-A:** Somewhere between prime and subprime. May have less documentation than prime, but still better characteristics than subprime

Data

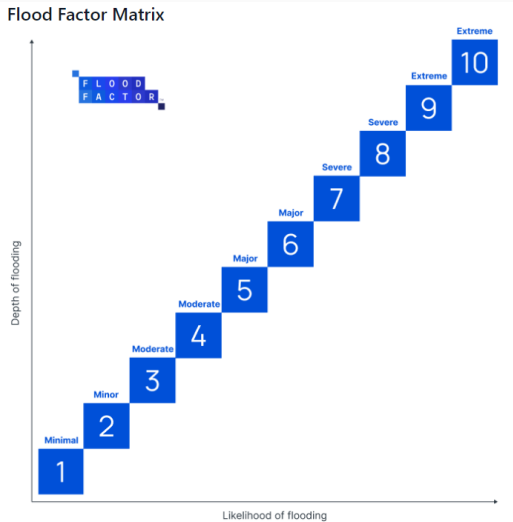
CoreLogic Private Label Securities-ABS (Subprime and Alt-A)

- Covers 90% of the market for subprime and Alt-A securities
- 6,142 deals covering 23 million mortgages
 - After cleaning, 15.6 million mortgages and about 3,500 deals between 1992-2009

Summary Stats

First Street Foundation Flood Factor

- Average Flood Factor (risk score) across all properties in a zip
 - Includes rainfall, storm surge, tidal, and riverine flooding



First Street Foundation Flood Factor

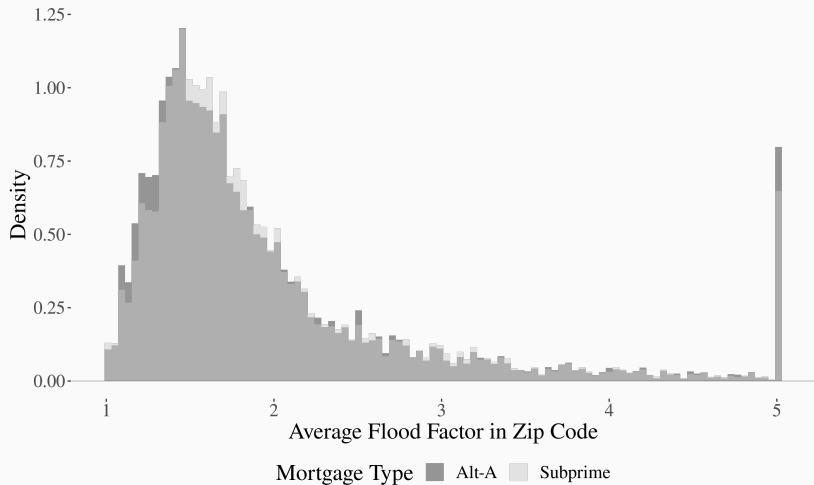
- Properties with $<0.2\%$ annual flood risk have Flood Factor of 1
- Over 30 years, Flood Factor has the following cutoffs:
 - $6\%+$ flood risk has a score of 2+
 - $26\%+$ flood risk has a score of 4+
 - $80\%+$ flood risk has a score of 5+
 - $99\%+$ flood risk has a score of 6+
- Scores are also a function of flood severity

Flood Risk

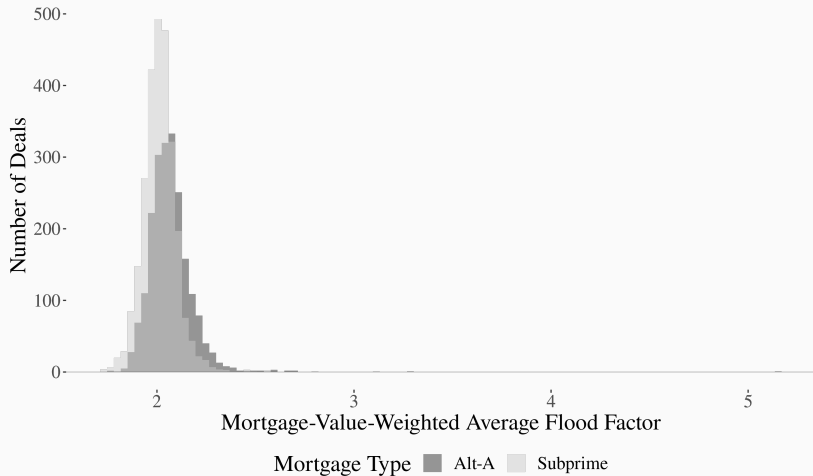
Calculating Flood Factor for MBS

- For each mortgage, assign it the Flood Factor of its zip code
- Aggregate mortgages into deals and assign the deal the origination-value-weighted Flood Factor

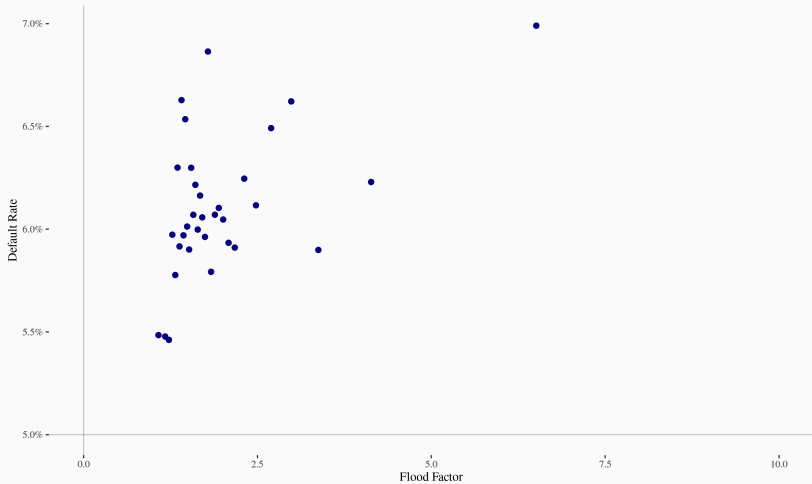
Distribution of Mortgage Flood Risk



Distribution of Deal Flood Risk



Binscatter of Mortgage Defaults and Flood Risk



Mortgage Performance and Flood Risk

Is Flood Risk Correlated with Mortgage Performance?

$$Y_{ist} = \beta_0 + \beta_1 \text{Flood}_i + \beta X_i + \lambda_t + \lambda_s + \epsilon_{ist}$$

- Y_{ist} : Mortgage i in state s at time t
 - **Default**: 90+DPD, foreclosed, prepaid with loss, or REO within 12 months of origination
 - Interest rate spread
 - Loan-to-value ratio of mortgage at origination
- Flood_i : binned zip code average Flood Factor for mortgage i
- X_i : vector of controls
 - Origination characteristics (e.g., LTV, FICO)
 - Macro variables (e.g., 12-month HPI change and county UR)
 - Tract-level ACS characteristics (e.g., median income)
- λ : state and quarter fixed effects
- Cluster at state level

Results

Dependent Variable:	Mortgage Default		
Model:	(1)	(2)	(3)
<i>Variables</i>			
Flood Risk (2, 4)	0.0001 (0.0019)	-0.0004 (0.0019)	0.0009 (0.0010)
Flood Risk (4, 6]	0.0041 (0.0029)	0.0030 (0.0030)	0.0016 (0.0013)
Flood Risk (6, 8]	0.0240*** (0.0069)	0.0233*** (0.0075)	0.0176*** (0.0064)
Flood Risk (8, 10]	0.0175*** (0.0028)	0.0173*** (0.0028)	0.0122*** (0.0024)
LTV	-0.0086*** (0.0026)	0.0022 (0.0044)	0.0036 (0.0047)
FICO	-0.0003*** (1.06×10^{-5})	-0.0003*** (1.14×10^{-5})	-0.0003*** (1.13×10^{-5})
DTI	0.0574*** (0.0042)	0.0532*** (0.0041)	0.0534*** (0.0039)
Log Orig. Amt	0.0372*** (0.0032)	0.0305*** (0.0023)	0.0298*** (0.0025)
Spread at Origination	0.0195*** (0.0009)	0.0200*** (0.0010)	0.0201*** (0.0010)
<i>Fixed-effects</i>			
Time FEs		Yes	Yes
State FEs			Yes
Dummies for missing values	Yes	Yes	Yes
Other Loan Controls	Yes	Yes	Yes
Local Economic Conditions	Yes	Yes	Yes
<i>Fit statistics</i>			
Observations	10,692,150	10,692,150	10,692,150
R ²	0.06250	0.06643	0.06763
Within R ²		0.04693	0.04533
Dep. Var. Mean	0.0592	0.0592	0.0592

Clustered (State FEs) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Interest Rate Results

Dependent Variable:	sato		
Model:	(1)	(2)	(3)
<i>Variables</i>			
Flood Risk (2, 4)	0.0279* (0.0156)	0.0265* (0.0152)	0.0148** (0.0069)
Flood Risk (4, 6)	0.0012 (0.0219)	-0.0057 (0.0259)	0.0065 (0.0130)
Flood Risk (6, 8)	0.1094*** (0.0341)	0.1222*** (0.0324)	0.0435** (0.0166)
Flood Risk (8, 10)	0.1861*** (0.0425)	0.1959*** (0.0399)	0.1292*** (0.0238)
LTV	2.108*** (0.0505)	2.018*** (0.0558)	1.968*** (0.0651)
FICO	-0.0100*** (0.0003)	-0.0097*** (0.0003)	-0.0097*** (0.0003)
DTI	0.0689** (0.0337)	0.0590* (0.0329)	0.0710* (0.0370)
Log Orig. Amt	-0.3963*** (0.0180)	-0.3136*** (0.0211)	-0.2974*** (0.0282)
<i>Fixed-effects</i>			
Time FEs		Yes	Yes
State FEs			Yes
Dummies for missing values	Yes	Yes	Yes
Other Loan Controls	Yes	Yes	Yes
Local Economic Conditions	Yes	Yes	Yes
<i>Fit statistics</i>			
Observations	10,239,981	10,239,981	10,239,981
R ²	0.64932	0.66242	0.66521
Within R ²		0.65105	0.64562
Dep. Var. Mean	2.223	2.223	2.223

Clustered (State FEs) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

LTV Results

Dependent Variable:	LTV		
Model:	(1)	(2)	(3)
<i>Variables</i>			
Flood Risk (2, 4]	-0.0026** (0.0013)	-0.0022* (0.0013)	-0.0028*** (0.0008)
Flood Risk (4, 6]	-0.0098*** (0.0017)	-0.0093*** (0.0014)	-0.0074*** (0.0021)
Flood Risk (6, 8]	-0.0018 (0.0040)	-0.0021 (0.0040)	-0.0080** (0.0031)
Flood Risk (8, 10]	-0.0106** (0.0046)	-0.0114*** (0.0042)	-0.0165*** (0.0021)
Mort. Spread	0.0208*** (0.0016)	0.0204*** (0.0011)	0.0198*** (0.0010)
FICO	0.0003*** (1.7×10^{-5})	0.0003*** (1.87×10^{-5})	0.0003*** (1.94×10^{-5})
DTI	0.0603*** (0.0042)	0.0651*** (0.0044)	0.0668*** (0.0044)
Log Orig. Amt	0.0672*** (0.0065)	0.0747*** (0.0092)	0.0777*** (0.0100)
<i>Fixed-effects</i>			
Time FEs		Yes	Yes
State FEs			Yes
Dummies for missing values	Yes	Yes	Yes
Other Loan Controls	Yes	Yes	Yes
Local Economic Conditions	Yes	Yes	Yes
<i>Fit statistics</i>			
Observations	10,239,981	10,239,981	10,239,981
R ²	0.44746	0.45602	0.46210
Within R ²		0.44732	0.43914
Dep. Var. Mean	0.8068	0.8068	0.8068

Clustered (State FEs) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Mortgage Analysis Summary

- Increased flood risk is associated with increased mortgage default
- Flood risk is barely adjusted for through mortgage interest rates
- Notable decreases in origination LTV -> higher down payment
- Do we see similar patterns for MBS deals?

Deal Performance and Flood Risk

Is Flood Risk Correlated with Deal Performance and Credit Protection?

$$Y_{it} = \beta_0 + \beta_1 \text{Flood}_i + \beta X_i + \lambda_t + \epsilon_{it}$$

- Y_i : share of deal i issued at time t that is
 - Defaulted in 12 months
 - Subordinated (below AAA or BBB-)
- Flood_i : balance-weighted average Flood Factor for deal i
- X_i : controls including
 - Avg interest rate, FICO, 12-month HPI change, LTV, coupon
 - Shares of the deal that are low-doc, IO, investor type
 - Geographic concentration (HHI using state shares of deal)
- λ : year-quarter and deal-type fixed effects

Deal-Level Default Results

Dependent Variable:	Defaulted Share of Deal	
Model:	(1)	(2)
<i>Variables</i>		
Avg. Flood Factor	0.0321*** (0.0073)	0.0155*** (0.0055)
LTV	0.0232 (0.0199)	0.0239 (0.0210)
FICO	-0.0005*** (0.0001)	-0.0005*** (0.0001)
Interest Rate	0.0010 (0.0007)	0.0025*** (0.0007)
Coupon Rate	0.0058*** (0.0008)	0.0035*** (0.0007)
Geographic Conc.	-0.0130* (0.0071)	0.0057 (0.0062)
<i>Fixed-effects</i>		
Time FEs		Yes
Other Deal Controls	Yes	Yes
<i>Fit statistics</i>		
Observations	3,499	3,499
R ²	0.65378	0.69132
Within R ²		0.58027
Dep. Var. Mean	0.0488	0.0488

Clustered (Time FEs) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Deal Subordination Results

Dependent Variables: Model:	Below AAA		Below BBB-	
	(1)	(2)	(3)	(4)
<i>Variables</i>				
Avg. Flood Factor	0.0425*** (0.0131)	0.0259** (0.0124)	0.0056*** (0.0011)	0.0038*** (0.0014)
LTV	0.2017*** (0.0282)	0.1875*** (0.0269)	0.0133*** (0.0026)	0.0123*** (0.0027)
FICO	-0.0006*** (0.0001)	-0.0006*** (0.0001)	4.89×10^{-6} (5.45×10^{-6})	2.19×10^{-6} (5.21×10^{-6})
Coupon Rate	0.0062*** (0.0017)	0.0073*** (0.0012)	0.0007*** (0.0001)	0.0007*** (0.0001)
Interest Rate	-0.0025* (0.0013)	0.0029*** (0.0010)	-0.0001 (0.0001)	0.0002** (0.0001)
Geographic Conc.	0.0102 (0.0135)	0.0617*** (0.0101)	-0.0045*** (0.0015)	-0.0010 (0.0016)
<i>Fixed-effects</i>				
Time FEs		Yes		Yes
Other Deal Controls	Yes	Yes	Yes	Yes
<i>Fit statistics</i>				
Observations	3,499	3,499	3,499	3,499
R ²	0.50346	0.57551	0.06931	0.12799
Within R ²		0.55226		0.07313
Dep. Var. Mean	0.1010	0.1010	0.0034	0.0034

Clustered (Time FEs) standard-errors in parentheses

Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Conclusion and Future Steps

- Flood risk is correlated with loan-level default
 - Little adjustment to interest rates, but lower LTVs
- Flood risk is correlated with deal-level default shares
 - Flood risk is offset by increased credit protection
 - Credit protection is mostly to AAA-tranche level holders, with a little protection for investment-grade investors overall
- Our paper has important implications for:
 - **Policymakers/Investors:** Private-label MBS markets may already be adjusting to climate risk
 - Is the agency-backed MBS market adjusting similarly?
 - Has the market adjusted enough?
 - **Lenders:** Lenders have multiple ways to adjust for increased risk
 - Are lenders adjusting enough? Are they just passing on risk to investors downstream?

Thank you!

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Appendix

ABS Summary Statistics

Statistic	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)	Max
Default	0.06	0.23	0	0	0	1
Loan Balance ('000)	175.97	150.51	75.98	134.90	230.00	25,450.41
LTV	0.81	0.15	0.75	0.80	0.90	1.00
FICO	646.89	70.68	597	646	697	944
Balloon Payment	0.12	0.33	0	0	0	1
DTI	0.23	0.21	0.00	0.30	0.43	9.52
Interest Rate	8.17	1.92	6.75	7.88	9.35	20.00
Low Doc	0.45	0.50	0	0	1	1
Investor Flag	0.12	0.32	0	0	0	1
Avg. Flood Factor	2.01	1.07	1.44	1.68	2.13	10.00

[Data Cleaning](#)[Back](#)

Data Cleaning

Filter	Mortgage Count
Starting Count	23,174,940
Only 15 or 30-year FRMs and 2, 3, or 5-year ARMs	18,601,778
Restricting Originations to Jan 1992 - Jun 2009	18,059,638
Dropping Negative Amortizing Mortgages	18,059,638
Dropping Invalid Zip Codes	17,796,383
Dropping Invalid Orig. Dates	17,766,772
Dropping LTV $\geq 100\%$ or Negative LTVs	17,494,721
Dropping interest = 0% or interest $\geq 20\%$	17,248,629
Restricting to 50 States, DC, and Puerto Rico	17,248,280
Dropping Missing Flood Scores	17,125,217
Dropping Missing HPI Changes	16,602,833

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