HOUSE ENVIRONMENT AND TRANSPORTATION COMMITTEE
Delegate Marc Korman, Chair
Delegate Regina T. Boyce, Vice Chair

January 21, 2025
11:00 AM
House Office Building, Room 250

Homeowners Insurance – Affordability and Coverage
BRIEFING AGENDA

I. Introductory Remarks

II. Maryland Insurance Administration
- Marie Grant, Acting Commissioner
- Joy Hatchette, Deputy Commissioner

III. Baltimore City
- Nicole Hart, Deputy Commissioner of Homeownership and Housing Preservation, Department of Housing & Community Development

IV. Worcester County and the Town of Ocean City
- Richard W. Meehan, Mayor of Ocean City
- Commissioner Anthony W. Bertino, Jr., Worcester County Commissioners (*Written Testimony Only)*

V. National Association of Mutual Insurance Companies (NAMIC) and Maryland Association of Mutual Insurance Companies (MAMIC)
- Matt Overturf, Assistant Vice President, State Affairs, NAMIC (*Virtual*)
- Bryson F. Popham, Esq., Lobbyist, MAMIC
- Christopher M. Roberts, Product Manager for Farmers of Salem Insurance, MAMIC

VI. Consumer Federation of America
- Sharon Cornelissen, Director of Housing

VII. University of Maryland, Robert H. Smith School of Business
- Dr. Clifford Rossi, Professor-of-the-Practice, Executive-in-Residence, and Director of the Smith Enterprise Risk Consortium

VIII. Questions

IX. Concluding Remarks

Maryland
INSURANCE ADMINISTRATION

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Maryland
INSURANCE ADMINISTRATION

House Environment and Transportation Committee Briefing

January 21, 2025

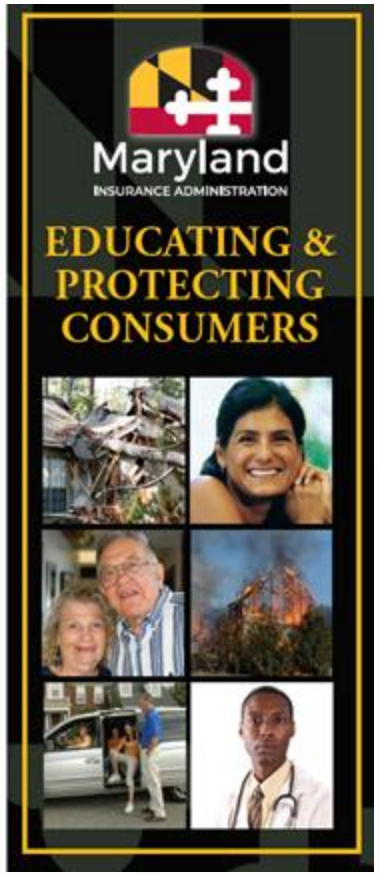
Agenda

- Introduction to the Maryland Insurance Administration
- Understanding what is Covered under a Homeowners Insurance Policy
- American Academy of Actuaries Report on Impacts of Climate Change
- U.S. Senate Budget Committee Staff Report on Impacts of Climate Change
- Rate Change History for the Top 10 Homeowners Insurers in Maryland
- 2023 Market Conduct Annual Statement Data
- 2024 Homeowners Market Hardening Survey
- Decreasing Availability of Coverage for Mobile/Manufactured Homes in Coastal Areas
- National Climate Resilience Strategy for Insurance
- Property & Casualty Insurance Market Intelligence Data Call
- Premium Discounts for Storm Loss Mitigation

What is the Maryland Insurance Administration?

The Maryland Insurance Administration (MIA) is the state agency that regulates insurance in Maryland. The MIA:

- Licenses insurers and insurance producers (agents or brokers).
- Examines the business practices of licensees to ensure compliance.
- Monitors solvency of insurers.
- Reviews/approves insurance policy forms.
- Reviews insurance rates to ensure rates are not inadequate, excessive or unfairly discriminatory.
- Investigates consumer and provider complaints and allegations of fraud.



The MIA's Authority to Regulate Homeowners Insurance

- The MIA regulates the homeowners insurance market in Maryland, including:
  - HO-4 (renters) policies;
  - HO-6 (condominium) policies;
  - HO-7 (mobile/manufactured home) policies; and
  - Dwelling fire policies.
- The MIA regulates the Maryland Joint Insurance Administration ("MDJIA"), which is the essential property insurer of last resort established under Title 25, Subtitle 4 of the Insurance Article. The MDJIA:
  - Had a 0.02% market share, ranking in 97th place, based on written premium in CY 2022.
  - Had a 0.02% market share, ranking in 98th place, based on written premium in CY 2023.

The MIA's Authority to Regulate Homeowners Insurance

The MIA has limited regulatory authority over surplus lines carriers, as it does not license them.

- An authorized insurer holds a valid certificate of authority (i.e., license) issued by the MIA.
- Authorized homeowners insurers are required to file policy forms, endorsements, rates, rating plans, rating rules and amendments to these items with the MIA.
  - All policy forms require the Commissioner's approval before they can be used.
  - Authorized insurers file *rating plans* with the MIA for review, but NOT *underwriting guidelines*.
- Surplus lines insurance provides coverage for specialized risks that authorized insurers do not cover.
- Surplus lines insurance is provided by unauthorized carriers that are generally exempt from rate and form filing requirements.

Common Coverages under a Homeowners Insurance Policy

- **Dwelling (Coverage A)** – provides protection if a covered peril damages or destroys your home
- **Other Structures (Coverage B)** – provides protection if a covered peril damages or destroys detached outbuildings and structures, like fences, that are not part of your dwelling
- **Personal Property (Coverage C)** – provides protection if your personal property is lost, damaged or destroyed by a covered peril
- **Additional Living Expenses** – may pay for additional expenses you incur when you cannot live in your home because of damage or loss that is covered by your policy
- **Liability Coverage** – may provide protection if you or a member of your family are legally responsible for an injury to another person or cause damage to another person's property
- **Medical Payments** – provides payment up to a specified amount for reasonable and necessary medical expenses incurred by people injured in an accident in your home regardless of fault (does not apply to you or member of your household)

Additional Coverages

- **Water/Sewer Backup** – provides protection if water backs up through sewers or drains, not due to your negligence
- **Ordinance or Law Coverage** – if your home is damaged during a disaster, you may be required to perform expensive upgrades to your property to comply with your county's current building codes, and this coverage would cover the cost of these upgrades
- **Buried Utility Lines Coverage** – covers the cost of repairing or replacing underground utility lines (e.g., water pipes, sewer lines, or electrical wires), that run from the street to your home, if they become damaged due to issues like freezing, tree root intrusion, or wear and tear

*** The Declarations Page of your policy identifies what is covered by the policy, what it costs, and the policy limits. ***

*** Many policies include an "anti-concurrent causation" clause, which provides that damages incurred by a combination of covered and non-covered perils are not covered. ***

American Academy of Actuaries Report

- In June of 2023, the American Academy of Actuaries published a report entitled *Climate Risks Pose Broad Impacts on Financial Security Systems*, which can be accessed at: https://www.actuary.org/sites/default/files/2023-06/CRIFS.pdf

- Executive Summary: "Both frequency and severity of climate-related events are accelerating, which affects both short-term and long-term financial modeling. As a result, awareness that climate change and climate risks will impact actuarial work across practice areas is important because these physical risks and the potential subsequent impacts of the transition risks will result in historical data having decreasing credibility to inform actuarial assumptions in the short, medium, and long term. In addition, investment strategies will need to reflect considerations of how companies are adjusting to climate change impacts."

American Academy of Actuaries Report

- The report highlights the increasing frequency of weather and climate disasters resulting in overall damages/costs that reach or exceed $1 billion.
- The report contains the chart below, which presents data published by the National Oceanic and Atmospheric Administration's National Centers for Environmental Information.

Billion Dollar Tropical Cyclone (Hurricane) Disasters

Decade	Billion-Dollar Disasters	Cost in Billions (CPI adj'd to 2022)	Avg Disaster Cost ($Billions)	Deaths
1982-1991	7	44.3	6.32	214
1992-2001	12	127.1	10.59	324
2002-2011	16	410.8	25.68	2,466
2012-2021	21	610.1	29.05	3,691
Totals:	56	1,192.3	21.29	6,695

American Academy of Actuaries Report

Climate change impacts that may present direct risks to Maryland's homeowners insurance market:

- **Hurricanes** – In the past decade, there has been a significant increase in the number of major hurricanes. Increasing water temperature, particularly in the Gulf of Mexico, has caused increased instances of significant hurricane intensification shortly before landfall. Increasing water temperature in the eastern Atlantic Ocean will lead to more northern hurricane formation, increasing the probability of strong storms making landfalls in the northern U.S.

- **Sea Level Rise** – Steady sea level rise is certain to continue, given the melting ice in Antarctica, Greenland, and the world's glaciers. Low-lying properties along coastal areas of the U.S. face an increasing risk of flooding from tropical storms, as well as "clear-sky" flooding during high tides.

- **Winter Storms** – In recent years, there has been an increase in the severity of Nor'easters, which often cause significant damage to mid-Atlantic and New England coastal states.

U.S. Senate Budget Committee Staff Report

- On December 18, the Senate Budget Committee released a dataset and accompanying staff report entitled *Next to Fall: The Climate-Driven Insurance Crisis is Here*, which can be accessed at: https://www.budget.senate.gov/chairman/newsroom/press/new-data-reveal-climate-change-driven-insurance-crisis-is-spreading

- The data set analyzed in the report:
  - Includes county-level non-renewal data collected from 23 companies that collectively account for about 65% of the national homeowners' insurance market;
  - Covers 249 million insurance policies; and
  - Covers a 6-year period from CY 2018 through CY 2023.

- The report focuses on non-renewal data because insurance industry experts have advised the Committee that spiking non-renewal rates are often an early sign of market destabilization.

U.S. Senate Budget Committee Staff Report

- Key conclusions of the report:
  - There is a correlation between rising non-renewal rates (decreasing availability) and rising premiums (decreasing affordability).
  - Counties/states that are most exposed to climate-related risks, such as wildfires (e.g, CA) or hurricanes (e.g., FL and LA), have the highest non-renewal rates.
  - Relatively high non-renewal rates in Southern New England, the Carolinas, New Mexico and certain counties in the Northern Rockies, Oklahoma, and Hawaii suggest that the full scope of climate-related effects (e.g., hurricanes, severe convective storms, hail, extreme precipitation, and sea level rise) contribute to destabilization in insurance markets.
- Ranking of 50 states + DC
  - MD had the 44th highest non-renewal rate for CY 2023 (0.65% of policies in force)
  - MD had the 27th highest annual non-renewal rate increase between 2018 and 2023 (+ 0.15%)

Maryland Homeowners Rate Change History 2017-2024

Top 10 Insurers Based on 2023 Written Premium

	Indicated			Proposed		
Submitted	High	Low	Range	High	Low	Range
2024	23.7%	2.6%	21.1%	16.1%	2.6%	13.5%
2023	57.0%	6.8%	50.2%	38.0%	3.6%	34.4%
2022	57.6%	4.0%	53.6%	12.4%	1.6%	10.8%
2021	30.7%	5.2%	25.5%	8.0%	0.0%	8.0%
2020	49.3%	2.1%	47.2%	6.2%	2.0%	4.2%
2019	23.1%	3.4%	19.7%	13.5%	3.4%	10.1%
2018	10.9%	7.3%	3.6%	3.1%	0.0%	3.1%
2017	10.9%	-7.0%	17.9%	3.0%	0.0%	3.0%

2023 Market Conduct Annual Statement Data

- The “MCAS” was developed through the National Association of Insurance Commissioners as a uniform system of collecting key market performance data for several insurance lines of business to help state insurance administrations effectively allocate market regulation resources.
- Homeowners insurers report MCAS data to each jurisdiction in which they are licensed and meet the premium threshold for reporting ($50,000 for 2023).
- Information reported in the MCAS is confidential. Only aggregate, noncompany-specific MCAS data can be shared publicly.
- 116 homeowners insurance companies reported MCAS data to MD in 2023.
- 2023 MCAS data showed that, in general, underwriting guidelines have become more stringent.
  - New homeowners policies written decreased by 5.77% between 2021 and 2023.
  - Company-initiated non-renewals increased by 62.34% between 2021 and 2023.

2024 Homeowners Market Hardening Survey

Background:

- The MIA has been monitoring changes in the homeowners insurance market which may be attributable to inflation, climate change, and other factors.
- In August of 2024, the MIA issued a survey to the top 30 homeowners insurers (by 2023 market share) plus one additional carrier domiciled in MD.
- The purpose of the survey was to determine the extent to which it has become more difficult for consumers to obtain and maintain coverage on properties with varying characteristics.
- The MIA published a report summarizing the survey findings in November of 2024 at: https://insurance.maryland.gov/Consumer/Appeals%20and%20Grievances%20Reports/Market-Hardening-Survey-Report-Homeowners-Insurance-Market-in-MD.pdf.

2024 Homeowners Market Hardening Survey

Survey Findings:

- After a decrease from 2021 to 2022, there was an increase in the number of new policies written between 2022 and 2023.
    - A decline in new policies written in recent years may be attributable to a decline in new home construction resulting from supply chain issues in the aftermath of the COVID-19 pandemic. It seems this trend is reversing.
- A significant increase in company-initiated nonrenewals from 2021 to 2022 and from 2022 to 2023 indicates that carriers have become more stringent in assessing risk within their existing book of business.
    - Out-of-date home maintenance was the leading reason. It seems carriers are dedicating more resources to inspect homes prior to renewal to assess whether proper maintenance has been completed and whether the level of risk has increased.
    - Underwriting was also a top reason. Some homes were no longer eligible for coverage due to a change in the carrier's underwriting guidelines. (Underwriting guidelines are NOT filed with the MIA, but must comport with rating plans that have been filed with the MIA.)

2024 Homeowners Market Hardening Survey

Survey Findings:

- There was an overall decrease in the number of company-initiated cancellations (other than for nonpayment) in most MD counties over the last 3 years.
  - The insured selling the home with no replacement coverage required on a new home was the leading reason.
  - Underwriting and out-of-date maintenance were also top reasons.
- Underwriting guidelines for the 29 survey respondents writing new business:
  - 23 restrict new business and/or renewals due to distance from coast/water exposure.
    - Most will not insure a home within 500 feet - 5 miles of a coastline.
    - Many indicated that coastline restrictions are primarily based on hurricane risk.
    - Coastline restrictions primarily apply to properties on the Eastern Shore. Worcester County is the county most frequently named in underwriting guidelines.

2024 Homeowners Market Hardening Survey

Survey Findings:

- Underwriting guidelines for the 29 survey respondents writing new business (continued):
  - 28 restrict new business and/or renewals for mobile and manufactured homes.
  - 11 restrict new business and/or renewals for roofs of a certain age.
  - 11 offer replacement coverage only for roofs. 18 offer actual cash value coverage for *qualifying* roofs (the most common determinant being the age of the roof).
  - 8 restrict new business and/or renewals due to the age of the home.
  - 4 increased their percentage deductibles between 2021 and 2023.
  - 15 have mandatory wind and/or hurricane deductibles that generally range from 1% to 5% and, in a few cases for non-coastal properties, from $500 to $1,000.

Decreasing Availability of Coverage for Mobile/Manufactured Homes in Coastal Areas

- Consumers and elected representatives from Worcester County shared concerns about the decreasing availability of insurance coverage for mobile/manufactured homes.

- The MIA solicited written comments and held a virtual informational hearing on October 23 to gather information concerning the scope of this issue, contributing factors, and potential solutions. Written or spoken comments were received by:
  - The Maryland Joint Insurance Administration ("MDJIA")
  - Del. Hartman and staff for Sen. Carozza (District 38C, Wicomico Co and Worcester Co)
  - Ocean City Mayor, Richard Meehan and the City Manager of Ocean City, Terry McGean
  - Private citizens
  - Consumer advocacy groups
  - Insurance companies, producers, and brokers
  - The American Property Casualty Insurance Association

Decreasing Availability of Coverage for Mobile/Manufactured Homes in Coastal Areas

- On January 7, the MIA published a report summarizing considerations addressed at the hearing and in written comments, as well as responsive action that the MIA has taken at: https://insurance.maryland.gov/Consumer/Appeals%20and%20Grievances%20Reports/Report-on-the-Decreasing-Availability-of-Insurance-Coverage-for-Mobile_Manufactured-Homes-in-Coastal-Areas.pdf
- Summary of findings:
  - It is extremely difficult to obtain *replacement cost* coverage on mobile/manufactured homes in Worcester County (as well as costal areas of VA and DE) that are 25 years or older. Since most lenders require replacement cost coverage to secure a mortgage, prospective buyers may be limited in how to finance a purchase and property values may be adversely impacted.

Decreasing Availability of Coverage for Mobile/Manufactured Homes in Coastal Areas

- Summary of findings (continued):
  - The MDJIA writes Dwelling Fire Form 1 ("DP1") policies for mobile/manufactured homes in Worcester County. Claims under a DP1 policy are paid on an *actual cash* value basis, which factors in depreciation.
  - Unlike site-built homes, mobile/manufactured homes tend to depreciate (although the value of the *land* to which a mobile/manufactured home is affixed usually appreciates) over time.
  - In many cases, the fully depreciated value (i.e., actual cash value) of an older mobile/manufactured home is significantly lower than the estimated cost to rebuild or replace it with similar materials at current prices (i.e., replacement cost value).
    - From an insurer's perspective, offering a replacement cost option on a severely depreciated asset may present a morale hazard.

Decreasing Availability of Coverage for Mobile/Manufactured Homes in Coastal Areas

- Summary of findings (continued):
  - Mobile/manufactured homes are not subject to the same building codes as site-built homes. Rather, they must be constructed in accordance with standards established by the U.S. Department of Housing and Urban Development (the "HUD Code").
  - Many mobile/manufactured homes are modified with carports, porches, and other additions that significantly increase structural vulnerability to high winds and other severe weather events.
  - The cost of catastrophe reinsurance, which carriers purchase to ensure solvency, is a primary factor that may deter carriers from writing mobile/manufactured homes (or site-built homes) in coastal areas.

Decreasing Availability of Coverage for Mobile/Manufactured Homes in Coastal Areas

- Summary of findings (continued):
  - Catastrophe models are used to analyze an insurer's portfolio of risks for the purpose of determining the amount of catastrophe reinsurance it needs to purchase. Reinsurers also use this information to determine the cost of reinsurance. Catastrophe models take into account the location, type of construction, age, building codes, values, concentration of insured risks, and the likelihood of a specific peril impacting the portfolio.
  - Factors that may impact catastrophe reinsurance costs include:
    - Increased frequency/severity of severe weather events due to climate change;
    - Change in reinsurers' perception of climate risks; and
    - Increased exposure to disaster risk due to population shifts into vulnerable areas.

National Climate Resilience Strategy for Insurance

- The National Association of Insurance Commissioners (NAIC) adopted the National Climate Resilience Strategy for Insurance in March of 2024. It can be accessed at: https://content.naic.org/sites/default/files/draft-naic-national-climate-resilience-strategy-12-1-2023-updated.pdf

- The goal of the strategy is to drive faster and more effective risk reduction by state insurance regulators to ensure that insurance continues to be available and reliable as a crucial backbone to communities facing climate risks. This strategy advocates for home hardening from wildfires, floods, and storms; utilizing catastrophe modeling information; better informing the public of risks; and making sure new solvency tools are updated to incorporate further analysis of climate risks.

Property & Casualty Insurance Market Intelligence Data Call

- In March of 2024, state insurance regulators issued a comprehensive, multi-state data call coordinated by the NAIC to collect and analyze data covering more than 80% of the U.S. property insurance market by premium volume.
- The data template and related criteria asked homeowners insurers to submit ZIP-code-level data on premiums, policies, claims, losses, limits, deductibles, non-renewals, and coverage types. In total, insurers were asked to provide more than 70 data points.
- The data call will provide insights into property insurance market costs, coverages, and protection gaps amid the increasing frequency and severity of natural disasters, escalating reinsurance costs, and continued inflationary pressures.
- Maryland and other participating jurisdictions are currently working to standardize and analyze the extensive data collected. A uniform set of metrics developed and analyzed across states (for parity) should be complete by late-March. The MIA expects to issue a report on Maryland-specific data soon thereafter.

Premium Discounts for Storm Loss Mitigation

- § 19-210 of the Insurance Article requires homeowners insurers to offer at least one actuarially justified premium discount to a policyholder who submits proof of qualifying improvements to the insured premises that mitigate loss from a hurricane or other covered storm.

- An insurer that offers a premium discount under § 19-210 must provide a policyholder with an annual statement regarding the availability of the discount and the method of applying for the discount.

- Improvements must be inspected by a contractor licensed by the Maryland Department of Labor and verified by the insurer to result in a premium discount.

    - An insurer may accept an inspection certificate issued by a governmental agency, or conduct its own inspection of the improvements.

Premium Discounts for Storm Loss Mitigation

- Improvements that may qualify a policyholder for a premium discount per § 19-210 include:
  - Installation of hurricane shutters, secondary water barriers, reinforced roof coverings, braced gable ends, reinforced roof to wall connections, tie downs, or reinforced opening protections;
  - Repair or replacement of exterior doors (including garage doors), hurricane resistant trusses or studs;
  - Repair or replacement of manufactured home piers, anchors, or tie down straps; and
  - Any other action that materially mitigates loss from a hurricane or other storm otherwise covered under the policy.

Resources for Consumers/Constituents

- Consumer Guide to Homeowners Insurance
  https://insurance.maryland.gov/Consumer/Documents/publications/homeownersinsguide.pdf

- Tips on shopping for homeowners insurance
  https://insurance.maryland.gov/Consumer/Documents/publications/homeownersshoppingtips.pdf

- Homeowners & Renters Insurance - A Comparison Guide to Rates (as of August 2024)
  https://insurance.maryland.gov/Consumer/Documents/publicnew/HORateGuide2024.pdf

- Understanding your Homeowners Declarations Page
  https://insurance.maryland.gov/Consumer/Documents/publications/understandinghodeclarationspage.pdf

- File and Use: What does it mean and how does it work?
  https://insurance.maryland.gov/Consumer/Documents/publications/ConsumerAdvisory-File-and-Use-What-Does-This-Mean-and-How-Does-It-Work.pdf

Contact Information

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800-492-6116 | 410-468-2000 | 800-735-2258 (TTY)

insurance.maryland.gov

MDInsuranceAdmin

en Español: MDInsuranceAdminES

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January 20, 2025

Chair Korman, Vice Chair Boyce, and members of the Environment and Transportation Committee:

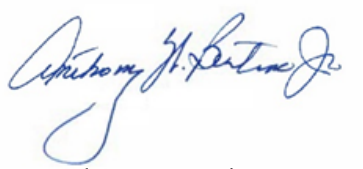
My name is Chip Bertino, a commissioner of Worcester County. I regret I am unable to attend this week's committee briefing as we are in session Tuesday morning. Please accept these written comments on behalf of the Worcester County Commissioners.

In recent months, Worcester County officials were made aware that property owners with older mobile and manufactured homes are struggling to secure insurance. While some have been advised by their insurance companies that their policies are being dropped, others only became aware of the issue when they tried to sell their property and prospective buyers were unable to get a mortgage, incapable of procuring insurance. That leaves thousands of property owners, whether they're in Ocean City's popular Montego Bay community or one of the county's unique campground subdivisions, in a precarious situation. Whether these individuals are retirees who reside in their mobile home full-time or second homeowners who have used their hard-earned savings to invest in Maryland's coast, these property owners deserve to be able to insure their homes. As long as these homes remain uninsured, those property owners are at risk and taxpayers will be the ones burdened if a natural disaster occurs and state and federal funds have to be used to rebuild. Furthermore, the lack of insurance options is already impacting the economy, as property owners with mobile homes in the resort have been unable to sell because buyers are unable to get a mortgage without insurance. If they are able to sell, it is only to cash buyers at reduced rates.

While we are grateful that the Maryland Joint Insurance Association updated its policy so that homeowners with no other options are able to purchase dwelling policies, insurance agents have advised that dwelling policies do not provide replacement coverage, which many mortgage lenders require.

We empathize with the struggle residents in California and North Carolina face as they try to rebuild their lives in the wake of recent disasters and that is why we feel it is important to protect our own residents from similar occurrences.
The objectives of your committee hearings will hopefully bring about a change that is in the best interest of our the homeowners who are impacted by this situation. We thank you for your interest in this matter and the invitation to express our concerns on this topic.

Sincerely,



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January 17, 2025

The Honorable Marc Korman
Chairman
House Environment and Transportation Committee
250 Taylor House Office Building
Annapolis, Maryland 21401

RE Homeowners Insurance - Affordability and Coverage - Briefing January 21, 2025

Chairman Korman and Members of the Committee,

On behalf of the Maryland Association of Mutual Insurance Companies (MAMIC), we are pleased to address the Committee on this important subject.

Attached you will find a brief description of the mutual insurers that comprise the membership of MAMIC, with a summary of our mission. Also attached is a copy of an article from the New York Times edition of January 17th, that may be helpful to Committee members in understanding the homeowners insurance market in Maryland.

Very truly yours,

Bryson Popham

Enclosure

MAMIC

Maryland Association of Mutual Insurance Companies

The Maryland Association of Mutual Insurance Companies (MAMIC) is an education and advocacy trade association and is comprised of 12 mutual insurance companies that write insurance business in the State of Maryland. The mission of MAMIC is multifaceted, but generally is to promote and protect the principles of mutuality and cooperation upon which the member companies are founded and to do any and all things that may be of service and benefit to mutual insurance generally, including the policyholders they serve. Approximately one-half of our members are domiciled in Maryland, and are key contributors and employers in our local communities. Together, MAMIC members offer a wide variety of insurance products and services and provide coverage for thousands of Maryland citizens.

Baltimore Equitable Insurance 1794

Brethren Mutual Insurance Company

Cumberland Mutual

DONEGAL INSURANCE GROUP

Farmers of Salem Insurance since 1851

Frederick Mutual Insurance Company

HARFORD MUTUAL INSURANCE GROUP

HSB A Munich Re company

MEDICAL MUTUAL Liability Insurance Society of Maryland

MUTUAL BENEFIT GROUP

NAMIC National Association of Mutual Insurance Companies

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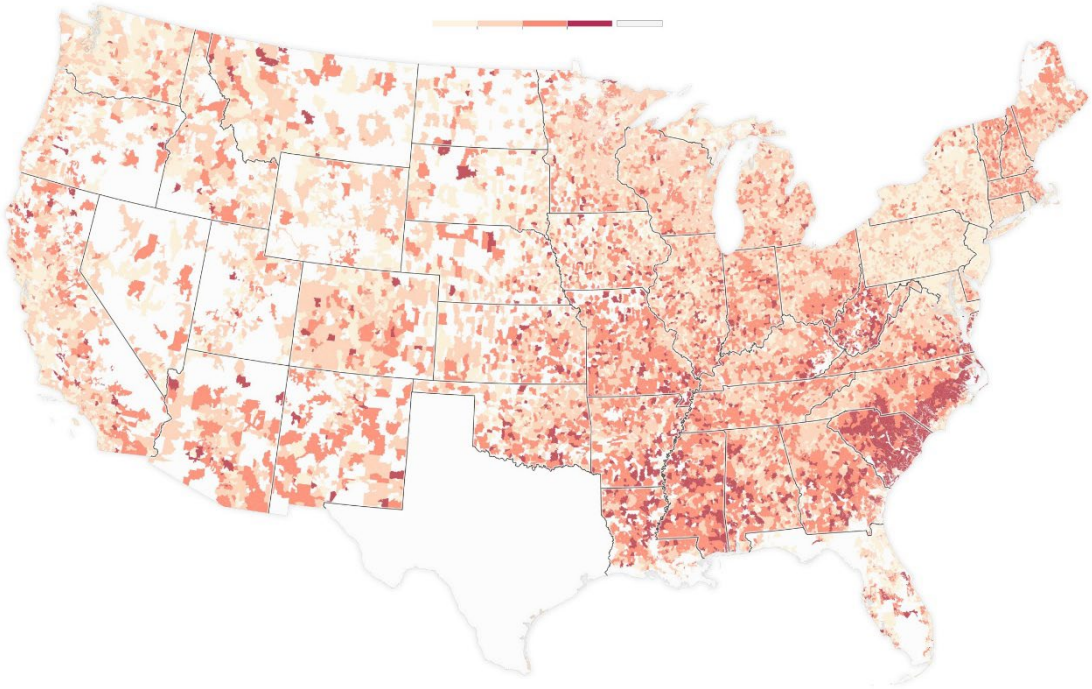
1844 WINDSOR NAVIGATING UNCERTAINTY TOGETHER

More Americans, Risking Ruin, Drop Their Home Insurance
By Christopher Flavelle and Mira Rojanasakul
Jan. 16, 2025

Homeowners in places most exposed to climate disasters are increasingly giving up on paying their insurance premiums, leaving them exposed to financial ruin, according to sweeping new government data. The numbers show how climate change is eroding the underpinnings of American life by making home insurance costlier and harder to hang on to, even as wildfires, hurricanes and other calamities increasingly threaten what is, for many people, their most valuable asset.



No data for Texas. Only partial information was available for seven other states. Source: National Association of Insurance Commissioners and Federal Insurance Office, U.S. Department of the Treasury.

"Homeowners' insurance is where many Americans are now feeling the financial effect of climate change directly, in their pocketbook," said Ethan Zindler, climate counselor at the Treasury Department. "Nature doesn't really care whether people are living in a blue state or a red state or another state, or whether you do or don't believe in climate change."

The rising cancellation rates are part of a broader trend captured by the Treasury Department, which analyzed information for 246 million insurance policies issued by 330 insurers nationwide from 2018 through 2022. The result is the most comprehensive look yet at the effect of climate change on the American home insurance market.

Homeowners with mortgages are generally required by lenders to carry insurance. But people who own a house outright, perhaps because the property has been in a family for decades or generations, have the option of dropping insurance.

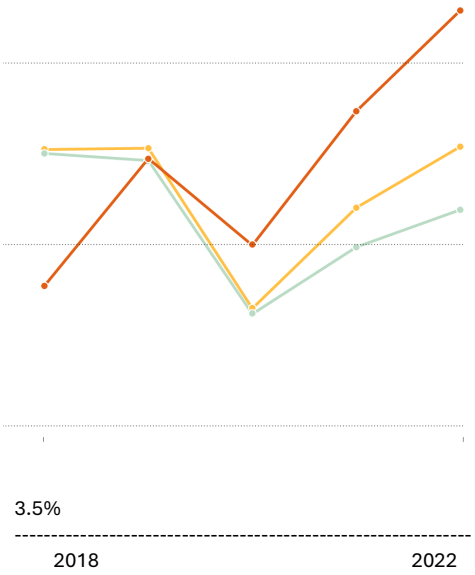
The cost and frequency of insurance claims are rising quickly in the highest-risk parts of the United States, as defined by the Federal Emergency Management Agency, according to the numbers. They show that the financial stress on insurers is also growing.

So, too, is the cost of insurance, which has risen far more in high-risk areas than elsewhere.

As those trends worsen, more people are getting thrown off their insurance plans. That happens two ways. One is through cancellations, when insurers drop homeowners who fail to pay their premiums. Another is through nonrenewals, in which insurers refuse to renew the policies of homeowners who want to keep paying for coverage.

The rates of both cancellations and nonrenewals are increasing, and those increases are most pronounced in high-risk areas.

Higher Risk, Fewer Insured
Homeowners policies in the riskiest areas have been increasingly dropped by insurance companies or cancelled for missed payments.



In more than 150 ZIP codes around the country, insurers canceled at least 10 percent of home insurance policies in 2022, the most recent year for which numbers are available, because homeowners failed to pay their premiums, according to the data. Cancellation rates were highest in coastal areas in the Carolinas, including Hilton Head, Charleston and Myrtle Beach, which are especially exposed to hurricanes. They were also high in parts of West Virginia, Arizona and California.

The data doesn't capture why homeowners chose to stop paying. But Nellie Liang, the Treasury Department's under secretary for domestic finance, said her team viewed it as an indicator of families facing growing financial stress worsened by climate change.

"Households are not able to bear the burden by themselves," Ms. Liang said.

As for cases where insurance companies refused to renew policies even for their paying customers, those nonrenewal rates were also higher, and grew faster, in high-risk areas. The ZIP codes with the greatest share of nonrenewals in 2022 were in coastal South Carolina as well as parts of California, including in Sonoma County and Yuba County, which have been hit by wildfires. Areas of Tennessee that have suffered severe storms also saw high nonrenewals.

The destabilization of the home insurance market doesn't hurt only homeowners, Ms. Liang said. It also threatens property-tax revenues that communities rely on, since tax receipts can decline if homeowners can't rebuild or if homes lose value. It also hurts local businesses that rely on homeowners as customers. "There's a lot to worry about," Ms. Liang said.

Homes and Communities at Risk: Our Insurance Crisis in Maryland

Sharon Cornelissen, PhD
Director of Housing, Consumer Federation of America

Briefing to Environment and Transportation Committee, Maryland General Assembly

January 21, 2025

Key Facts on Our Insurance Crisis

Why steep price increases since 2021?

- Inflation in building materials and construction costs
- Risk adjustment based on climate disasters and future loss expectations
- Unregulated reinsurance markets

- *Individual impacts:* becoming and staying a homeowner
- *Systemic impacts:* Community impacts of uninsured neighbor

“Exposed” Report (2024, CFA)

- Nation-wide: 7.4% (2021)
- Maryland: 5%
- **They are disproportionally:**

- *Lower-income*
- *Homeowners of color*
- *Have no mortgage (anymore)*
- *Have inherited their home*
- *Own manufactured homes*

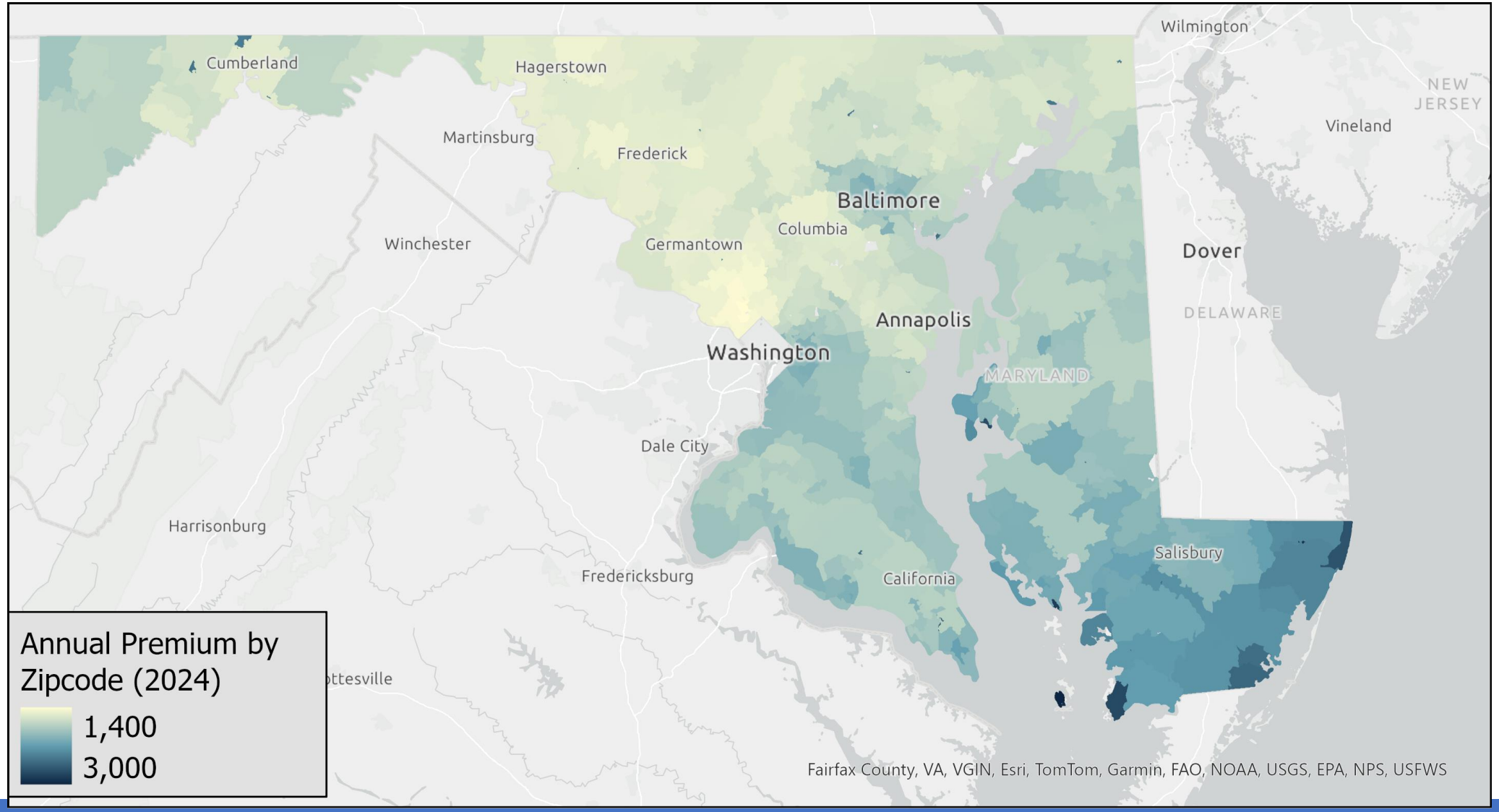
Source: CFA Analysis of 2021 American Housing Survey

"Overburdened" Report *(Forthcoming)*

- Percentage increase 2021-2024: 18.4%
- Typical 2024 premium in Maryland: $1,716
- The typical Maryland homeowner spent $267 per year more on homeowners insurance in 2024 compared to 2021

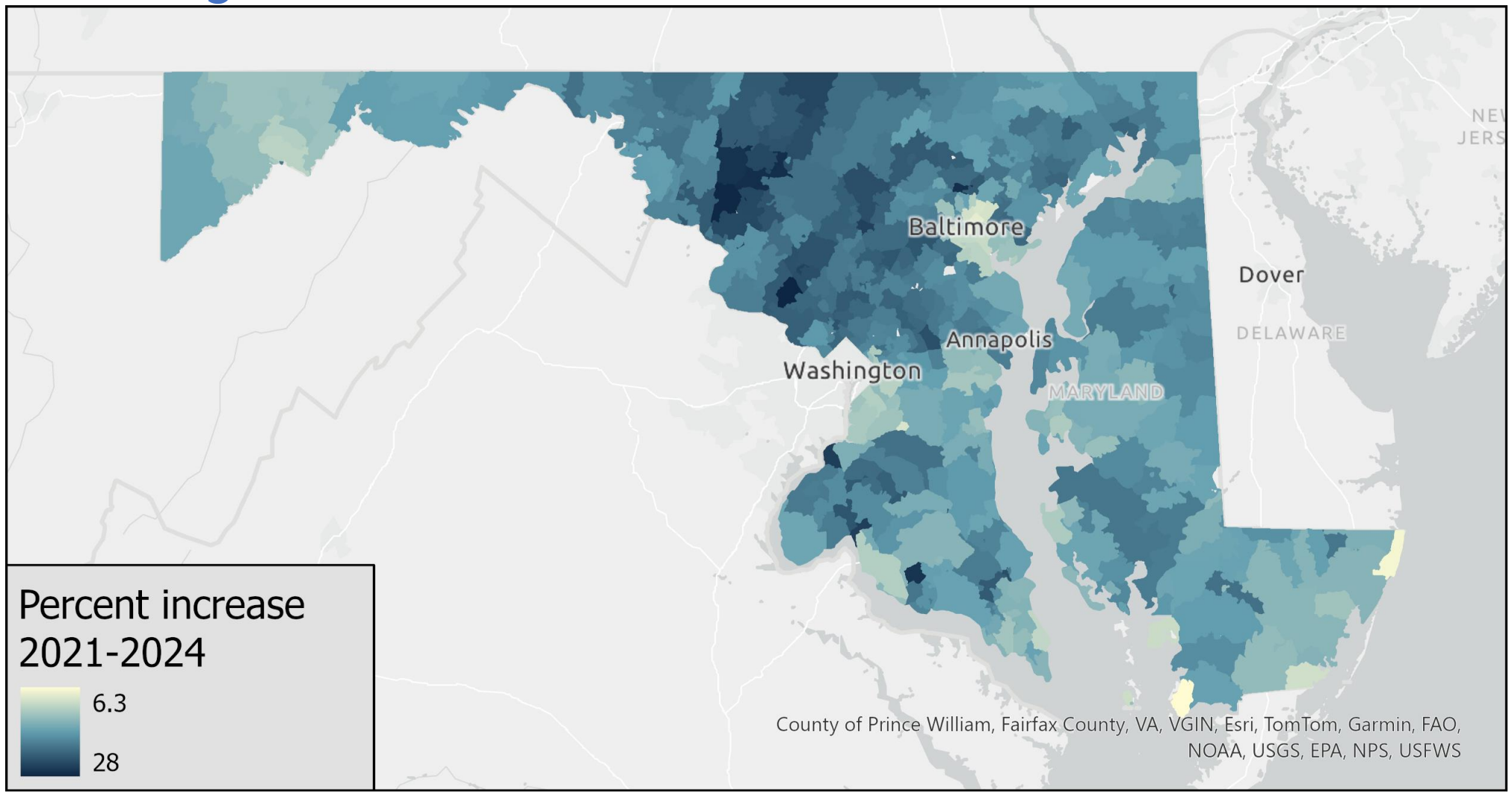
Source: CFA Analysis of Quadrant Industry Data 2021 & 2024

Typical Cost of Home Insurance 2024



Source: Forthcoming CFA report (2025), analysis of Quadrant data

Maryland Premium Increases 2021-2024



Source: Forthcoming CFA report (2025), analysis of Quadrant data

Average Loss Ratios in Maryland

Year	Loss Ratio
2018	69%
2019	53%
2020	54%
2021	52%
2022	61%
Average	***58%***

Source: CFA Analysis of 2025 Federal Insurance Office data

Zip Codes with Highest Nonpayment Non Renewal (2022)

Rank	Zipcode	Town	Nonpayment Non Renewal
1	21714	Braddock Heights	8.5%
2	21223	Baltimore	3.8%
3	20868	Spencerville	3.8%
4	21864	Stockton	3.5%
5	21205	Baltimore	3.5%
6	21835	Linkwood	3.4%
7	21912	Warwick	3.3%
8	20144	Delaplane	3.3%
9	21213	Baltimore	3.2%
10	21051	Fork	3.1%
	All of Maryland	--	***0.9%***

Source: CFA Analysis of 2025 Federal Insurance Office data

Policy Recommendations (I of II)

- ***Better protect homeowners against sudden non-renewal:***

- Maryland MD Insurance Code § 27-602 (2024): currently only 10 days for nonrenewal due to nonpayment and 45 days for other reasons nonrenewal

- Extend “grace period” after nonpayment. Specifically, require insurer to send notice of intent to non-renew due to nonpayment, and give homeowners 30 days after insurer sends this notice.

- Model: California, Cal. Code Regs. tit. 10 § 2274.53

Policy Recommendations (II of II)

- ***Work with insurance companies on risk reduction through mitigation investments.***
- Reduction of risk (physical resiliency) versus pricing of risk. CRA-like requirements at the State level.
- Model: Massachusetts “Insurance Industry Community Investment Initiative” (since 1998) → tax credit in exchange for investment dollars in housing, community, and economic development

https://www.pcifund.com/

Thank you!

Contact: scornelissen@consumerfed.org

SERC

SMITH ENTERPRISE RISK CONSORTIUM

Maryland Homeowners Insurance: Long-term Solutions

Dr. Clifford Rossi

Professor-of-the Practice, Executive-in-Residence and Director, Smith Enterprise Risk Consortium

Maryland House Environment and Transportation Committee - Briefing

Homeowners Insurance – Affordability and Coverage

January 21, 2025

Opening Statement – The Problem

- The US has an emerging crisis in the provision and cost of homeowners insurance to consumers that threatens the stability of the housing market
- Principal drivers of this problem are:
  - Significant uncertainties surrounding the frequency and severity of natural hazards and the inability of insurers and reinsurers to reliably measure those risks
  - Significant increases in building and reinsurance costs
  - Increased housing concentrations in geographies facing growing risk from natural hazards

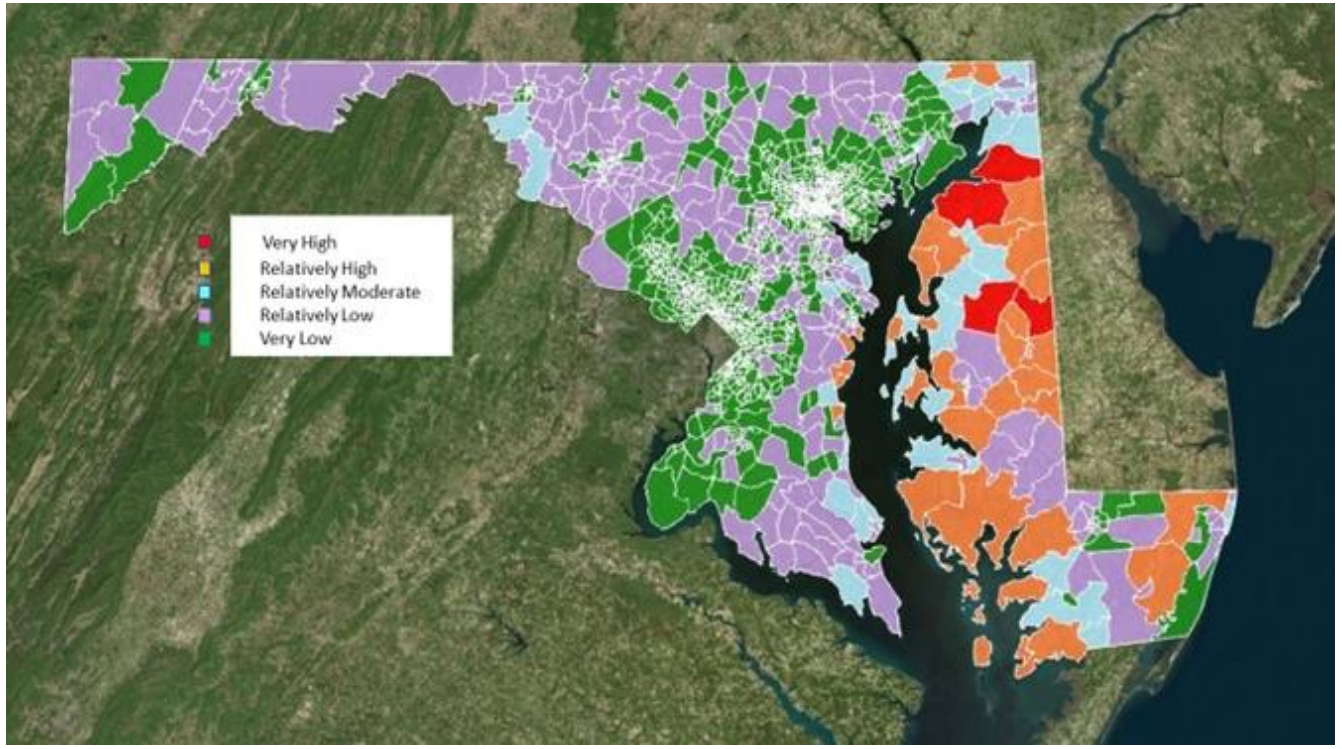
Opening Statement – The Solution

- States across the country are trying to tackle these issues in various ways to limited effect
- Natural disaster risk and insurability against such risks is not something an individual state can address on its own
- Rather a comprehensive national solution (National Hazard Insurance Corporation) is required due to the failure of insurance markets to accurately assess rising natural hazard risk and the limitations of many homeowners to absorb escalating premiums and deductibles or self-insure when insurance is not available

Scope of the Problem for Maryland Homeowners

- According to FEMA's National Risk Index (NRI), Maryland's western shore has relatively low exposure to 15 natural hazards in contrast to the state's eastern shore
- However, this aggregate exposure varies by hazard type (e.g., coastal flooding vs drought)
- These risk assessments, however, are not forward looking and that's where great uncertainty in how to reliably price homeowners insurance comes in

Expected Annual Losses by Census Tract from Natural Hazards

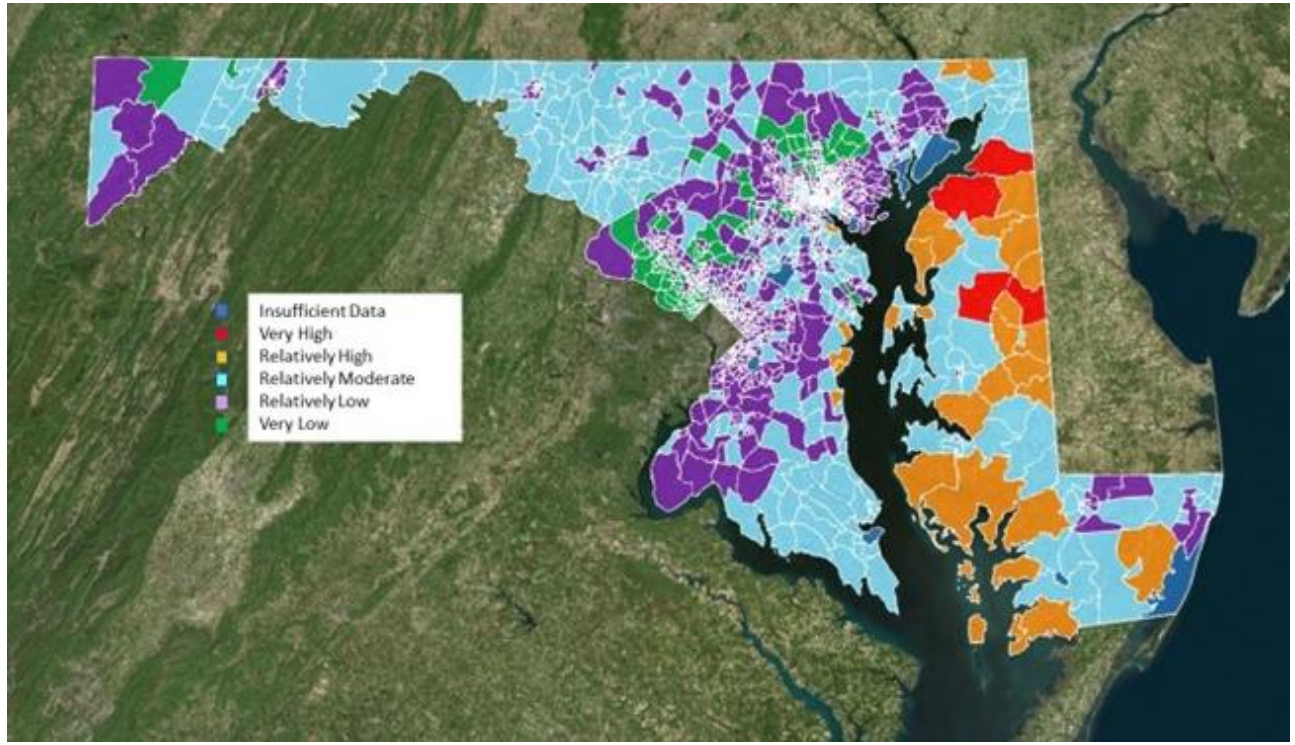


Source: Assessing Maryland Homeowner Financial Vulnerability to Extreme Weather Events, C. Rossi, 2023

Homeowner Vulnerability to Natural Hazards

- Overlaying the SERC Homeowner Financial Vulnerability Index to FEMA NRI data indicates significant homeowner financial vulnerability on the eastern shore to natural hazards
- While smaller geographically, some areas on the western shore such as around Annapolis and Baltimore have significant homeowner financial vulnerability to natural hazards from greater housing density

Census Tracts with Above Average Homeowner Financial Vulnerability and Exposure to Natural Hazards



Source: Assessing Maryland Homeowner Financial Vulnerability to Extreme Weather Events, C. Rossi, 2023

Homeowner Financial Vulnerability

- Homeowners are under tremendous financial strains in paying their mortgage PITI*:
  - Principal and interest
    - House price increases
    - Higher mortgage rates
  - Taxes and Insurance
    - Escalation in property tax rates
    - Substantial increases in homeowners insurance premiums
- Underserved markets and low-and moderate-income homeowners are particularly impacted
- *"From the Great Recession to the present, homeowners insurance prices have increased 74 percent while home prices have increased more than 40 percent, even after adjusting for inflation. Real premiums have risen approximately 20 percent between 2020–2023 alone."*
  - The Insurance Crisis Continues to Weigh on Homeowners, Steve Koller, Joint Center for Housing Studies, Harvard University, 12/9/2024

* Principal, Interest, Taxes and Insurance

What's Driving Up Homeowners Insurance Premiums?

- Rising rebuilding costs (labor and materials)
- Rising reinsurance costs
- Increase in insurer losses due to natural hazards
- Model risk
  - P&C insurers use catastrophe risk models ("cat models") to determine premiums
  - A component of cat models are physical climatological models estimating the frequency and severity of various natural hazards over a series of potential outcomes
  - These models are not able to reliably estimate the risk of increasing natural disasters, are not transparent and have undergone limited independent validation

Current Solutions to Homeowners Insurance Crisis

- State-managed insurance programs – not financially viable
  - Florida's Citizens Insurance
  - California's FAIR Plan
- Financial incentives (subsidies) to attract small insurers
- Financial support to homeowners to invest in climate resilient structures
  - Elevating heat pumps
  - Hardening windows, roofs and siding
  - Landscaping
- None of these solutions will address the homeowners insurance crisis

A Comprehensive Solution to the Homeowners Insurance Problem

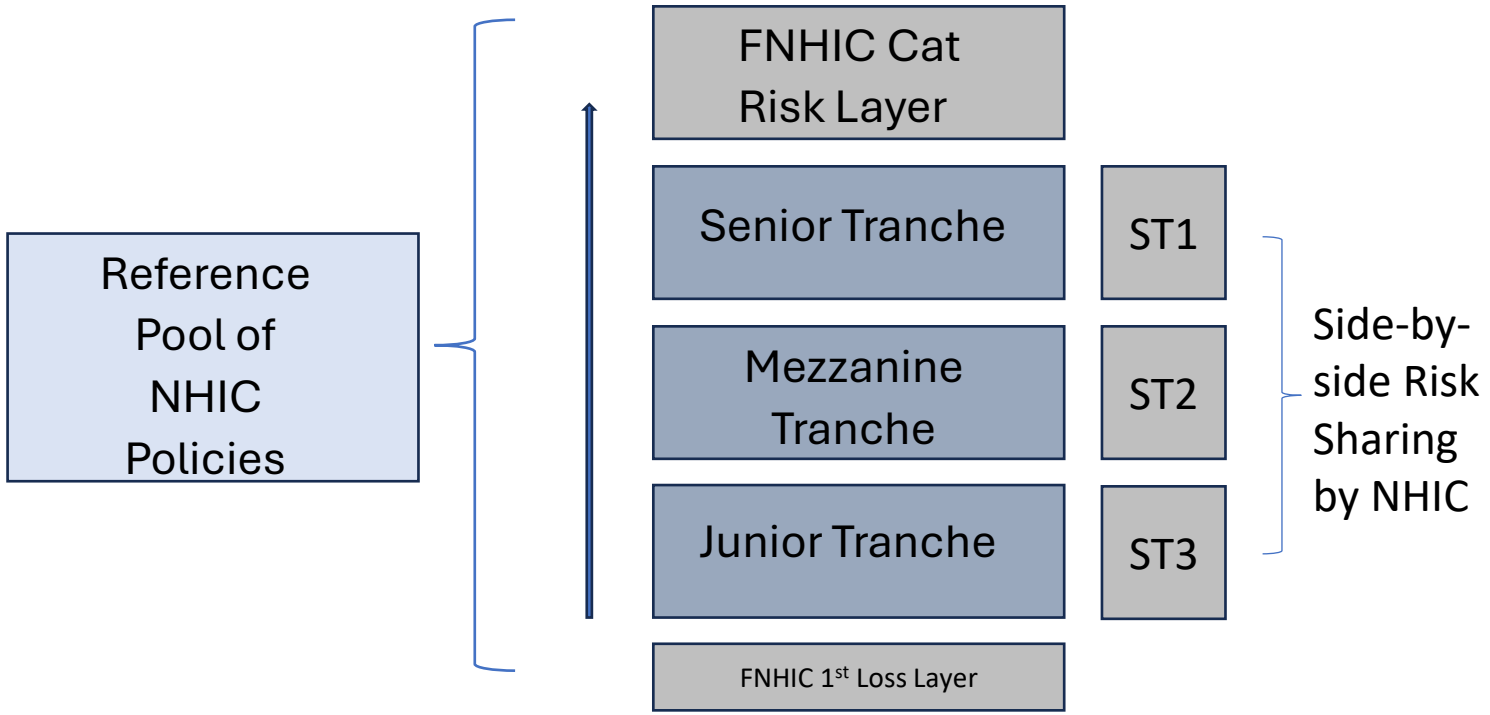
- Natural hazard risk in the US is a national problem
- Changes in the environment that cannot be measured reliably create a market failure in the P&C insurance business – imperfect information problem
- That market failure cannot be addressed by individual state actions without significant economic dislocations and harm to homeowners
- Nor can other market solutions such as expansion of the cat bond market or reinsurance fully address the market failure
- Rather, this is where a private-public solution is required by creating a federally chartered National Hazard Insurance Corporation (NHIC)

National Homeowners Insurance Corporation

- Spins National Flood Insurance Program (NFIP) out of FEMA and into a government-sponsored enterprise (like Freddie Mac and Fannie Mae for housing before their conservatorship), reducing US taxpayer direct contingent liability
- Extends coverage to all major natural hazards (e.g., wind, hurricane, wildfire)
- Homeowners with mortgages would be required to carry 2 policies
  - Standard homeowners policy for risks other than natural hazards
  - NHIC policy
- Insurers would retain control over underwriting and pricing of standard policies as well as the losses
- NHIC would act much like NFIP today but operated more like a true insurance company with appropriate technical and financial resources that would distribute risk back to investors (insurance and reinsurance companies) via Natural Hazard Risk Transfer securities (NHRTs) much like credit risk transfer securities (CRTs) issued by Fannie and Freddie today

NHRTs Redistribute Risk from NHIC to Investors

- NHIC, unlike NFIP, would sell tranches of natural hazard risk to insurance and reinsurance companies
- The regularization of issuance would ensure a deep liquid market for securities and pricing for investors and provide greater confidence in the risk taken by insurers and reinsurers



Benefits to Maryland Homeowners

- NHIC would ensure access to affordable insurance for natural hazards to all homeowners
- Selling NHRTs would bring greater certainty over the risks insurance and reinsurance companies want to take based on their own risk appetites
- Consequently, NHIC would only retain the most catastrophic risk while leaving the remainder of natural hazard risks to be absorbed by insurance markets or other investor types
- Provides a mechanism for supporting low- and moderate-income (LMI) and underserved housing segments from excessive insurance costs by permitting differential pricing for such homeowner segments
- Addresses issues of force-placed insurance issues for lenders and GSEs
- Eliminates need for state-run insurance of last resort

Questions?

UNIVERSITY OF MARYLAND
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Assessing Maryland Homeowner Financial Vulnerability to Extreme Weather Events

CLIFFORD V. ROSSI. PHD

JANUARY 2023

ROBERT H. SMITH SCHOOL OF BUSINESS

Executive Summary

Homeownership extends well beyond making a monthly mortgage payment. Ongoing maintenance and investment in a property help preserve and enhance home value and extend to neighborhoods and local communities as well. Owning a home also comes with the realization that every so often a costly repair can occur either unexpectedly or not, potentially placing strains on household budgets or leading to deferred maintenance over time.

Today, many Marylanders find themselves facing another costly threat to their homes that has been slowly sneaking up on them; namely the costs associated with extreme weather events. An increase in extreme weather events will negatively affect homeowners in years to come. Solutions to these problems must come from a combination of public and private investments and comprehensive strategies to build long-term resilient communities.

Understanding which communities in Maryland have higher rates of homeowner financial vulnerability to unexpected outlays either for weather-related damages or not is critical to helping target financial products and services as well as public investment in weather resiliency projects. This study leverages a variety of rich data sources for mortgage borrowers as well as natural hazards and associated risks to provide new empirical insights that can serve as a guide to inform public policy and industry investment strategy.

A newly developed Homeowner Financial Vulnerability Index (HFVI) is used to identify areas in Maryland with a higher likelihood of experiencing financial strain from an unexpected large out-of-pocket outlay such as repairs following a storm. The study aims to answer the following questions:

- What areas (counties and tracts) in Maryland are most at-risk from natural hazards?
- What hazards present the greatest risk to Marylanders in terms of expected annual losses (EAL)?
- What areas have the greatest homeowner financial vulnerability?
- How many areas have high homeowner financial vulnerability and are located in high hazard risk areas?
- What are the demographics; income, minority, poverty rates of these high hazard risk areas?
- Can we identify any statistically significant differences between high hazard risk census tracts and all others on the basis of borrower and other relevant characteristics?

This study provides new tools for analyzing the effects of extreme weather events and homeowner financial resiliency. Identifying areas with the greatest exposure to extreme weather and that have high homeowner financial vulnerability can help target public and private resources optimally. For example, by using tract-level measures of hazard risk combined with loan level measures of financial vulnerability, federal, state and local funding can be better allocated to support community-based resiliency projects such as investments in shoreline protection, flood control and the like as well as help facilitate the design of innovative insurance and mortgage products for individual homeowners.

For more information, please contact Dr. Clifford Rossi at crossi@umd.edu.

Contents

A file containing the tract level NRI and HVFI ratings along with several other tract-level statistics may be found at https://www.rhsmith.umd.edu/centers-initiatives/financial-policy or by contacting the author directly. Maps developed for this study may also be found at that website. The author provides these for informational purposes.

Extreme Weather in Maryland and Effects on Homeowners

Homeownership extends well beyond making a monthly mortgage payment. Ongoing maintenance and investment in a property help preserve and enhance home value and extend to neighborhoods and local communities as well. Owning a home also comes with the realization that every so often a costly repair can occur either unexpectedly or not, potentially placing strains on household budgets or leading to deferred maintenance over time.

Today, many Marylanders find themselves facing another costly threat to their homes that has been slowly sneaking up on them; namely the costs associated with extreme weather events. Residents and business owners in Ellicott City, for example, know far too well the impacts of such events. Within a two-year period, the city experienced two extreme flood events. The first of these occurred in 2016 when six inches of rain fell within a two-hour period causing significant flooding and property damage.[1] Then in 2018, another storm dropped eight inches of rain again in a two-hour period resulting in a flash flood with a height of over 10 feet resulting again in extensive property damage as well as two deaths.[2] In each instance, the amount of rainfall was reported to have had a 1-in-1,000 year chance of occurring and yet it happened twice in two years.[3]

Unfortunately, the Ellicott City floods are one of many potential natural hazards facing Marylanders. Drought, tornados, hurricanes, wind and hail storms pose significant risks each year to Maryland residents and so gaining a better understanding of the potential impact such events may have on homeowners is crucial for making homeowners and their properties more resilient to such hazards. Many parts of the 11,684 miles of shoreline of the Chesapeake Bay face ongoing threats of erosion, coastal and riverine flooding and increasing nuisance flood events.[4]

[1] National Weather Service, National Oceanic and Atmospheric Administration, Ellicott City Historic Rain and Flash Flooding of July 30th, 2016, https://www.weather.gov/lwx/EllicottCityFlood2016.

[2] National Weather Service, National Oceanic and Atmospheric Administration, May 27th 2018 Flooding, Ellicott City and Catonsville, MD, https://www.weather.gov/lwx/EllicottCityFlood2018

[3] John Bacon, USA Today, Why a 1-in-1,000 year rain event devastated Ellicott City, Maryland – again, May 28, 2018.

[4] National Park Service, Chesapeake Bay Facts,https://www.nps.gov/chba/learn/nature/facts-andformation.htm#:~:text=At%20its%20widest%20point%2C%20just,21%20feet%20(7%20m)

Parts of Annapolis and Baltimore have experienced significant increases in the number of days of nuisance flooding over the last decade.

However, Dorchester County, one of the poorest counties in the state on Maryland's eastern shore with the motto, "Water Moves Us," doesn't receive the kind of media attention that Annapolis and Baltimore receive on extreme weather events and yet its experience paints an ominous picture for what awaits county residents in the future without major changes from policymakers and private industry.

One study, for instance, found that nearly 60% of Dorchester County lies within the 100-year floodplain and that about half the population is exposed to some damage from minor storm surges not related to hurricane-like events.[5] Homeowners face a variety of potential damages to various critical components to their homes from such events including HVAC systems and ductwork, roofs, siding and windows and mold in crawlspaces among the costly repairs these homeowners can encounter.

Residents of Maryland in areas with elevated threats from extreme weather events need to prepare for the increasing direct and indirect cost of homeownership

Dorchester County faces a number of significant challenges in hardening public and private infrastructure from the ongoing threats of extreme weather events. The county ranks 19th out of 24 in terms of income with an average per capita income in 2017-2020 of $55,652; has a poverty rate of 15%; and more than a third of residents are nonwhite.[6] Still, a relatively large percentage (69%) of residents own a home with a median property value of about $190,000. Compared with a wealthier and larger county such as Anne Arundel County that has a budget of more than $1.7 billion, Dorchester County's budget of $75.7 million severely constrains the county's ability to finance urgently needed projects to address its climate-related problems. These include increased nuisance flooding in Cambridge, the county's largest city, as well as coastal erosion in a number of small communities such as Hoopers Island and failure of many bermed impervious ponds (BIPs) serving homeowners across Dorchester County as a type of community septic system. This latter problem underscores the fact that state and local governments when approving such infrastructure for residential development nearly 30 years ago did not anticipate or understand the impact of those decisions now affected by changes in weather patterns that in recent years have put many of those ponds at capacity and in dire need of mitigation.

Residents of Maryland in areas with elevated threats from extreme weather events need to prepare for the increasing direct and indirect cost of homeownership. These costs include out-of-pocket expenses that lie beyond

[5] Wanda Diane Cole, Maryland Eastern Shore Resource Conservation & Development Council, 2008.

[6] U.S. Census, QuickFacts, Dorchester County, Maryland data.

insurance payouts or show up as higher premiums and deductibles for homeowners and flood insurance policies. According to one estimate by Nationwide, two-thirds of homeowners are underinsured, exposing them to significant financial risk as well as increasing their chances of defaulting on their mortgage.[7]

Evidence of higher default risk for extreme weather events has been found over the years. Fannie Mae, for example found a substantial difference between delinquency rates following Hurricane Katrina in regions affected by that storm. The rate of mortgages 30 days past due or more was 4.24% in areas affected by the hurricane versus 1.99% for areas left unaffected.[8] This author also found that when controlling for borrower, property and loan risk factors, both the frequency and severity of hurricanes resulted in statistically significant higher default rates on mortgages.[9]

This study provides some of these answers by empirically identifying those communities in Maryland with the greatest homeowner financial vulnerability that happen to be exposed most to natural hazards

An increase in extreme weather events will negatively affect homeowners in years to come. Solutions to these problems must come from a combination of public and private investments and comprehensive strategies to build long-term resilient communities. Some of these investments will require major planning and resource commitment. An example today is the rebuilding of James and Barren Islands off the Dorchester County coast by the US Army Corps of Engineers that have all but disappeared as decades of coastal storms and rising sea levels have taken their toll on those barrier islands that serve as buffers to many homes along that shoreline. Deciding on how to optimally allocate such resources is always a challenge, however, a first step requires identifying where such resources are needed most. This study provides some of these answers by empirically identifying those communities in Maryland with the greatest homeowner financial vulnerability that happen to be exposed most to natural hazards.

Study Objectives and Approach

Understanding which communities in Maryland have higher rates of homeowner financial vulnerability to unexpected outlays either for weather-related damages or not is critical to helping target financial products and services as well as public investment in weather resiliency projects. This study leverages a variety of rich data sources for mortgage borrowers as well as natural hazards and associated risks to provide new empirical insights that can serve as a guide to inform public policy and industry investment strategy.

[7]Nationwide, "Underinsurance: Is your home covered for all it's worth?https://www.nationwide.com/lc/resources/home/articles/underinsurance.
[8]Fannie Mae Capital Markets, Historical data provides insights into past hurricane experience, November 6, 2017.

[9] Clifford Rossi, Journal of Risk Management in Financial Institutions, Volume 14 / Number 4 / Autumn/Fall 2021, pp. 426-442(17).

The study leverages a newly developed **Homeowner Financial Vulnerability Index (HFVI)** to identify areas in Maryland with a higher likelihood of experiencing financial strain from an unexpected large out-of-pocket outlay such as repairs following a storm

The study leverages a newly developed **Homeowner Financial Vulnerability Index (HFVI)** to identify areas in Maryland with borrowers having a higher likelihood of experiencing financial strain from an unexpected large out-of-pocket outlay such as repairs following a storm.[10] The HFVI is based on a multivariate statistical model trained on hundreds of thousands of historical mortgage loans originated between 2000-2016 with performance on those loans to the present and sold to Fannie Mae and Freddie Mac. This index ranks borrowers based on their financial capacity to support not just their mortgage payment but also recurring and nonrecurring expenses associated with their properties, controlling for other factors such as the borrower's credit and other loan and property characteristics.

As will be examined in more detail in a later section, the index is then paired with data from the **Federal Emergency Management Agency (FEMA) National Risk Index (NRI)** that provides a rating and score at the census tract or county level for 18 different natural hazards. While the HFVI is calculated at the loan level, **Home Mortgage Disclosure Act (HMDA) 2021 data** is used to generate a HFVI for every loan originated in Maryland for that year and then aggregated for all census tracts and counties in Maryland. While the HMDA data only highlights loans originated in 2021, it is representative of the financial profile of Maryland homeowners for that year.

The study aims to answer the following questions:

- What areas (counties and tracts) in Maryland are most at-risk from natural hazards?
- What hazards present the greatest risk to Marylanders in terms of expected annual losses (EAL)?
- What areas have the greatest homeowner financial vulnerability?
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- Can we identify any statistically significant differences between high hazard risk census tracts and all others on the basis of borrower and other relevant characteristics?

[10] HFVI was developed by Chesapeake Risk Advisors, LLC.

Data Sources

Three publicly available data sources were used in this study; the 2021 HMDA data, the FEMA NRI data and Fannie Mae and Freddie Mac loan-level credit performance data. Some description of each of these data sources is instructive to understand the analysis that follows.

FEMA NRI Data

FEMA developed a National Risk Index comprised of three factors: expected annual loss (EAL) associated with a hazard, a community resiliency score and a social vulnerability score.[11] The relationship of these three factors in determining the NRI is as follows:

$$(1) \qquad NRI = EAL * SV * (1/CR)$$

Where SV is social vulnerability and CR is community resiliency. The social vulnerability component of the NRI reflects the the degree to which demographic groups are affected by different natural hazards. Community resiliency takes into account the ability for communities to handle various natural hazards by incorporating 49 different factors representing 6 categories of community resiliency such as community capital, social, and housing/infrastructure.

The NRI is calculated for every county and census tract in the US. The 18 hazard types in the NRI data were selected based on FEMA-approved state plans and are listed in Table 1 displaying the total EAL for each hazard in Maryland. Three hazards are not represented in the data for the state but all others sum to an EAL of $221.1 million with the hazards presenting the largest exposure to Maryland being drought, tornados and coastal flooding in that order.

EAL in dollars is defined as the following:

$$(2) \quad EAL = E_H * F_H * HLR_H$$

Where E_H is the total dollar of exposure to hazard type H from losses associated with damages to buildings, agriculture or people, F_H is the annual frequency of hazard H and HLR_H is the hazard loss ratio associated with hazard H.[12] For Maryland across all hazard types, 43 percent of the state EAL is attributed to damage and losses to buildings including residential and commercial structures.

Table 1: EAL ($) Hazard for Maryland

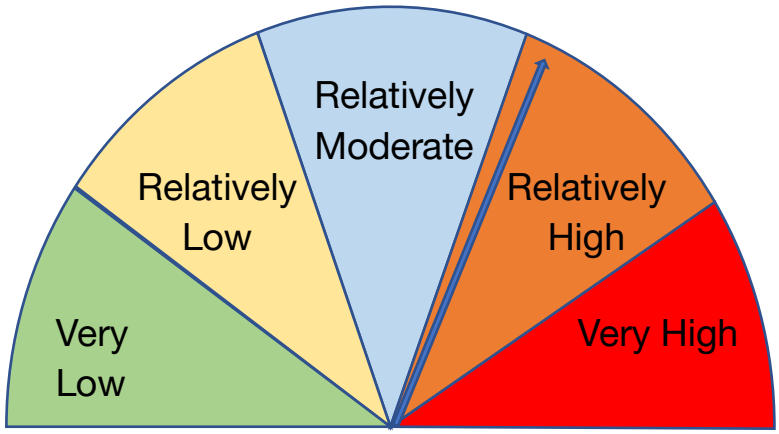
Hazard	EAL($)
Avalanche	NA
Coastal Flooding	34,626,461
Cold Wave	2,068,859
Drought	51,219,782
Earthquake	5,969,847
Hail	1,115,174
Heat Wave	13,994,782
Hurricane	14,492,073
Ice Storm	2,073,257
Landslide	1,460,897
Lightning	7,011,153
Riverine Flooding	26,314,416
Strong Wind	15,264,119
Tornado	38,100,420
Tsunami	NA
Volcanic Activity	NA
Wildfire	2,647,044
Winter Weather	4,839,674
All	221,197,958

[11] FEMA, National Risk Index, https://hazards.fema.gov/nri/.

[12] FEMA NRI Technical Documentation, November 2021.

There are only a few counties that have Very High EAL exposure: Caroline, Anne Arundel and Baltimore City

FEMA produces a risk score and rating for each hazard and for all hazards combined reflecting all three components defined in equation 1. In addition, a risk rating and score is produced based only on EAL, social vulnerability and community resiliency. The measure of hazard risk for this study is EAL in dollars for each census tract and county in Maryland as it isolates the financial costs of each hazard. Finally, this study uses the hazard EAL risk rating rather than the numeric score as the ratings provide a more convenient way of categorizing hazard risk against financial vulnerability.[13] FEMA assigns one of the five following risk ratings for each natural hazard (and for all hazards combined) by census tract or county:[14] A total of 1394 Maryland census tracts were in the NRI dataset for analysis.



Tables 2a and 2b provide more detail on the risk to Marylanders by county for each type of hazard by EAL rating and EAL exposure in dollars. Fortunately, there are only a few areas that have Very High EAL exposure. These are Caroline County for drought, Anne Arundel County for lightning and Baltimore City for winter weather. Despite the large amount of shoreline around the Chesapeake Bay and Atlantic Ocean, coastal and riverine flooding along with hurricanes do not show up as having significant EAL exposure at the county level. Some care must be taken, however, in drawing a conclusion at the county level. Exposure to various hazards tends to wash out as the level of geographic unit expands and thus the focus later on at the tract level provides a more granular view of natural hazard risk in Maryland. Likewise, these results could change over time should extreme weather events increase in frequency and intensity in the future.

[13] FEMA used a machine learning algorithm to determine each risk rating.
[14] More detail on how FEMA developed these ratings can be found in their technical documentation.

Table 2a and 2b: Maryland County NRI EAL Ratings and Dollars by Hazard

COUNTY	All Hazards	Coastal Flooding	Cold Wave	Drought	Earthquake	Hail	Heat Wave	Hurricane	Ice Storm	Landslide	Lightning	Riverine Flooding	Severe Windstorm	Tornado	Wildfire	Winter Weather
Allegany	RL	NA	RM	NA	VL	VL	RL	RL	VL	RH	RL	RM	RM	RL	VL	RM
Anne Arundel	RM	RH	RM	RL	RL	VL	RH	RM	RL	RM	VH	RM	RH	RH	RL	RH
Baltimore	RM	VL	RM	RM	RL	VL	RM	RM	RM	RL	RM	RM	RH	RH	VL	RM
Calvert	RL	RM	RL	RL	VL	VL	RM	RM	RL	RH	RM	VL	RM	RL	RL	RM
Caroline	RM	RL	NA	VH	VL	RL	RM	RL	VL	VL	RL	RL	RL	RL	VL	RL
Carroll	RL	NA	RM	RL	RL	VL	RM	RL	RL	RM	RH	RL	RH	RM	VL	RM
Cecil	RM	RM	NA	RH	RL	RL	RM	RL	RM	RM	RM	RL	RM	RM	VL	RM
Charles	RL	VL	RL	RL	RL	RL	RM	RM	VL	RM	RM	VL	RM	RL	VL	RM
Dorchester	RL	RL	NA	RL	VL	RL	RL	RL	RM	VL	RL	RM	RL	RL	RM	RL
Frederick	RM	NA	RM	RM	RL	VL	RM	RL	RL	RM	RH	RH	RH	RM	VL	RH
Garrett	VL	NA	RM	NA	VL	RL	NA	VL	VL	RM	RL	RL	RL	RL	VL	RL
Harford	RL	RL	RL	RL	RL	RL	RM	RM	RL	RM	RH	RM	RH	RM	VL	RH
Howard	RL	VL	RM	RM	RL	VL	RM	RL	RL	RM	RH	RM	RH	RM	VL	RH
Kent	RM	RM	NA	RH	VL	RL	RL	RL	RL	RL	RL	RL	RL	RL	VL	RL
Montgomery	RM	VL	RH	RM	RL	VL	RH	RM	RM	RM	RH	RM	RH	RH	VL	RH
Prince George's	RM	RL	RM	RL	RL	VL	RH	RM	RM	RM	RH	RL	RH	RH	VL	RH
Queen Anne's	RM	RM	NA	RH	VL	RL	RM	RL	RL	RL	RL	RL	RL	RL	VL	RM
St. Mary's	RL	RL	RL	RL	VL	VL	RM	RM	RL	RM	RM	RL	RM	RM	VL	RM
Somerset	RL	RM	NA	RL	VL	RL	RL	RL	VL	RL	RL	RL	RL	VL	RM	RL
Talbot	RL	RM	NA	RM	VL	RL	RM	RL	RL	VL	RL	RL	RL	RL	VL	RM
Washington	RL	NA	RM	RM	VL	VL	RM	RM	RL	RL	RL	RM	RL	RM	VL	RM
Wicomico	RL	RM	NA	RL	VL	RL	RL	RL	RM	VL	RM	VL	RL	RL	RL	RM
Worcester	RL	RM	NA	RH	VL	VL	RL	RL	RL	RL	RL	RM	RL	RL	RL	RL
Baltimore	RM	VL	RM	NA	RL	VL	RH	RH	RM	RM	RH	RM	RH	RH	NA	VH

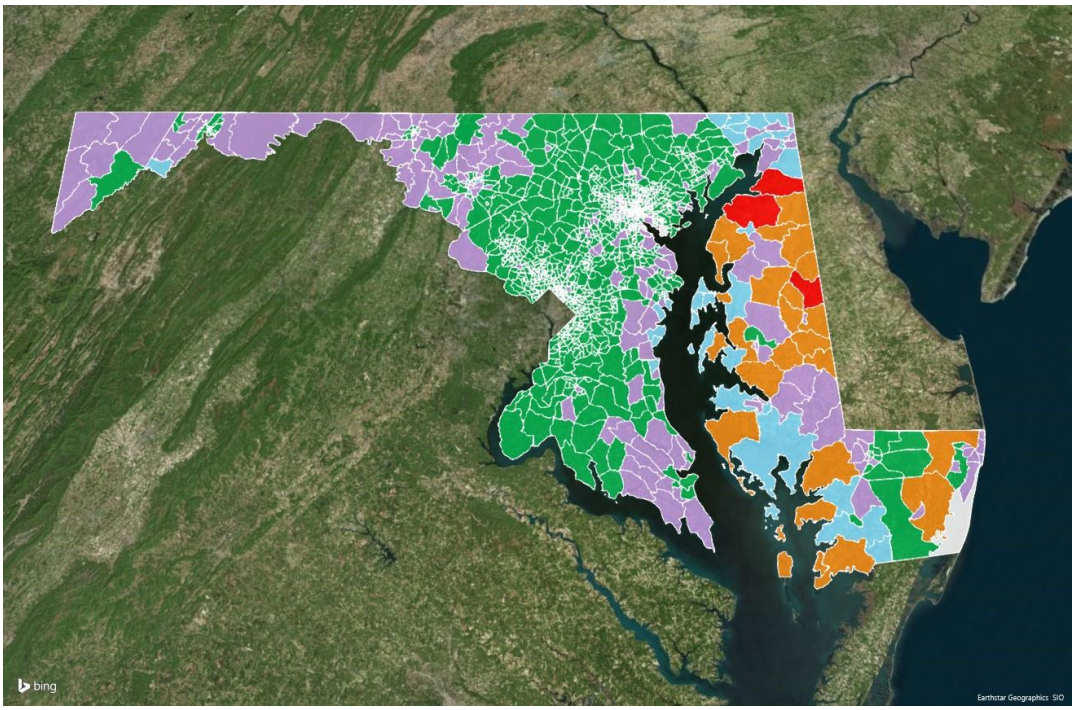
COUNTY	All Hazards	Coastal Flooding	Cold Wave	Drought	Earthquake	Hail	Heat Wave	Hurricane	Ice Storm	Landslide	Lightning	Riverine Flooding	Severe Windstorm	Tornado	Wildfire	Winter Weather
Allegany	$ 3,428,056		$ 151,651	$ -	$ 16,727	$ 4,854	$ 68,254	$ 63,910	$ 14,798	$ 170,655	$ 34,972	$ 2,165,852	$ 276,293	$ 372,431	$ 4,532	$ 83,127
Anne Arundel	$ 22,409,392	$ 10,625,966	$ 171,717	$ 202,499	$ 664,949	$ 21,487	$ 1,643,534	$ 525,224	$ 96,734	$ 51,255	$ 1,331,590	$ 953,657	$ 1,019,385	$ 4,410,061	$ 35,793	$ 655,541
Baltimore	$ 11,716,946	$ 44,460	$ 140,707	$ 362,497	$ 897,456	$ 10,990	$ 542,082	$ 3,094,337	$ 245,975	$ 28,903	$ 143,996	$ 1,273,015	$ 1,543,327	$ 3,242,812	$ 1,029	$ 145,360
Calvert	$ 5,578,921	$ 3,213,964	$ 28,439	$ 42,009	$ 81,513	$ 6,985	$ 239,325	$ 551,316	$ 42,083	$ 202,973	$ 211,182	$ 141,491	$ 339,801	$ 267,065	$ 70,549	$ 140,227
Caroline	$ 18,387,432	$ 537,424	$ -	$ 16,378,678	$ 39,119	$ 145,176	$ 172,973	$ 117,437	$ 13,202	$ 3,278	$ 39,136	$ 537,034	$ 112,055	$ 228,778	$ 23,654	$ 39,489
Carroll	$ 4,280,917		$ 106,910	$ 266,634	$ 146,234	$ 20,194	$ 365,820	$ 200,265	$ 74,267	$ 106,241	$ 359,019	$ 780,554	$ 911,739	$ 816,048	$ 147	$ 126,846
Cecil	$ 14,177,435	$ 1,807,988	$ -	$ 9,402,079	$ 123,917	$ 115,474	$ 221,443	$ 129,916	$ 137,823	$ 73,511	$ 124,578	$ 563,547	$ 553,694	$ 782,601	$ 2,851	$ 138,013
Charles	$ 3,138,061	$ 51,940	$ 46,893	$ 79,104	$ 200,764	$ 58,923	$ 364,935	$ 485,218	$ 12,187	$ 51,782	$ 253,740	$ 143,691	$ 578,199	$ 680,403	$ 8,480	$ 121,801
Dorchester	$ 4,182,049	$ 653,423	$ -	$ 49,919	$ 43,304	$ 86,306	$ 41,364	$ 131,341	$ 227,714	$ 416	$ 53,616	$ 1,315,551	$ 206,233	$ 296,654	$ 1,050,996	$ 25,210
Frederick	$ 11,802,736		$ 224,091	$ 794,754	$ 204,561	$ 4,023	$ 736,203	$ 306,668	$ 79,238	$ 84,278	$ 535,631	$ 5,667,035	$ 741,561	$ 2,154,363	$ 2,324	$ 268,007
Garrett	$ 932,194		$ 77,499	$ -	$ 12,182	$ 48,595	$ -	$ 24,699	$ 7,418	$ 125,031	$ 33,413	$ 348,393	$ 79,627	$ 159,049	$ 3,199	$ 13,090
Harford	$ 6,443,811	$ 610,206	$ 57,818	$ 264,387	$ 268,323	$ 63,061	$ 497,860	$ 583,342	$ 83,814	$ 87,742	$ 616,518	$ 1,317,471	$ 858,089	$ 796,677	$ 1,179	$ 337,323
Howard	$ 7,897,973	$ 155	$ 100,894	$ 395,225	$ 284,567	$ 5,926	$ 735,128	$ 374,121	$ 74,089	$ 84,127	$ 476,912	$ 2,773,366	$ 1,142,515	$ 1,245,918	$ 230	$ 204,799
Kent	$ 11,249,612	$ 1,680,761	$ -	$ 8,559,342	$ 37,365	$ 92,312	$ 110,572	$ 137,035	$ 22,915	$ 15,842	$ 45,775	$ 198,330	$ 130,784	$ 193,712	$ 1,368	$ 23,499
Montgomery	$ 14,181,989	$ 77	$ 312,359	$ 467,055	$ 1,038,444	$ 17,962	$ 1,643,276	$ 1,016,967	$ 140,880	$ 63,702	$ 721,971	$ 1,436,943	$ 2,191,061	$ 4,661,712	$ 1,283	$ 468,299
Prince George's	$ 15,631,784	$ 324,457	$ 276,212	$ 181,655	$ 854,973	$ 22,637	$ 2,235,865	$ 992,886	$ 118,596	$ 81,119	$ 588,214	$ 347,737	$ 1,641,821	$ 7,474,904	$ 3,692	$ 487,016
Queen Anne's	$ 14,123,914	$ 4,997,014	$ -	$ 7,068,104	$ 54,546	$ 126,783	$ 193,091	$ 279,176	$ 35,345	$ 22,104	$ 88,024	$ 457,713	$ 241,181	$ 451,575	$ 29,491	$ 79,767
St. Mary's	$ 3,596,278	$ 110,618	$ 33,716	$ 140,553	$ 97,428	$ 21,277	$ 311,677	$ 759,960	$ 64,053	$ 66,945	$ 212,340	$ 357,231	$ 391,251	$ 847,180	$ 31,270	$ 150,779
Somerset	$ 5,699,623	$ 3,733,532	$ -	$ 51,133	$ 13,898	$ 66,564	$ 31,111	$ 146,646	$ 14,250	$ 14,154	$ 37,062	$ 355,731	$ 75,812	$ 104,652	$ 1,038,298	$ 16,780
Talbot	$ 6,073,295	$ 3,574,044	$ -	$ 943,249	$ 64,117	$ 44,555	$ 145,619	$ 92,423	$ 23,214	$ 5,007	$ 89,410	$ 522,041	$ 115,803	$ 358,085	$ 26,983	$ 68,746
Washington	$ 5,392,218		$ 141,778	$ 465,421	$ 96,791	$ 3,289	$ 268,032	$ 450,454	$ 75,275	$ 35,820	$ 41,268	$ 2,155,368	$ 240,881	$ 1,286,644	$ 4,808	$ 126,388
Wicomico	$ 3,541,823	$ 1,340,882	$ -	$ 72,240	$ 90,637	$ 82,975	$ 116,052	$ 306,302	$ 236,375	$ 3,914	$ 187,262	$ 141,032	$ 197,483	$ 456,175	$ 227,815	$ 82,680
Worcester	$ 8,102,005	$ 1,315,211	$ -	$ 5,033,245	$ 45,961	$ 39,367	$ 51,669	$ 215,392	$ 31,715	$ 14,757	$ 60,504	$ 936,796	$ 97,605	$ 163,537	$ 77,075	$ 19,170
	$ 19,229,494	$ 4,340	$ 198,175	$ -	$ 592,070	$ 5,460	$ 3,258,896	$ 3,507,037	$ 201,296	$ 67,340	$ 725,019	$ 1,424,837	$ 1,577,920	$ 6,649,384	$ -	$ 1,017,718
Maryland Total	$ 221,197,958	$ 34,626,461	$ 2,068,859	$ 51,219,782	$ 5,969,847	$ 1,115,174	$ 13,994,782	$ 14,492,073	$ 2,073,257	$ 1,460,897	$ 7,011,153	$ 26,314,416	$ 15,264,119	$ 38,100,420	$ 2,647,044	$ 4,839,674

Another view of the risk of natural hazards on Maryland is seen in Figure 1. Here, the NRI rating for each census tract is shown. Taking into account all three factors; EAL, social vulnerability and community resilience, most of Maryland's higher risk tracts (i.e., Very High or Relatively High) are located on the eastern shore of the Chesapeake Bay.

Decomposing the NRI by its three factors helps provide more context on the nature of hazard risk at the tract level. First, a view on EAL exposure from all hazards is shown in Figure 2 for each census tract. The results by either overall NRI or NRI EAL rating for Maryland census tracts is skewed toward lower risk. Most tracts show up as having either Very or Relatively Low EAL risk. However, note the disproportionate share of eastern shore census tracts that are rated as either Relatively or Very High risk.

Taking into account all three factors; EAL, social vulnerability and community resilience, most of Maryland's higher risk tracts (i.e., Very High or Relatively High) are located on the eastern shore of the Chesapeake Bay

Figure 1: NRI Rating for Maryland Census Tracts



Figures 3 and 4 show the NRI social vulnerability and community resiliency ratings for each tract. Panning out on the map (which readers can do by opening up the Excel spreadsheets of each map available on the Chesapeake Risk Advisors, LLC website), areas where high social vulnerability exists are found around Baltimore City, as well as the western part of the state and eastern shore. In terms of Community Resiliency, Maryland exhibits a relatively

Areas where high social vulnerability exists are found around Baltimore City, as well as the western part of the state and eastern shore

Figure 2: Overall EAL Hazard Risk for Maryland Census Tracts

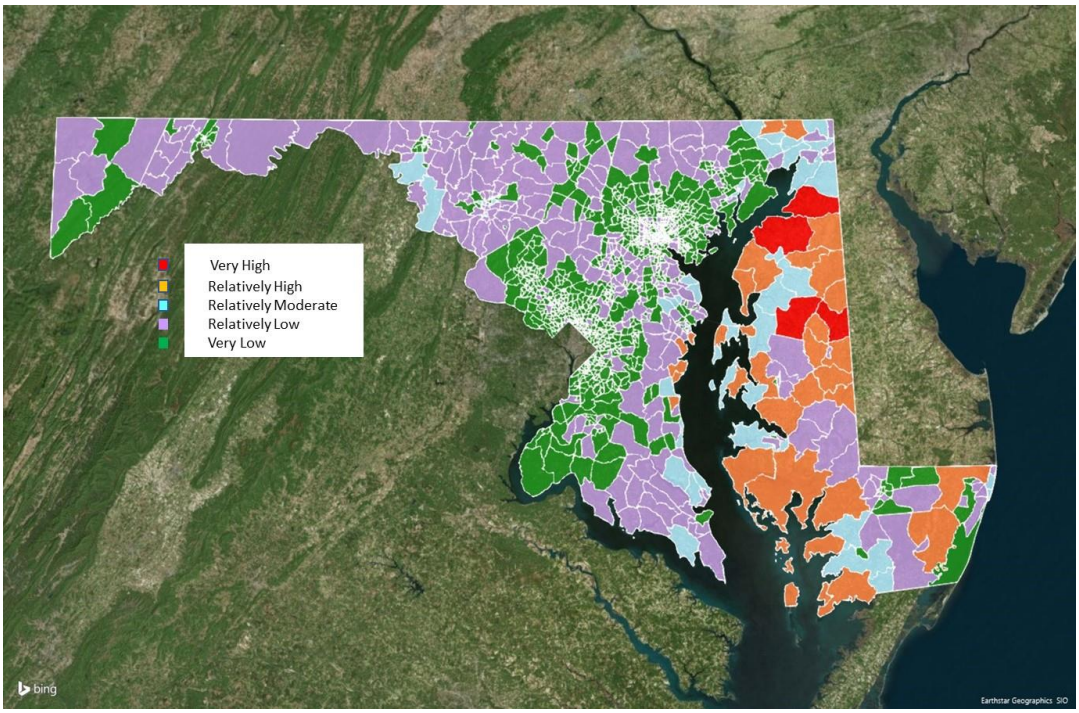
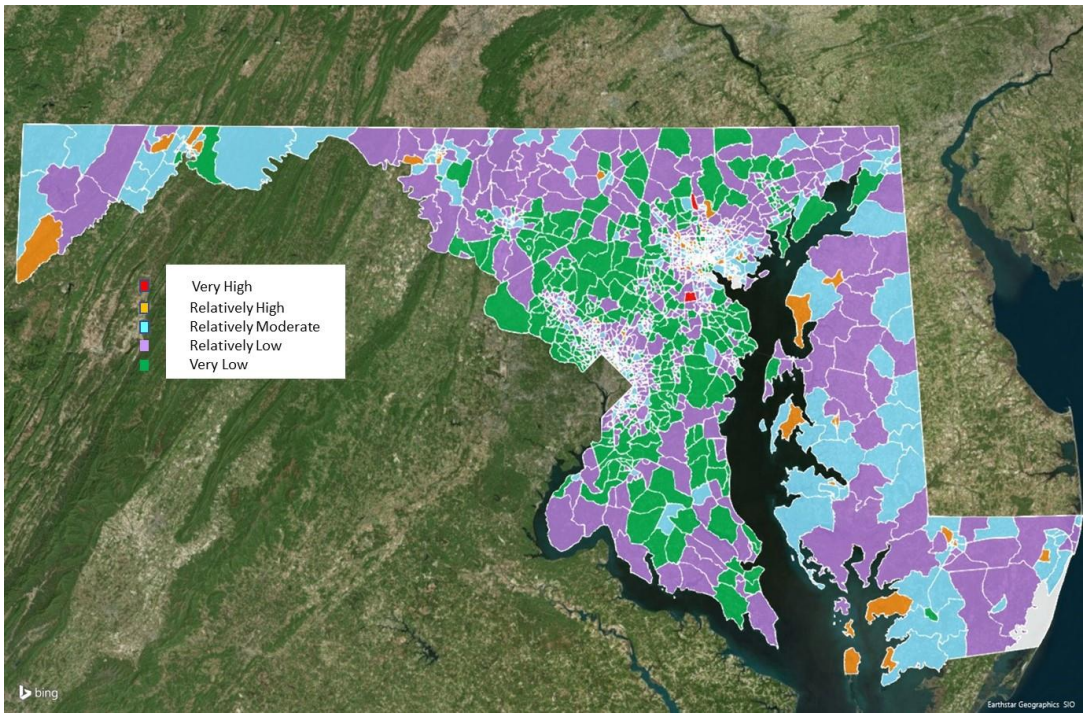


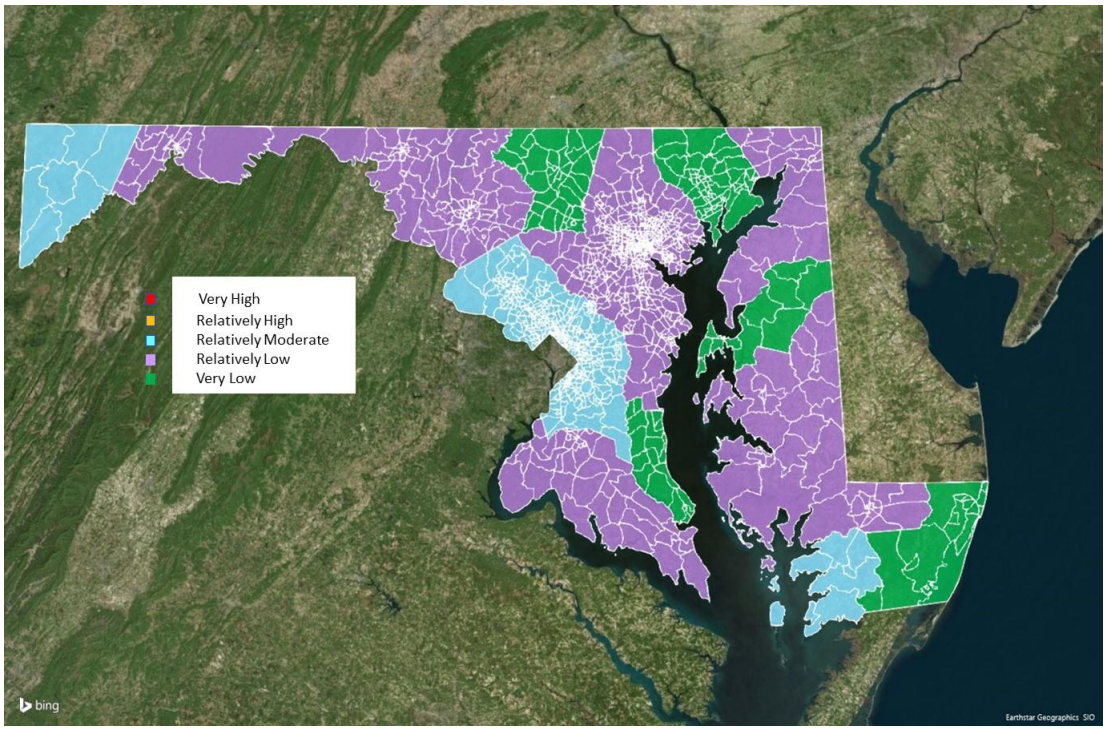
Figure 3: Social Vulnerability Rating by Maryland Census Tract



In terms of Community Resiliency, Maryland exhibits a relatively high level of community resiliency to hazard risk

high degree of community resiliency to hazard risk. It is important to keep in mind that FEMA developed these ratings not at a state level but nationally such that components, including financial resources for Maryland may, by comparison with other states, generate relatively favorable outcomes on community resiliency.

Figure 4: Community Resiliency Rating by Maryland Census Tract



HMDA Data

The 2021 HMDA data provides extensive detail on 23.3 million mortgage loan applications for that year in the US. Of these applications, 15 million loans were originated.[15] This information includes both 1st and 2nd lien mortgages as well as loans sold to Fannie Mae and Freddie Mac, FHA, VA, Rural Housing Service and privately-held mortgages making this one of the most comprehensive data sources on new mortgage loans available.

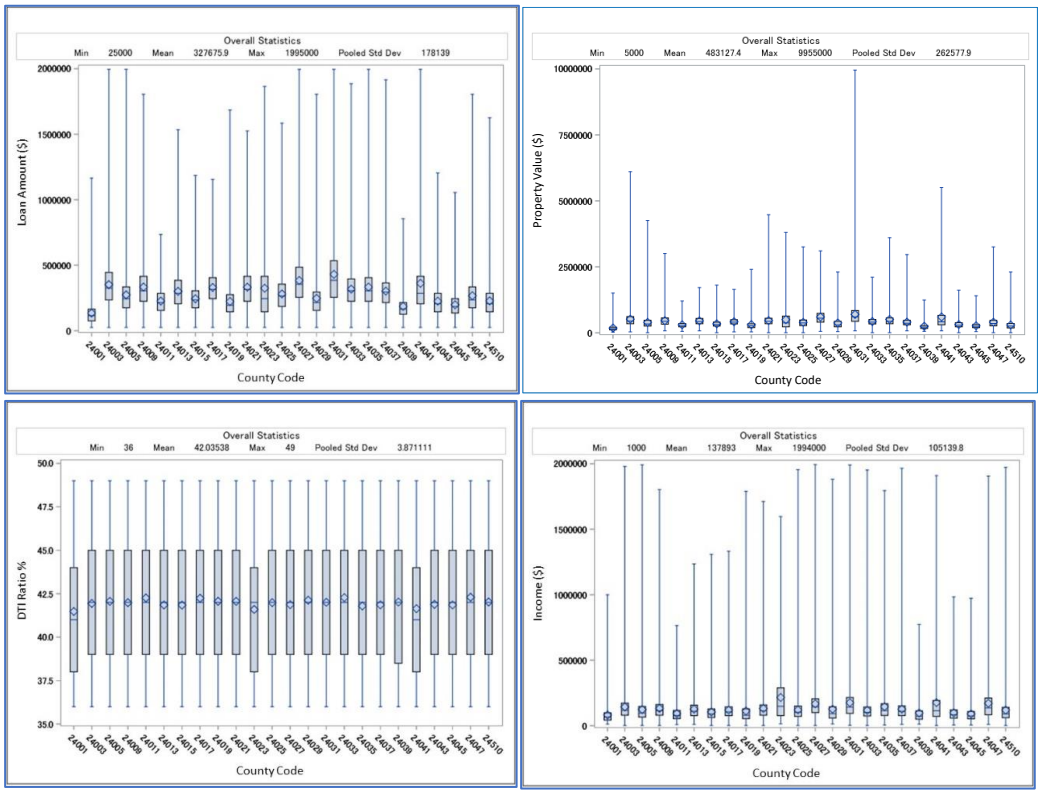
While the HMDA data does not capture any loan performance history since these reflect new loans, it does provide a great deal of information on key risk and demographic attributes useful for this study. Critical among them are such

[15] Consumer Financial Protection Bureau, Summary of 2021 Data on Mortgage Lending, June 16, 2022, https://www.consumerfinance.gov/data-research/hmda/summary-of-2021-data-on-mortgage-lending/.

COUNTY	Code
Allegany	24001
Anne Arundel	24003
Baltimore	24005
Calvert	24009
Caroline	24011
Carroll	24013
Cecil	24015
Charles	24017
Dorchester	24019
Frederick	24021
Garrett	24023
Harford	24025
Howard	24027
Kent	24029
Montgomery	24031
Prince George's	24033
Queen Anne's	24035
St. Mary's	24037
Somerset	24039
Talbot	24041
Washington	24043
Wicomico	24045
Worcester	24047
Baltimore City	24510

factors as loan-to-value (LTV) ratios, debt-to-income (DTI) ratios, loan amount, borrower income, age, race and ethnicity as well as a number of tract level statistics such as tract minority population percent. After scrubbing the HMDA data for missing data and outliers, a total of 595,874 loan applications for Maryland in 2021 remained in the sample. From these applications, 291,208 1st and 2nd lien loans were originated in Maryland. Figure 5 depicts some key statistics in boxplots for these loans across Maryland counties.

Figure 5: Borrower DTI, Income, Loan Amount and Property Value Statistics by County



Not surprising, there is little variability in DTIs of borrowers across counties. Differences emerge, however, when examining other attributes such as property values, loan amounts and borrower incomes. Here, the range in these variables is noticeable which will be important later in the analysis of hazard risk to discern any clear differences in financial and demographic characteristics across census tracts.

Fannie Mae and Freddie Mac Credit Performance Data

Both Fannie Mae and Freddie Mac have as part of their credit risk transfer (CRT) initiative made publicly available the loan level data associated with the vast majority of their insured portfolios consisting of millions of loans originated from 1999 to the present.[16] The data provide both the borrower, loan, and property attributes of the borrowers such as credit scores, LTV and DTI ratios and more as well as detailed information on the performance of each loan over time. Specifically, the data enables a user to determine whether a loan remained current or prepaid, went delinquent, was modified or entered default. This data was used to develop the HFVI used in this analysis. Random samples from the Fannie Mae and Freddie Mac data were taken and combined in historical proportions to their market share. More than 250,000 loans across the US from origination years 2000-2016 were used in developing the HFVI.

Homeowner Financial Vulnerability Index (HFVI)

The HFVI leveraged for this analysis measures a borrower's financial vulnerability to unexpected housing or nonhousing costs

The HFVI leveraged for this analysis was developed by Chesapeake Risk Advisors, LLC in a separate initiative to measure a borrower's financial vulnerability to unexpected housing or nonhousing costs. As mentioned earlier, over the course of a loan's life, borrowers' invariably encounter any number of unexpected expenses, small and large. In the case of housing, such unexpected large expenses would include major system breakdowns such as HVAC, appliances, windows, roofs, sewer and waterline replacement and repair, among others. While substantial academic literature exists relating to mortgage default, less is known about the degree of financial frailty of borrowers as it relates to unexpected outlays. However, the insurance company Hippo recently conducted a survey of new homeowners and found that within the first year of owning their home, a significant repair costing more than $1,000 happened for two-thirds of the homeowners in that sample.[17]

[16] Details on the Fannie Mae and Freddie Mac datasets are found at the following links: https://capitalmarkets.fanniemae.com/credit-risk-transfer/single-family-credit-risk-transfer/fannie-mae-single-family-loan-performance-data. https://www.freddiemac.com/research/datasets/sf-loanlevel-dataset

[17] Sarah O'Brien, "Many homebuyers face surprise repair costs soon after moving in, survey shows, CNBC, March 31, 2022, https://www.cnbc.com/2022/03/31/many-homebuyers-face-surprise-repair-costs-soon-after-moving-in.html.

Hippo found that within the first year of owning their home, a significant repair costing more than $1,000 happened for 2/3rds of the homeowners in their survey

Factors that are predicted to affect financial vulnerability include debt burden, borrower income diversification, relative capital costs of equipment and component replacement to borrower income, the age and type of property (e.g., single family vs condo), equity stake in the property by the borrower, relative income and occupancy status, among others.

Taking each of these in turn, clearly a borrower's debt burden, defined as total monthly housing and nonhousing obligations divided by monthly income is expected to be positively related to financial vulnerability. Moreover, multiple borrowers with incomes tend to be more insulated from a financial stress event due to income diversification. A variety of property-related features are considered to factor into the cost of repairs or replacement to important components in a home. These include the age and condition of the structure and its critical components, structure size and building materials, among others. The HFVI model takes into account the idea that these factors are embodied within the property value and that borrowers with lower incomes will have a greater financial shock from an unexpected home repair the larger that property happens to be.

Extreme weather events could affect homeowner financial vulnerability as stated earlier. Costs associated with such events include the impact on property insurance premiums and out-of-pocket costs for protecting property against natural disasters, as well as higher deductibles and any expenses not otherwise covered by insurance after an event occurs. Homeowner insurance costs, for example, rose more than 12 percent between 2021 and 2022 according to one study.[18] And those in states more susceptible to disasters not surprisingly are seeing significant increases in premiums. Ominously in some areas, obtaining a homeowners policy is becoming increasingly difficult as underwriters assess the insurability of these homes. For instance, Florida's homeowners insurance market is under extraordinary financial pressure, with homeowners in at-risk areas facing non-renewal notices or much higher premiums and deductibles.[19]

The release of FEMA's new risk-based pricing for flood insurance called Risk Rating 2.0 has greatly improved the flood insurance program in a number of important ways including taking into account a property's cost of construction premiums for lower-valued homes.[20] In Maryland, the premium impact on

[18] Kate Dore, "As climate change threatens more homes, some properties are getting too costly to insure," CNBC, August 9, 2022, https://www.cnbc.com/2022/08/07/climate-change-is-making-some-homes-too-costly-to-insure.html

[19] Ed Leefeldt, Why is Homeowners Insurance in Florida Such a Disaster? Forbes Advisor, November 22, 2022.

[20] FEMA, Risk Rating 2.0: Equity in Action, https://www.fema.gov/flood-insurance/risk-rating

Ninety-seven percent of Maryland policyholders under the FEMA NFIP 2.0 program experienced an annual premium increase no more than $10

homeowners from Risk Rating 2.0 has been negligible. Ninety-seven percent of policyholders under the FEMA NFIP 2.0 program experienced an annual premium increase no more than $10 and more than 61% realized lower premiums.[21]

The HFVI is a proprietary statistically-based model that predicts the likelihood of borrower financial vulnerability. Financial vulnerability is marked by an event of such significance that it places the homeowner in a state of financial distress. Events triggering financial distress could include a major unexpected outlay or loss of income or employment, death or illness or divorce. Typically proxies of these trigger events are used in modeling mortgage default, and similar approaches can be leveraged to examine financial vulnerability. HFVI controls for and strips away those elements not directly related to financial vulnerability. The multivariate statistical model was validated on a large sample of mortgage loans and found to have a high degree of discriminatory power in distinguishing between borrowers that came into financial distress versus all others over time.[22]

For this analysis, the HFVI model was applied to all 2021 HMDA loans in Maryland and a predicted probability of financial distress computed. The average predicted probability of financial distress for the sample was 9% with a range of 0 to 19% and a standard deviation of 1.8%. From there, the probabilities were transformed into the HFVI score using an industry standard credit scoring algorithm. Scores for HFVI range from 0 to 400 with 50 points doubling the odds of a borrower becoming financially distressed. The average HFVI in the 2021 Maryland HMDA sample was 168. Lower scores are indicative of greater financial distress and vice versa.

For each Maryland census tract a weighted (based on each loan's unpaid principal balance) HFVI score was produced from HMDA loans in that tract. Then a rule was applied to establish an HFVI risk rating for each tract. The definitions for each HFVI rating are shown in **Table 3** along with the number and percentage of tracts for each category. Within this sample, 13.7 percent of Maryland tracts are designated as either Relatively High or Very High homeowner financial vulnerability. Borrowers in these two risk categories are 2-3 times more likely to enter financial distress sometime in the life of their loan than Relatively Moderate borrowers.

[21] Association of State Floodplain Managers and The Pew Charitable Trusts, Risk Rating 2.0 Interactive Map, https://www.arcgis.com/apps/dashboards/44d08581aaf14f39bc0da5d02f378007.

[22] For example, one diagnostic measure used to test the validity of HFVI is the Kolmogorov-Smirnov (KS) test. The out-of-sample KS score was 47 for the HFVI model, indicative of a relatively high level of discriminatory power.

To provide some insight into important differences between groups, the percentage of homeowners with a Very High financial vulnerability rating having DTIs above 40% is 63.7% of that rating category versus less than 1% for the other rating groups. Moreover, the ratio of borrower income to median income for all Maryland borrowers averaged .79 for borrowers in the Very High financial vulnerability category versus an average of 1.14 for all others. Similarly, the ratio of property value to borrower income averages 4.85 for borrowers in the Very High financial vulnerability category versus 3.86 for all other borrowers. These statistics individually are indicative of borrowers with greater vulnerability to unexpected financial events such as an extreme weather due to the potential relative costs of repairs to financial resources available to these borrowers.

13.7 percent of Maryland tracts are designated as either Relatively High or Very High homeowner financial vulnerability

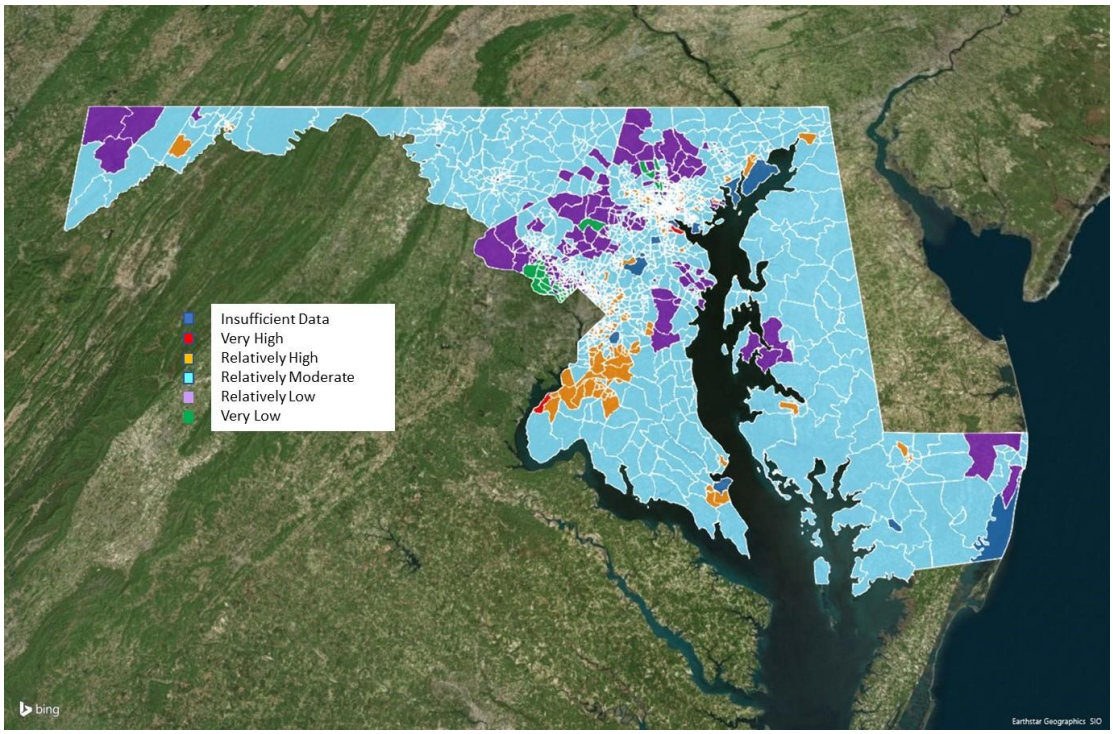
Table 3: HFVI Rating Definitions and Tract Counts for Maryland[23]

HFVI Rating	HFVI Score	Risk Multiple	Number of Tracts	% of Tracts
Very Low	>375	.25Xs	32	2.41
Relatively Low	>325-375	.50Xs	180	13.57
Relatively Moderate	>275-325	1.00Xs	933	70.36
Relatively High	>225-275	2.00Xs	170	12.82
Very High	<=225	3.00Xs	11	0.83

Figure 9 provides more insight into where borrowers with the greatest financial vulnerability are located. The majority of Maryland census tracts are located in Relatively Moderate or Very Low HFVI tracts. In terms of population density, we see portions of Prince Georges County, Baltimore City and County and Charles County as having Relatively and Very High homeowner financial vulnerability tracts, however, there are pockets of higher risk tracts in each corner of the state.

[23] Note: this total of 1,326 tracts excludes 69 that reported an insufficient number of loans in the tract for analysis. To preserve statistical integrity, each census tract had to have at least 50 mortgage loan observations.

Figure 9: HFVI Rating by Maryland Census Tract



The majority of Maryland census tracts are in Relatively Moderate to Very Low HFVI tracts

Maryland Natural Hazard Risk & Financial Vulnerability

So far, the NRI risk ratings and homeowner financial vulnerability ratings have been examined in isolation from each other. Putting these ratings together presents a clearer picture of where extreme weather events have the greatest impact to homeowners in Maryland. Based on these ratings, only 4 tracts in Maryland are designated as having very high combined hazard risk and financial vulnerability as shown in Table 4 (orange cells). An additional 30 tracts fall into the next highest combined risk category (yellow cells). The vast majority of tracts thus fall into Relatively Moderate to Low Risk. Greater geographic detail on combined hazard risk and financial vulnerability is provided in Figure 10. We find the vast majority of the highest risk tracts are found on the eastern shore and to a lesser extent in tracts along the western shore of the Chesapeake Bay. These areas are some of the least densely populated areas in the state where agriculture and fishing are major industries.

Additional perspectives on the various groups are provided in Tables 5 and 6. Table 5 displays the median income for each rating combination. While there is some variation in income across rating combinations (e.g., VL EAL Ratings and RH and VH HFVI), no clear pattern emerges suggesting that homeowners living in high hazard areas have significantly lower incomes than other lower risk areas.

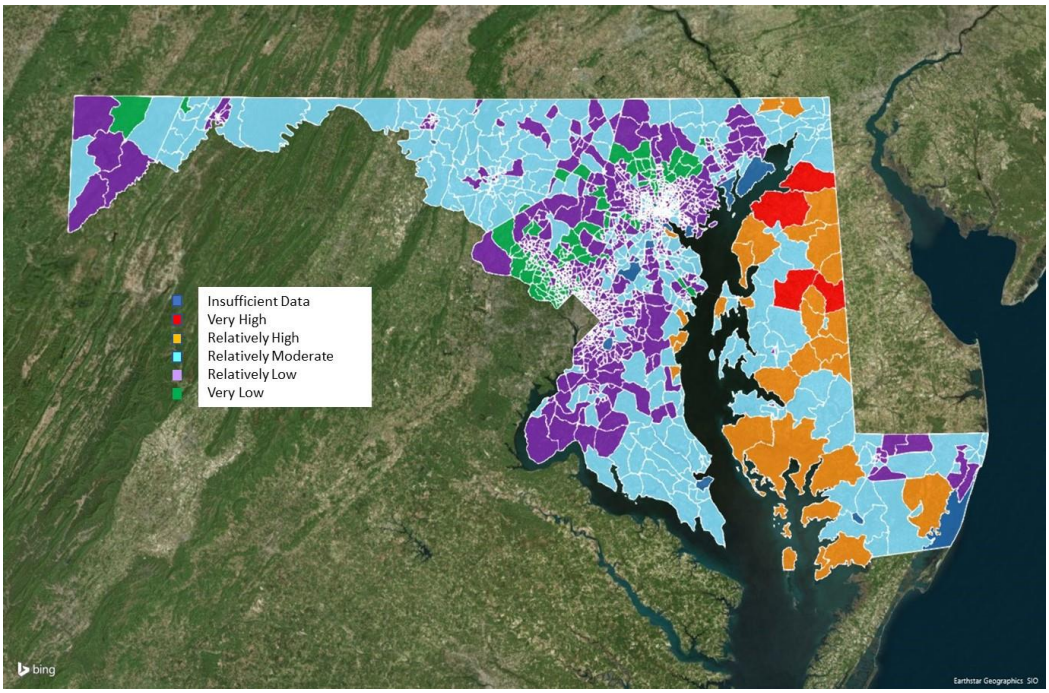
Only 4 tracts in Maryland are designated as having very high combined hazard risk and financial vulnerability

Table 4: Combined NRI (EAL) and HFVI Ratings for Maryland Census Tracts

	HFVI Rating						
NRI EAL Rating	VL	RL	RM	RH	VH	Totals	NRI*HFVI Legend
VL	29	125	614	143	9	920	Very Low
RL	2	47	247	27	2	325	Relatively Low
RM	1	4	40	0	0	45	Relatively Moderate
RH	0	4	28	0	0	32	Relatively High
VH	0	0	4	0	0	4	Very High
Totals	32	180	933	170	11	1326	

Looking at the minority percentages in these areas, Table 6 suggests that overall minority populations are considerably lower in higher hazard, financially vulnerable areas. Once again, it is important to point out that individual tracts in certain high hazard risk areas have much higher minority percentages and lower income and as a result the utility of these ratings is found in examining their characteristics at the individual tract level for public policy.[24]

Figure 10: Map of Combined NRI (EAL) and HFVI Ratings for Maryland Census Tracts



[24]Making the HFVI and NRI ratings available at the tract level provides policymakers with that level of detail.

Overall minority populations are considerably lower in higher hazard, financially vulnerable areas

Table 5: Median Income ($) by Hazard and Homeowner Financial Vulnerability Rating

	HFVI Rating				
NRI (EAL) Rating	VL	RL	RM	RH	VH
VL	202,645	176,987	118,510	98,877	93,094
RL	111,233	156,799	124,747	136,492	-
RM	-	170,487	142,722	157,468	-
RH	-	-	127,835	141,816	-
VH	-	-	119,283	-	-

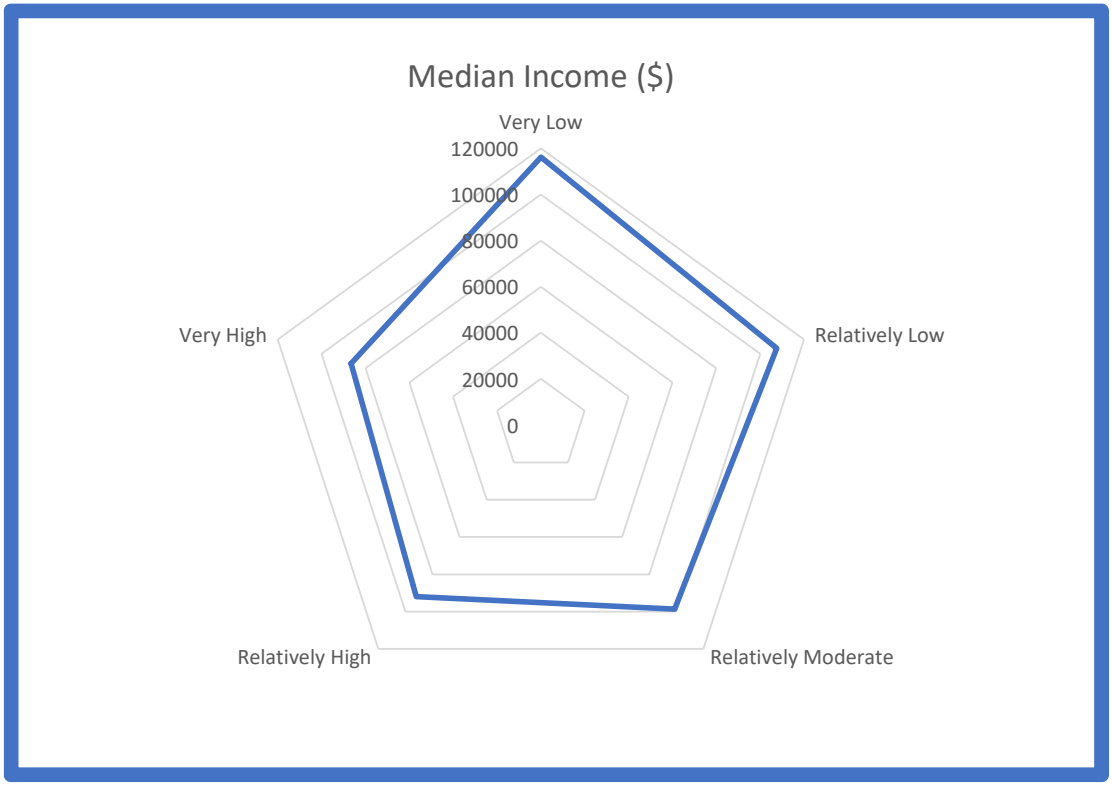
Table 6: Average Minority Share of Population (%) for Tracts by Hazard and Homeowner Financial Vulnerability Rating

	HFVI Rating				
NRI EAL Rating	VL	RL	RM	RH	VH
VL	39.0	38.2	50.3	83.6	60.0
RL	14.4	30.0	31.4	35.0	NA
RM	NA	34.0	17.4	9.5	NA
RH	NA	NA	18.3	16.8	NA
VH	NA	NA	13.2	NA	NA

Another way to examine differences in median income is by the radar plot in Figure 11. The pattern that emerges seems to suggest that median incomes in the VH and RH EAL rating categories tend to be a bit lower than the other categories. Further assessment of any differences in income by hazard risk rating is performed in a multivariate analysis.

Figure 12 presents additional insight on the relationship of median income for the highest risk EAL categories taking financial distress into account. Here we tend to see higher median income tracts (larger bubbles) oriented toward the lower end of the EAL axis and again not surprising also at the lower end of the financial distress axis.

Figure 11: Median Income by EAL Hazard Rating Radar Plot



Median incomes in the VH and RH EAL rating categories tend to be a bit lower than the other risk categories

Figure 12: Median Income by EAL Hazard Rating and Financial Distress Radar Plot

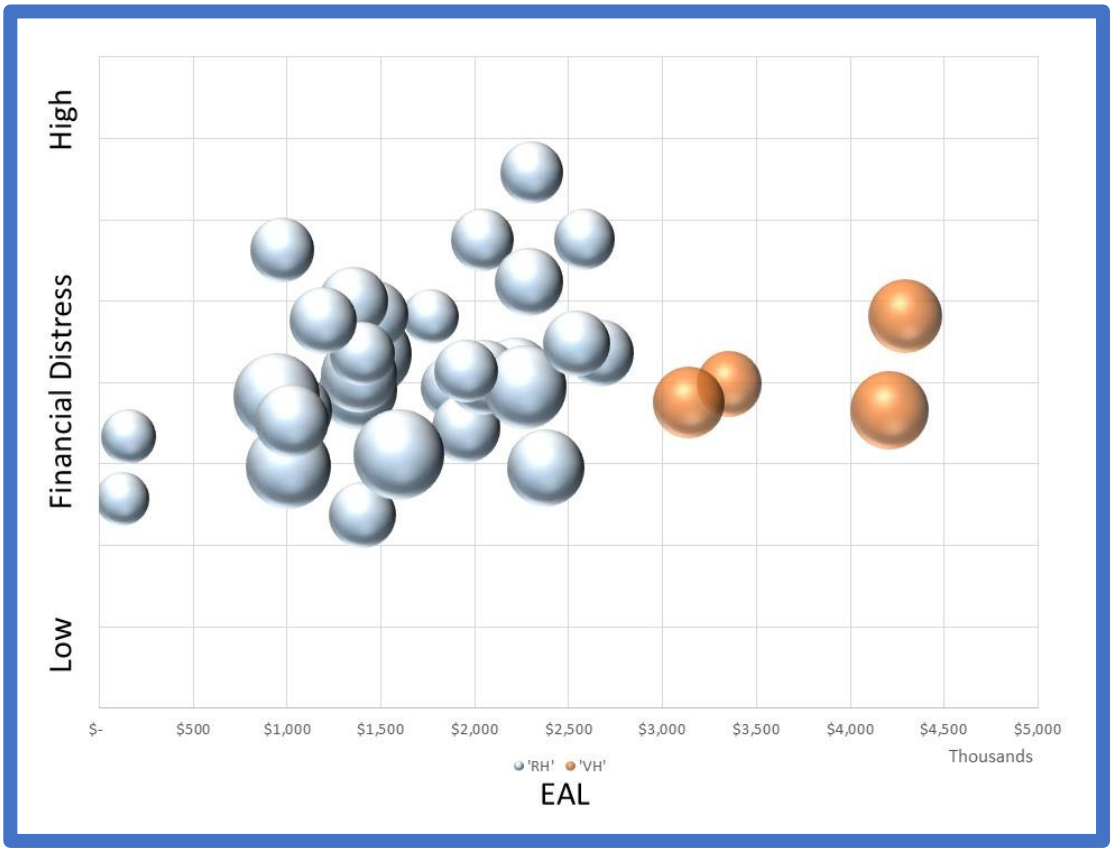
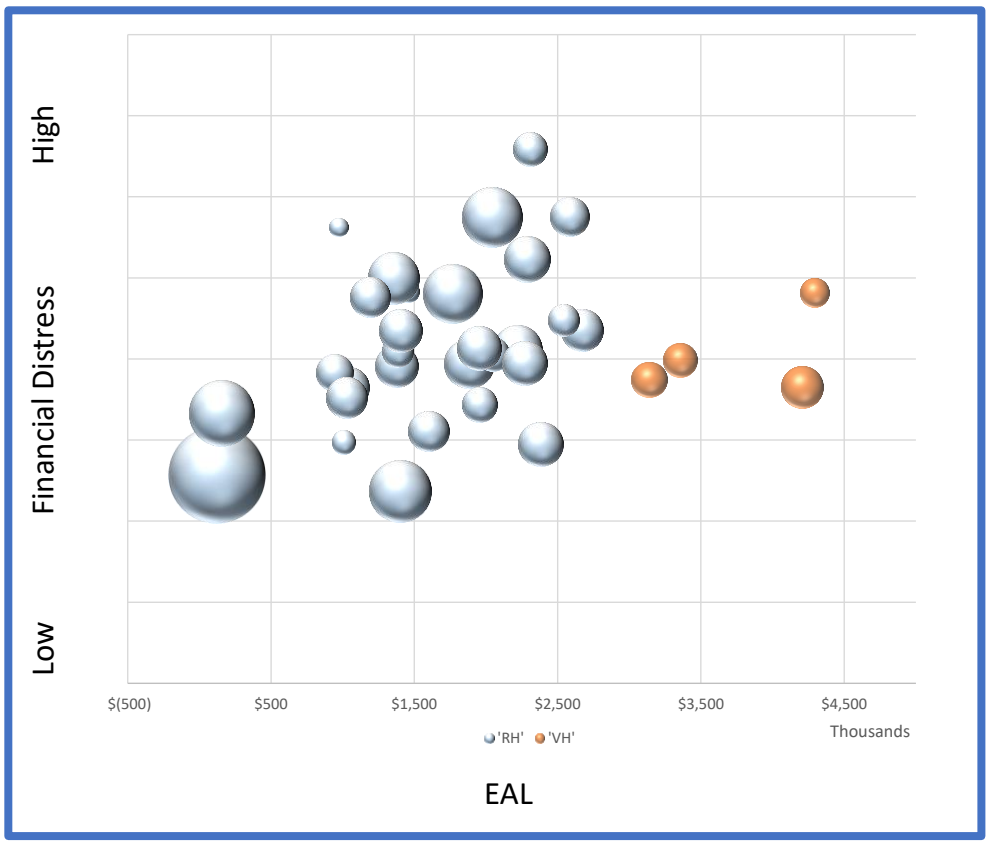


Figure 13 presents a multilayered view of minority presence in high hazard risk areas. For just the Relatively High and Very High tracts, there appears to be some relationship between tracts with higher EAL and financial distress though less of a clear relationship emerges between higher minority percentages (larger bubbles) and EAL or HFVI. Figure 14 provides another view of the relationship between minority percentage and combined EAL and HFVI rating. What this figure shows is that tracts with Very Low EAL and HFVI risk have the highest tract-level minority percentage while the highest two combined EAL and HFVI rating categories show the lowest minority percentages.

Tracts with Very Low EAL risk have the highest tract-level minority percentage

Figure 13: Tract Minority Percent by EAL



Finally, an examination of the age of housing stock of borrowers by EAL risk ratings from Figure 15 can provide some insight into the potential costs for homeowners should an extreme weather event occur. Damage to newer homes, particularly stick-built structures, could be more costly due to restoration and or repair costs for these structures as compared with older homes. Many factors beyond age factor into the cost of repair such as composition and materials used in construction, for example. But on this one dimension, no clear pattern emerges on the radar plot. Tracts with Very Low

Figure 14: Minority Percent by EAL Hazard Rating and Financial Distress Radar Plot

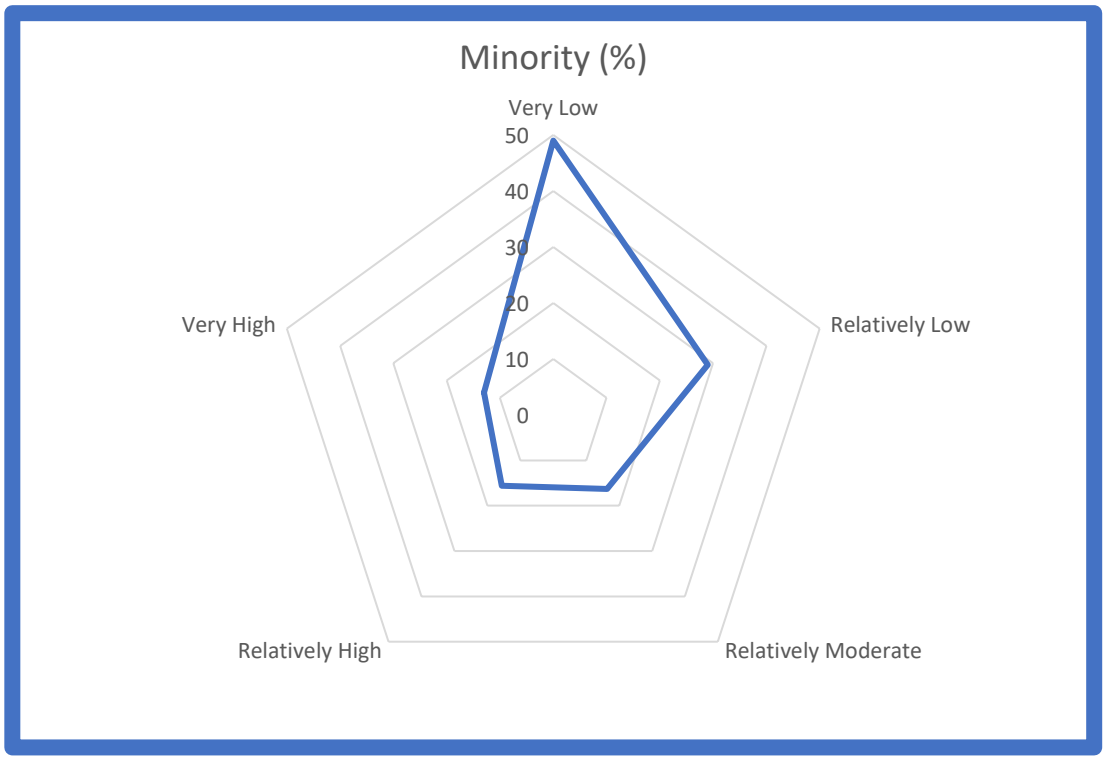
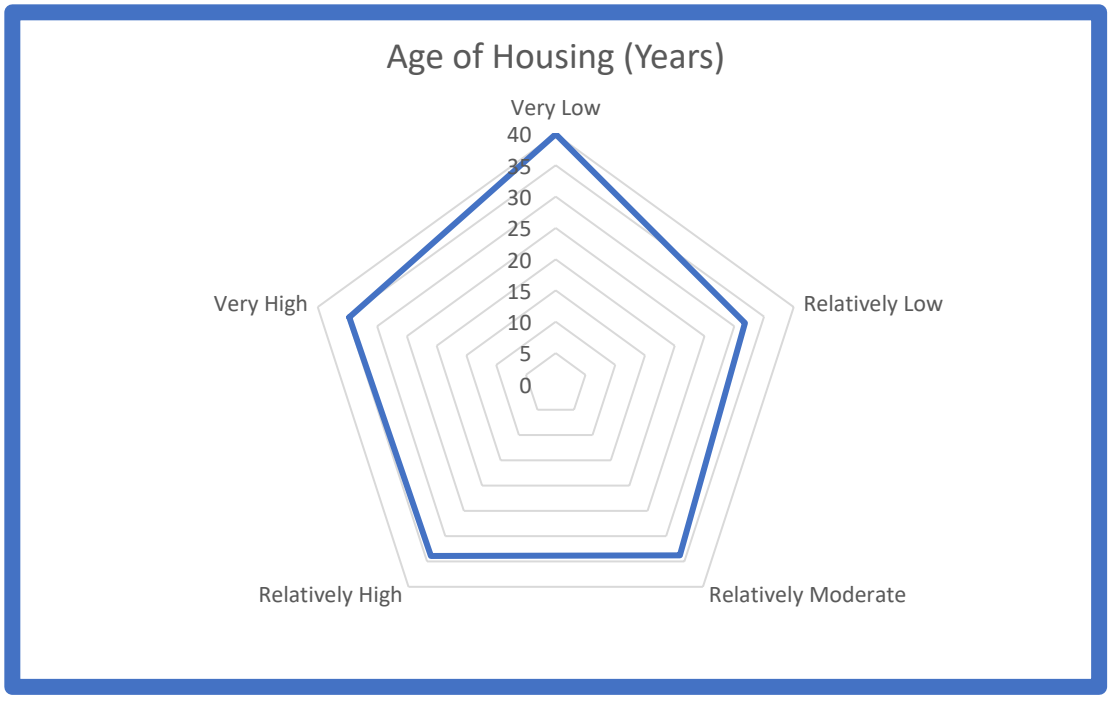


Figure 15: Age of Housing by EAL Hazard Risk and Financial Distress Radar Plot



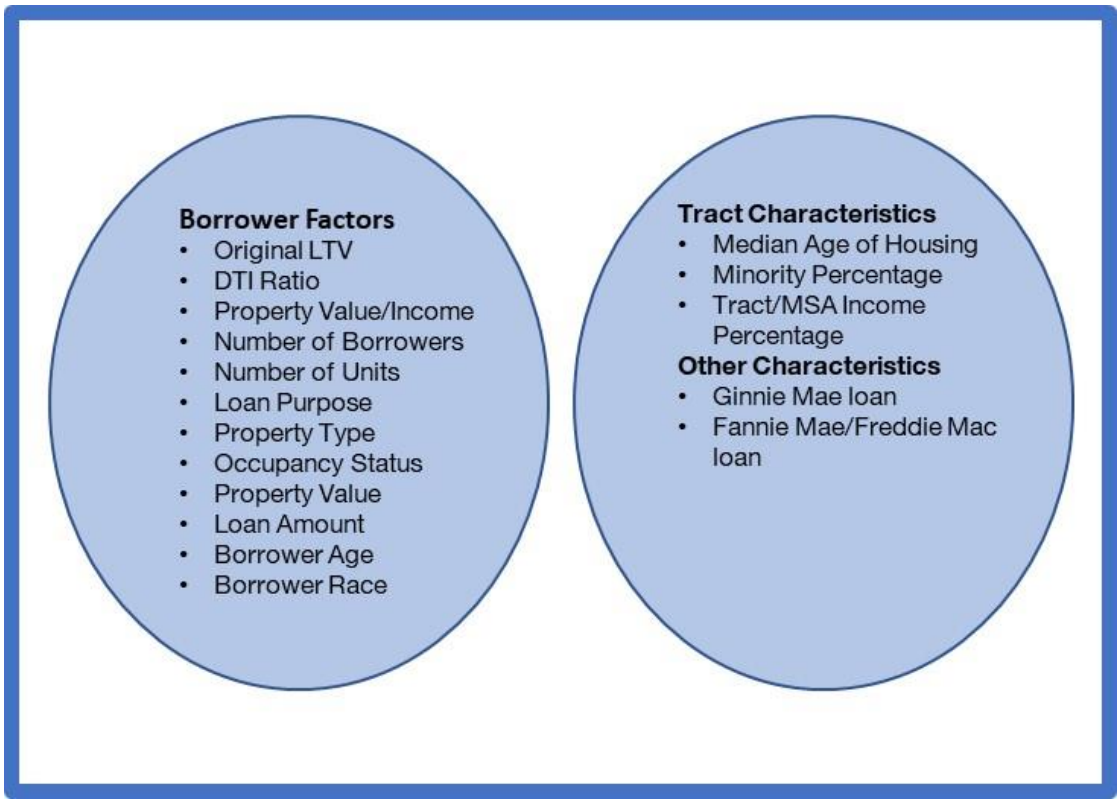
Tract minority percentages are lowest for the two highest combined EAL and HFVI rating groups

combined risk show a somewhat older housing stock than the other categories but beyond that very little difference in age across risk ratings is observed.

While examining individual borrower and tract characteristics can shed light on homeowner vulnerability to extreme weather events, a more robust approach requires a multivariate analysis where individual attributes can be controlled for against other characteristics. For this purpose, a logistic regression model was estimated using the Maryland 2021 loan level data combined with the NRI data. This type of model is commonly used when examining differences between groups. The variable of interest, or dependent variable was whether the property underlying the loan was located in a high hazard risk area (i.e., Relatively High or Very High) as designated by the EAL Rating. High EAL risk loans are designated as 1 in the data and 0 for all others. A number of other borrower, tract and housing market factors were identified as candidate explanatory variables. A list of candidate variables for the analysis are found in Figure 16.

A statistical analysis of MD loans identified several factors distinguishing high hazard risk areas from others

Figure 16: Candidate Variables for Multivariate Analysis



The idea was to discern whether some combination of these variables would have statistical significance in distinguishing between loans in high EAL risk areas and all others. While a hypothesis for each variable regarding its relationship with the dependent variable could be drawn, some relationships

are not readily apparent and so using this type of analysis can help identify important patterns in the data in this case.

After estimating a large number of models with different specifications, the set of variables leading to the model with the most discriminatory power among all alternatives is shown in Figure 16 along with the odds ratios for each variable.[25] All variables were significant at the 1% level. The variable with the largest odds ratio was the dummy variable for Ginnie Mae loans. The variable was designated as a 1 if the loan was a Ginnie Mae loan or 0 otherwise. The odds ratio for that variable of 1.31 implies that properties associated with Ginnie Mae loans are 1.31 times more likely to be in high EAL risk areas than other loans. Several specifications tested whether there was any difference between GSE (Fannie Mae and Freddie Mac) and nonGSE loans and in all instances that variable was not significant. One implication from these results is that government loans such as FHA, VA and Rural Housing are more likely to be in high risk areas. This result begs the question of whether these agencies are being adversely selected by loan originators. Agencies insuring the credit risk on these loans then from this analysis would be well-served to understand the risk to borrowers from extreme weather events as they could pose higher default risk over time. Conversely, there does not seem to be any adverse selection with GSE loans given the lack of significance between GSE and nonGSE loans by EAL risk rating.

One implication from these results is that government loans such as FHA, VA and Rural Housing are more likely to be in high hazard risk areas

Factors also associated with a higher likelihood of a property being in a high EAL risk area were borrower relative income defined as the ratio of a borrower's income to median income for the HMDA sample and loan purpose defined as whether the loan was a cashout refinance (=1) or not (=0). While this variable is an important predictor of mortgage default, it was hypothesized that there might be a positive relationship between taking equity out of the property and its hazard exposure. The effect in this case was moderate, based on the odds ratio of 1.2. All other factors in the table were negatively related to the dependent variable.

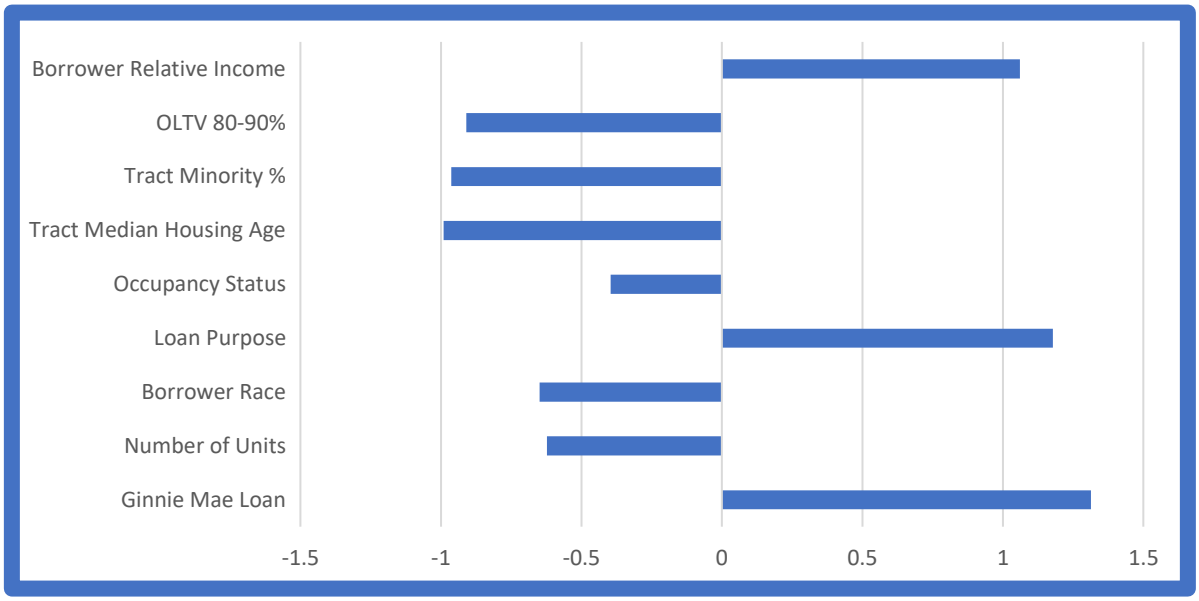
The odds ratio for instance of the housing age variable was statistically significant and implies that for every 1 year increase in the age of a house, the likelihood of being in a high EAL risk area falls by 1%. Other significant factors are that the higher the percentage of minorities in a tract, the lower the liklihood that tract would be in a high EAL risk area. Borrower race is consistent with that tract-level effect as well.

What this analysis shows is that there is variation among tracts on the basis of their EAL risk rating from borrower, tract and other characteristics. The

[25] An odds ratio is defined as e^b where b represents an explanatory variable's estimated coefficient in the model. The final model reported a KS of 66.7 and an AUC of .89.

analysis sheds new light on the characteristics of homeowners in high hazard risk areas and information such as this can help guide policymakers in developing programs aimed at helping borrowers mitigate risk from extreme weather events.

Figure 16: Odds Ratios Differentiating High Hazard Risk Tracts



By using tract-level measures of hazard risk combined with loan level measures of financial vulnerability, federal, state and local funding can be better allocated to support community-based resiliency projects

Summary and Conclusions

Homeownership remains of the most important financial achievements for individuals in this country and has significant public policy implications for the economy and social welfare. More than two-thirds of Marylanders own their home and for most, it is the most valuable asset that they own. Protecting this asset against loss from extreme weather events now and in the future is critical. Policymakers as well as the insurance and mortgage industry need to improve the tools available to assess the risk to homeowners from such events.

This study provides new tools for analyzing the effects of extreme weather events and homeowner financial resiliency. Identifying areas with the greatest exposure to extreme weather and that have high homeowner financial vulnerability can help target public and private resources optimally. For example, by using tract-level measures of hazard risk combined with loan level measures of financial vulnerability, federal, state and local funding can be better allocated to support community-based resiliency projects such as investments in shoreline protection, flood control and the like as well as help facilitate the design of innovative

Tools such as the HFVI when combined with FEMA's NRI data can provide the kind of information needed to better insulate homeowners from the unexpected

insurance and mortgage products for individual homeowners.

Current and prospective homeowners living in high hazard risk areas will need new products and services to help them understand and manage the physical and financial risks they face from extreme weather events now and in the future. For new homeowners, having tools that help identify the physical risks of their area is critical before making a purchase. Today there are tools available for prospective homeowners to obtain estimates of a property's value and also its flood risk. While these are certainly valuable at the property level, assessing this risk along a broader set of hazards and at the tract level can provide potential homeowners with a sense of the risks of not just living in the home but also the effects extreme weather might have on the community, local infrastructure and commerce over time.

Current homeowners can likewise benefit from these tools, especially forward-looking tools that can provide them with perspectives on hazards happening not just this year but 5-10 years and more down the road. Today, in Maryland about 42% of residential properties considered to be at-risk have flood insurance.[26] Further, as the frequency and severity of extreme weather events increases, today's seemingly low-risk property might become tomorrow's high risk home, making the need to obtain insurance more critical. And with flood risk being just one of many potential hazards to a home over the life of a mortgage, providing homeowners with better information is imperative.

In addition, financial products that cater toward proactive investment by homeowners in weather resiliency projects should be developed. This could include adjustable balance mortgages that incent homeowners to invest in qualifying remediation/resiliency projects that add value to the home and spread those investment costs flexibly over time at a lower rate, thus making such investments more feasible. Other products post-disaster could be imagined that provide similar financial relief to homeowners for renovation and repair costs not otherwise covered by insurance. Ideas such as extreme weather/climate banks could be established for instance from guarantee fees charged by credit investors such as the GSEs and FHA and allocated based on need.

Ultimately, the first step in developing these capabilities, products and programs is to identify those homeowners most in need of help. Tools such as the Homeowner Financial Vulnerability Index when combined with FEMA's NRI data can provide the kind of information needed to better insulate homeowners from the unexpected costs of extreme weather events.

[16] Meg Stefanac, Maryland Flood Insurance, Trusted Choice, February 18, 2022.

Assessing the impact of hurricane frequency and intensity on mortgage delinquency

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Abstract Considerable meteorological research suggests that the frequency and intensity of North Atlantic hurricanes are rising. This analysis focuses on estimating the impacts of hurricane intensity and frequency on mortgage delinquency. Based upon a large loan-level dataset of mortgages purchased by Freddie Mac between 1999 and 2015, loans with an average lifetime Saffir–Simpson hurricane rating of 3 or more were found to be 88 per cent more likely to become delinquent than other loans in the same locations, controlling for all other risk factors. This result has important implications for mortgage and insurance markets and homeowners. First, if long-term hurricane trends bear out, mortgage default risk in areas with a higher incidence of major hurricanes will likely rise significantly over time. Secondly, investors in mortgage credit risk from these locations will face higher default losses in the future. Thirdly, private investors in mortgage credit-risk transfer (CRT) securities could experience higher credit losses of loans from hurricane-prone areas. Investors in lower-rated tranches would be particularly impacted given the nature of their exposure to losses earlier than more highly rated tranches. Catastrophe bonds could be used to diversify hurricane risks to investors that may be in a better position to assess and hold this risk.

Keywords: *hurricane risk, mortgage default, risk management, reinsurance*

INTRODUCTION

Considerable meteorological research suggests that the frequency and intensity of North Atlantic hurricanes are on the rise. The destructive power of these storms is well documented, that in addition to deaths and injuries, major hurricane events cause significant economic losses, business disruption and life-changing dislocation for individuals and families. The Congressional Budget Office estimates that annual economic losses from hurricanes in the United States are US$54bn, with losses from the residential sector accounting for US$34bn of that amount.[1] Moreover, according to Pielke et al., 85 per cent of damage caused by hurricanes is associated with hurricanes rated 3–5 on the Saffir–Simpson Hurricane Wind Speed Scale.[2]

Extensive modelling of hurricanes suggests that while the overall frequency of hurricanes in the future may actually decline over the next century, the frequency and intensity of the strongest hurricanes, that is, those rated Category 3–5, are likely to significantly increase over this period. At

the upper end, one study suggests that the aggregate strength of North Atlantic hurricanes could rise 300 per cent above where they have been in the recent past.[3] Other studies suggest a more moderate path for future hurricane intensity and frequency despite the fact that the aggregate power of hurricanes as measured by the Power Dissipation Index (PDI) in 2007 was approximately six times the PDI level of the early 1980s, signalling that this recent period was not only marked by more hurricanes but ones with greater intensity.[4]

The linkages between hurricanes and mortgage default are emerging from a variety of empirical studies on this topic. Fannie Mae, for example, found mixed results when reviewing the impacts from two major hurricane events: Hurricanes Katrina (August 2005) and Sandy (October 2012).[5] In the months immediately following Hurricane Katrina for instance, loans delinquent 180 days or more (D180+) peaked at a rate approximately five times the D180+ rate in the months leading up to the storm. By contrast, Fannie Mae found that D180+ rates following Hurricane Sandy remained relatively steady. The impact of hurricanes on mortgage delinquency could be affected by various risk mitigation practices put in place by credit investors. For instance, following hurricanes in 2017, government-sponsored enterprises (GSEs) provided relief to affected borrowers in the form of forbearance and modification plans.[6] Early analysis of borrowers offered modifications following Hurricanes Irma, Harvey and Maria indicated that 97 per cent were current or had prepaid.[7] These policies were not in place at the time of Hurricanes Sandy or Katrina. Underscoring the magnitude of potential risk for the mortgage sector, CoreLogic estimates that 7.4 million residential and multifamily properties, accounting for approximately US$1.8tn in replacement costs would be affected by storm surge from hurricanes in the United States.[8]

The focus of this analysis is to understand the specific impacts of hurricane intensity and frequency on mortgage delinquency. Using a sample of more than 100,000 mortgage loans purchased by Freddie Mac that were originated between 1999 and 2015, a model describing a borrower's probability to default as defined by either a loan that becomes delinquent 90 days or more (D90+) or not, and augmented with data on hurricanes from the Federal Emergency Management Agency (FEMA) Disaster Declarations Summaries was estimated. In addition to standard risk attributes associated with the borrower, loan product and property, a factor describing the intensity of hurricanes experienced in counties where these properties are located was statistically significant.

Loans where a Category 3, 4 or 5 hurricane was experienced during the loan's life were found to be 88 per cent more likely to become 90 days delinquent or more, respectively than other loans in the same locations, controlling for all other risk factors. Moreover, a machine learning analysis of the data revealed that the average hurricane rating and number of hurricanes experienced by borrowers in the sample ranked second and third in feature importance to predicting D90+ rates among all risk attributes. Only current loan to value (LTV) ranked higher in explaining mortgage delinquency. These findings have significant implications for credit investors, whether they are GSEs, portfolio lenders or investors in credit risk transfer securities.

First, if long-term hurricane trends bear out, mortgage default risk in areas with a higher incidence of major hurricanes will likely rise significantly over time. Secondly, investors in mortgage credit risk from these locations will face higher default losses in the future. At the same time, unless the GSEs Fannie Mae, Freddie Mac and the Federal Housing Administration (FHA) factor such risk into their pricing of credit risk, these agencies would be underpricing hurricane risk effects on default. This could also affect risk-based capital requirements and loan loss reserve estimates for Fannie Mae and Freddie Mac over time. Thirdly, private investors of GSE credit-risk transfer (CRT) securities could experience higher credit losses associated with pools of loans from hurricane-prone areas. Those investors in lower-rated tranches would be particularly impacted given the nature of their exposure to losses earlier than more highly rated tranches. Further use of catastrophe bonds (cat bonds) could be one vehicle to diversify hurricane risks away from specific investors that may be in a better position to assess and hold this risk. A cat bond could be set up as part of a CRT transaction that would transfer hurricane default risk to another

investor such as a reinsurer. Alternatively, a residual tranche specifically allocated to hurricane-related defaults could be added to CRT issues in the future.

THEORETICAL LINKAGES BETWEEN MORTGAGE DEFAULT AND HURRICANE RISK

This study builds upon a large academic literature treating mortgage default in an option-theoretic framework. The contingent-claims literature starting with Black and Scholes (1973) and Merton (1973) serves as the foundation for describing mortgage cash flows.[9,10] Examples of early work to describe mortgage valuation in an option-theoretic framework included Cunningham and Hendershott (1984) and Epperson, Kau, Keenan and Muller (1985).[11,12] Completing the contingent-claim mortgage valuation framework requires consideration of the competing risk nature of the default (put option) and prepayment (call option) options as described in Kau, Keenan, Muller and Epperson (1992).[13] Fundamentally, mortgage value (V_M) can be viewed as comprising three components as described in Equation 1: the value of a risk-free bond (V_{RF}) less the value of two embedded borrower options; the option to default on the mortgage (V_D) and the option to prepay the mortgage (V_{PP}), where ΔH represents changes in home prices that affect property value and hence the borrower's incentive to exercise the default option where unpaid principal balance (UPB) of the loan at the time of default represents the default option strike 'price', Δr represents changes in mortgage rates which affects the borrower's incentive to exercise their prepayment option and Δt reflects changes in time over which the value of all three components change.

$$V_M(\Delta H,\Delta r,\Delta t) = V_{RF}(\Delta H,\Delta r,\Delta t) - V_D(\Delta H,\Delta r,\Delta t) - V_{PP}(\Delta H,\Delta r,\Delta t) \quad (1)$$

The focus of the present analysis is to empirically analyse the effect of hurricane intensity and frequency on the mortgage default component V_D of Equation 1. The classic depiction of a mortgage default option is of a borrower ruthlessly exercising that put option whenever the value of the property falls below the UPB at the time of default. In reality, borrowers are not perfectly efficient in exercising their default option due to a variety of friction costs and other contributing factors or default triggers that can induce a default event. Friction costs include the impact of default on borrower credit and future foregone access and cost of credit opportunities following default. Default trigger events include job loss, reduction in income, divorce, serious medical or other catastrophic life event. Empirically, we are typically unable to observe the actual trigger event that is the catalyst for mortgage default; we can, however, characterise the risk factors into several categories: borrower-specific, product- or loan-specific, property-specific, macroeconomic-specific and external-specific.

In terms of borrower-specific risk factors, mortgage underwriting has been influenced for decades by the 3Cs of underwriting, representing credit, capacity and collateral. The credit factor represents the borrower's willingness to repay the mortgage obligation. Typical proxies for borrower creditworthiness include credit score and/or detailed credit attributes from the borrower's credit report. Capacity represents the borrower's ability to repay the obligation and typical proxies include borrower income or relative measures such as borrower debt-to-income ratios (DTI). Multiple borrowers on the mortgage note tend to reduce default propensity due to income diversification. Finally, collateral measures the borrower's leverage in the property, or alternatively their equity stake. This factor may be captured in various ways including the LTV ratio and with house price volatility, among others. Borrower underwriting takes into account the LTV at origination; as both the loan amount and property value, however, vary over time and especially at the time of default, current LTV (CLTV) is more representative of default over time. Collateral risk factors lie at the heart of the borrower's default option decision as the underlying property value changes relative to the borrower's remaining loan balance. A good example of this interaction was during the financial crisis of 2008 when many residential properties declined significantly below the value of the mortgage balance due to plummeting home values during this time. The

crash in home prices drove many borrower CLTVs above 100 per cent, leaving them effectively 'underwater' on their mortgages and thus incented to default, notwithstanding the friction costs mentioned earlier.

Loan product risk factors may also influence the borrower's incentive to default. Factors such as product type; that is, whether the loan is a fixed-rate amortising mortgage (FRM) or adjustable-rate mortgage (ARM) or has a 30-year or 15- or 20-year term, for example, can affect mortgage default. The variable nature of the ARM product along with potential borrower selection issues can elevate default risk relative to fixed-rate products. Likewise, loans with shorter amortisation periods, despite their higher monthly payments may reflect borrower preferences, financial wherewithal and intentions to pay off the mortgage more quickly. The borrower's note rate, relative to prevailing mortgage rates may provide market signals regarding the borrower's credit risk. For example, if the spread between the prevailing fixed-rate 30-year amortising mortgage rate at the time of origination and the actual 30-year note rate obtained by the borrower is positive, this could be an indication that the borrower carries incrementally higher credit risk that is priced into the mortgage rate. Subprime borrowing rates are an example of how credit risk can be priced into a mortgage rate. Another important risk factor affecting default is loan purpose. There are several reasons why a mortgage is taken out. One reason is the borrower is purchasing a home, another is they are taking advantage of lower mortgage rates on an existing property (hence exercising their prepayment option to refinance the home), or they could be extracting equity from the property for other uses such as a remodelling project or nonresidential purpose (eg taking a vacation). The latter purpose tends to be a riskier proposition than the other two alternatives. Lastly, the channel through which the loan was originated can contribute to credit risk. Loans that are originated through retail branches of the lender tend to have lower default risk than broker- and correspondent loan channels. These nonretail outlets may reflect issues associated with less robust loan manufacturing processes.

Property attributes can also affect mortgage default. Dwellings other than single-family homes such as condominiums, manufactured housing or mobile homes and coop units may influence the default outcome. Likewise, whether the home is a 1-unit or 2–4-unit property can affect default. The occupancy status of the property can affect default. This factor embodies the borrower's psychic attachment to the property as well as an indication of the potential leverage in housing assets a borrower has and the stability of income flows on investment properties. Occupancy status is usually reflected by three categories: primary residence, second home and investor-owned. The latter typically is a riskier outcome followed by second-home properties.

As described earlier, several macroeconomic factors can affect default including changes in home prices, unemployment rates and mortgage rates. Underwriting models do not include these factors in arriving at loan decisions, but they are routinely included in loan pricing and loss measurement modelling where intertemporal changes in default and prepayment are captured in computing discounted mortgage payment cash flows, defaults and prepayments over the life of the loan.

External events such as natural disasters form the last category of risk factors in mortgage default analysis. Specifically, for this analysis, the impact of hurricane events is of primary interest. Over the years, a number of studies have examined the impact of floods and hurricane events on mortgage default, but until now, none have directly measured the impact of hurricane intensity and frequency on mortgage default propensity. The linkage between hurricanes and mortgage delinquency is posited to come about in several ways through key economic relationships that affect the borrower's default option. Hurricanes, depending on their severity, can directly and indirectly affect a borrower's propensity to default on their mortgage. Indirect effects include business interruptions with the potential for job loss, infrastructure damage and other negative effects on an impacted area for some time that could lead to borrowers defaulting on their mortgage.

A direct effect from a hurricane occurs when damages are sustained on a borrower's property from high winds and/or extensive flooding events. In the specific case of Hurricane Harvey, Kousky, Palim and Pan found a statistically significant relationship between property damage and 90-day delinquency

rates.[14] Hurricane damage tends to lower values of affected properties, thus raising the likelihood of default.[15] Notwithstanding the existence of national flood insurance and homeowner hazard insurance policies, high deductibles (eg hurricane events often require higher deductibles) and in some cases undervalued policies may leave homeowners with few options than to default on their mortgage if the costs to rebuild exceed insurance payouts plus any additional resources the borrower may have to put towards rebuilding. A potential mitigant to hurricane damage-induced default could be strengthening building codes in areas where moderate-to-severe flood and wind events from hurricanes are likely to occur. The combination of above and below-ground improvements such as high wind-rated windows and shutters, sealed roofing structures and sump pumps could reduce damage and thus limit direct factors that could trigger a default.

Research findings on the effect of hurricanes on mortgage default, not surprisingly vary given the specific focus of hurricane research. At the individual storm level, for instance, Fannie Mae's assessment of two major hurricane events, Hurricanes Katrina and Sandy, show divergent results. Hurricane Katrina exhibited a clear spike in D180+ delinquency rates in the 6 months afterward that were approximately five times greater than D180+ rates preceding the storm.[5] Fannie Mae reported that weighted average delinquency rates (30 days and greater) were 4.24 per cent in Katrina-affected areas versus 1.99 per cent elsewhere.[5] After Hurricane Sandy, however, Fannie Mae found no such spike in D180+ delinquency rates, although weighted average 30+delinquency rates were higher for affected areas (8.4 per cent) versus those not affected by the hurricane (5.31 per cent). Analysis on Hurricane Florence in 2018 by CoreLogic found mortgage default rates doubled 3 months following the storm.[16]

Hurricane Katrina, the costliest hurricane affecting the United States started as a Category 5 hurricane before weakening to become a Category 3 by the time it made landfall in Louisiana and Mississippi and eventually causing US$125bn in damage.[17] Hurricane Sandy was the second costliest hurricane in US history at US$50bn.[18] It started as a Category 3 hurricane before weakening to a Category 1 when it made landfall along the northeast coast of the United States. Looking at hurricane risk at a macro level, Kahn and Ouazad examined the impact of hurricane events over a 180-year period in the United States and found that a natural disaster would increase the probability of foreclosure by 1.6 per cent taking into account a variety of the risk factors described earlier.[19]

This analysis is unique in that it is the first to examine the intensity and frequency of hurricanes on mortgage delinquency. The reason why this aspect of hurricane event dynamics is critical to understand is that a number of meteorological studies are finding that the strength and frequency of these natural disasters could be on the rise over this century. The Saffir–Simpson Hurricane Wind Scale is a familiar metric for relating wind intensity to damage on a logarithmic scale. Figure 1 provides insight into the relationship between wind speed and potential damage. For instance, when Hurricane Katrina first came ashore in Louisiana as a Category 3 hurricane with sustained winds of 125 mph, the potential damage from those winds was 60 times worse than a Category 1 hurricane with 75 mph winds. The Saffir–Simpson scale thus illustrates the wide divergence in potential hurricane impacts. The scale also does not account for other storm damages such as surge, rainfall and tornadic events that if accounted for would drive the potential damage multipliers higher.

To measure the combined effects of hurricane frequency, intensity and duration, Emanuel (2005) developed the power dissipation index (PDI). PDI is defined according to Equation 2 where V^3 is the cubed maximum sustained wind speed at an altitude of 10 m.[20] Historical trends of hurricanes along two important dimensions of frequency and intensity provides some insight into

$$PDI = \int_0^t V_{Max}^3 \, dt \tag{2}$$

hurricane dynamics. Figure 2 summarises the annual frequency of hurricanes in the United States between 1851 and 2006.[3] The number of hurricanes has risen over time overall and for major hurricanes.

Figure 3 plots the PDI and sea surface temperatures (SST) over time.[4] Consistent with Figure 2, between 1980 and the mid-2000s, the PDI

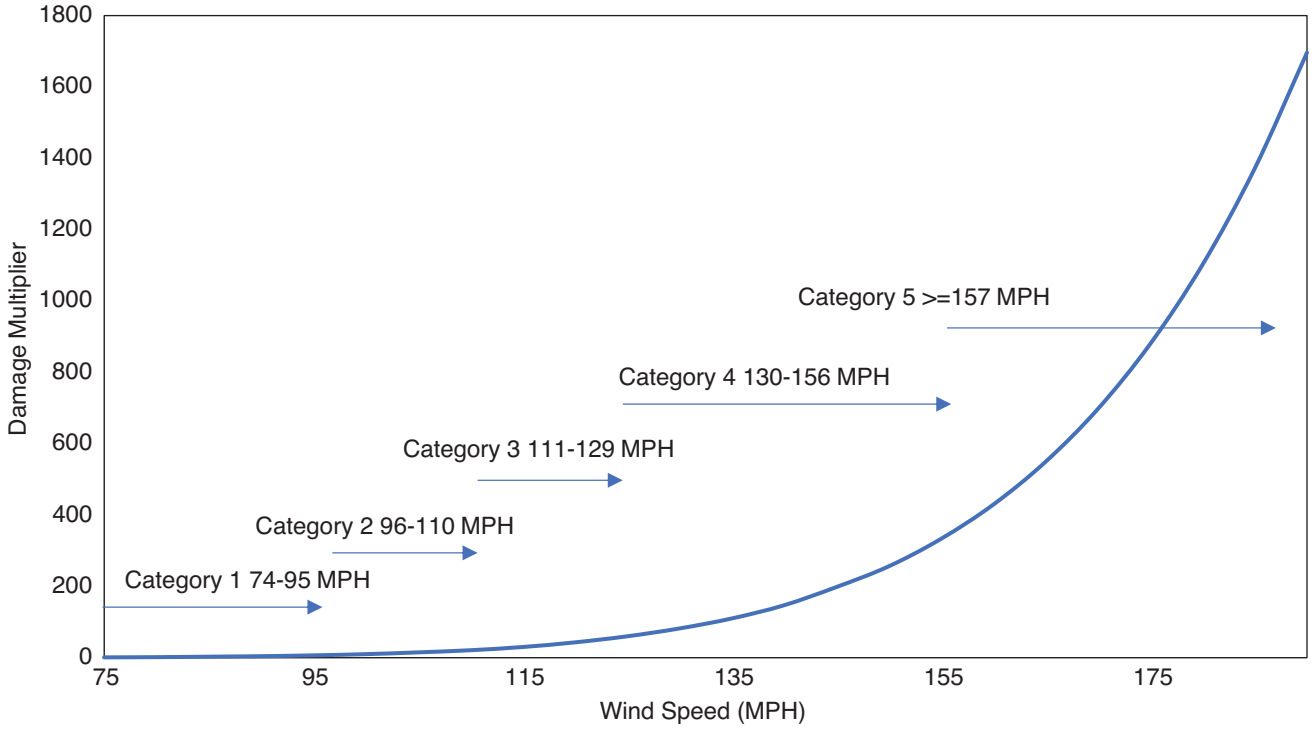

Figure 1: Saffir–Simpson hurricane wind speed and potential damage relationship[21]

of hurricanes rose sharply. Considerable research has been conducted to understand the degree to which anthropogenic causes such as man-made fossil fuel emissions and other sources have resulted in higher sea surface temperatures and their impact on hurricanes. Debate continues among meteorological researchers as to the extent to which climate change from whatever source poses a long-term increase in the frequency and intensity of North Atlantic hurricanes.

Changes in SST over time as a result of man-made activities have been a central focus of much of the research to understand the trajectory of future hurricane risk. Research examining historical correlations between SST and hurricane PDI results in a wide range of potential outcomes over this century in terms of PDI. On an absolute basis, the relationship between SST and PDI for tropical Atlantic hurricanes applied to 24 different hurricane models suggest a 300 per cent increase in hurricane PDI by the year 2100.[22] Alternatively, if SST is measured relative to mean tropical SST rather than to tropical Atlantic SST, the impact on PDI is slight. Other studies tend to support the results of Vecchi et al. that a long-term increase in hurricane PDI would be small.[23, 24] Bender et al., however, found that the number of Category 4 and 5 Atlantic hurricanes could increase 90 per cent over time. Corroborating this result, Knutson et al. reported large percentage increases in Category 4 and 5 hurricanes in the early (45 per cent) and late (39 per cent) part of the 21st century.

MORTGAGE AND HURRICANE DATA STRUCTURE AND SUMMARY

The statistical analysis of mortgage default and hurricane intensity and frequency is based on two datasets. Data on individual mortgage performance is sampled from the Freddie Mac Single-Family Loan-Level Dataset. The data includes details on 27.8 million fixed-rate mortgages purchased by Freddie Mac originated between 1999 and 2020. Monthly performance updates on each loan are

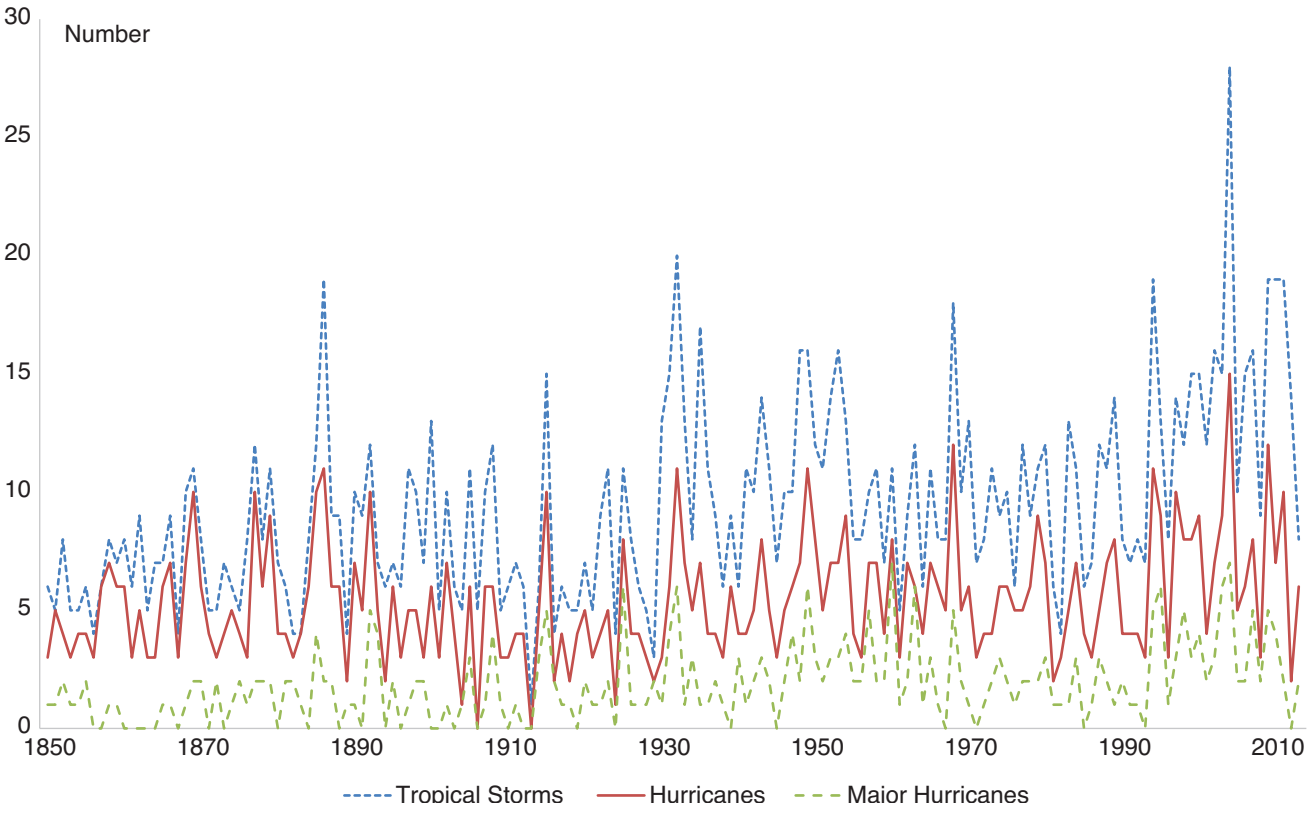

Figure 2: Atlantic basin hurricane counts (1851–2013)

available through December 2020. Key risk factors described earlier are included in the data files such as Fair, Isaac and Company (FICO) score, original and combined LTV, debt-to-income ratio, loan purpose, amortisation, owner-occupancy, first-time homebuyer indicator, number of units, number of borrowers, property type, loan amount (UPB) and origination channel. UPB was transformed into a relative median UPB measure. That is, each loan's UPB was divided by the median UPB of the MSA or state (if identified as a rural property). Relative median UPB is a more accurate reflection of the relative size of each loan in its MSA or state in terms of its relationship with default. The states included in the analysis were Alabama, Connecticut, Florida, Georgia, Louisiana, Massachusetts, Maryland, Maine, Mississippi, North Carolina, New Hampshire, New Jersey, New York, Rhode Island, South Carolina, Texas and Virginia. A random sample of 102,620 loans originated between 1999 and 2015 was taken from the full dataset for properties in Gulf and east coast states impacted by hurricane events during this period according to FEMA records. The definition of delinquency applied in the analysis was any loan that became 90 days past due or more (D90+). For the final sample, the mean D90+ rate was 5.4 per cent. A summary of key attributes of the Freddie Mac data is found in Tables 1–11.

The bivariate results of individual risk factors by D90+ delinquency rate in Tables 2–11 generally conform to the earlier discussion of how borrower, loan and property factors relate to mortgage delinquency risk. Noticeably, key variables such as CLTV, FICO and DTI exhibit a nonlinear relationship to default. For example, D90+ rates for borrowers with FICOs at or below 620 are more than 12 times greater than those with FICO scores over 750. Likewise, borrowers with CLTVs greater than 80 per cent experience D90+ rates that are over

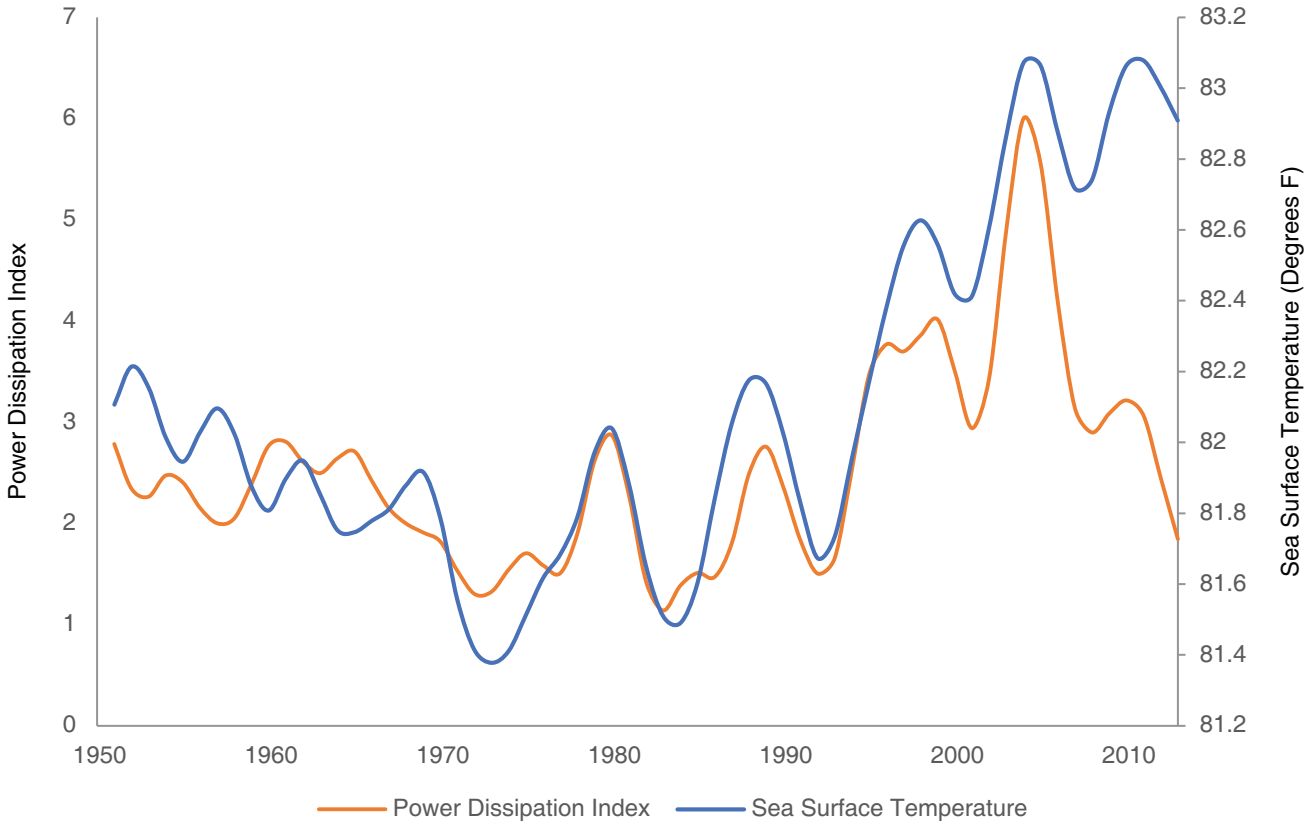

Figure 3: North Atlantic tropical cyclone activity according to the power dissipation index 1951–2013

Table 1: Key risk factor statistics

Attribute	Mean	Standard deviation	Mini-mum	Maximum
FICO	735	55.0	300	850
Current LTV (%)	14	23.7	0	178.1
DTI (%)	34	11.4	1.0	65.0
Relative median UPB	105.0	51.7	7.4	440.6

DTI, Debt-To-Income ratio; FICO, Fair, Isaac and Company score; LTV, Loan to Value; UPB, Unpaid Principal Balance.

Table 2: Occupancy status

Attribute	Number	Percentage of total	D90+ rate (%)
Investor owned	5,580	5.44	5.41
Primary residence	91,161	88.83	5.48
Second home	5,879	5.37	3.67

Table 3: Property type

Attribute	Number	Percentage of total	D90+ rate (%)
Condominium	7,756	7.56	5.48
Co-op	495	.48	3.43
Planned Unit	24,534	23.91	3.44
Manufactured housing	603	.59	14.10
Single family	69,232	67.46	5.98

Table 4: Loan purpose

Attribute	Number	Percentage of total	D90+ rate
Cash-out refinance	25,648	24.99	6.92
Rate and term refinance	29,290	28.54	4.38
Purchase	47,682	46.46	5.14

Table 5: First-time homebuyer

Attribute	Number	Percentage of total	D90+ rate
No	58,654	30.22	3.07
Yes	12,954	57.16	6.54

Table 6: Number of units

Attribute	Number	Percentage of total	D90+ rate
1	100,554	97.99	5.33
2	1,654	1.61	7.01
3	272	.27	8.46
4	140	.14	5.00

Table 7: Origination channel

Attribute	Number	Percentage of total	D90+ Rate
Broker	5,460	5.32	2.73
Correspondent	18,549	18.08	1.76
Retail	46,681	45.49	4.36
Third party originated	31,930	31.11	9.40

Table 8: Number of borrowers

Attribute	Number	Percentage of total	D90+ rate
1	47,246	46.04	7.11
2	55,374	53.96	3.89

Table 9: Credit score

Attribute	Number	Percentage of total	D90+ rate
≤620	3,082	3.00	21.12
620–660	8.403	8.19	15.53
660–700	15,920	15.51	9.17
700–750	27,607	26.90	4.63
>750	47,608	46.39	1.72

Table 10: Current loan to value

Attribute (%)	Number	Percentage of total	D90+ rate
<=50	91,356	89.02	1.18
50–80	9,500	9.26	27.87
80–90	796	.78	91.58
>90	968	.94	94.94

Table 11: Debt to income

Attribute (%)	Number	Percentage of total	D90+ rate
<30	40,941	39.90	3.41
30–40	31,946	31.13	5.48
>40	29,733	28.97	7.94

90 per cent. Of course, these summary results are uncontrolled for other factors that will be examined in more detail in the next section.

The other dataset used in the analysis is the FEMA OpenFEMA Dataset: Declarations Summaries. The data consists of information on each federally declared disaster since 1953. The data includes information on the type of disasters such as a hurricane, the hurricane name, beginning and end date of the event, state and county. In order to merge this data with the Freddie Mac loan level data, several additional steps were taken. First, only hurricane and tropical storm events occurring during the loan origination periods of the Freddie Mac data, that is, 1999–2015 were included. The Saffir–Simpson Hurricane Category for each named hurricane was obtained from National Hurricane Center Tropical Cyclone Reports and the category at the time of the first landfall in the United States was used to designate the initial hurricane strength in the modelling. It is recognised that the strength of each storm could change as it moved inland or over water; however, the initial rating used provides a reasonable benchmark for gauging overall impact relative to other storms and categories during the 1999–2015 period of interest. According to the FEMA data, there were 122 named hurricanes in the Atlantic region that resulted in a disaster declaration. A distribution of storms by category is shown in Table 12. Figures 4 and 5 display the average number of hurricanes and the average hurricane rating experienced for each property by county. The D90+ rates by

average hurricane rating are displayed in Table 13. On an uncontrolled basis, there appears to be some association between hurricane rating and default rates, although that relationship is not monotonic for category 4 or 5 storms. Further analysis is required on a multivariate basis to determine the nature of this relationship in a more robust fashion. Table 14 depicts the relationship between the average number of hurricanes experienced by

Table 13: Sample average hurricane rating by D90+ rate (%)

Category	D90+
0–1	4.24
>1–2	6.92
>2–3	5.43
>3–4	5.30
>4–5	11.10

Table 12: Tropical storm and hurricane sample counts

Storm category	Number in sample data
Tropical storm	54
1	61
2	19
3	25
4	8
5	9

Table 14: Sample average number of hurricanes and D90+ rate (%)

Average number of hurricanes	Number	D90+ rate
0–1	87,091	5.42
>1–2	14,006	4.69
>2–3	1,059	8.12
>3	464	9.27

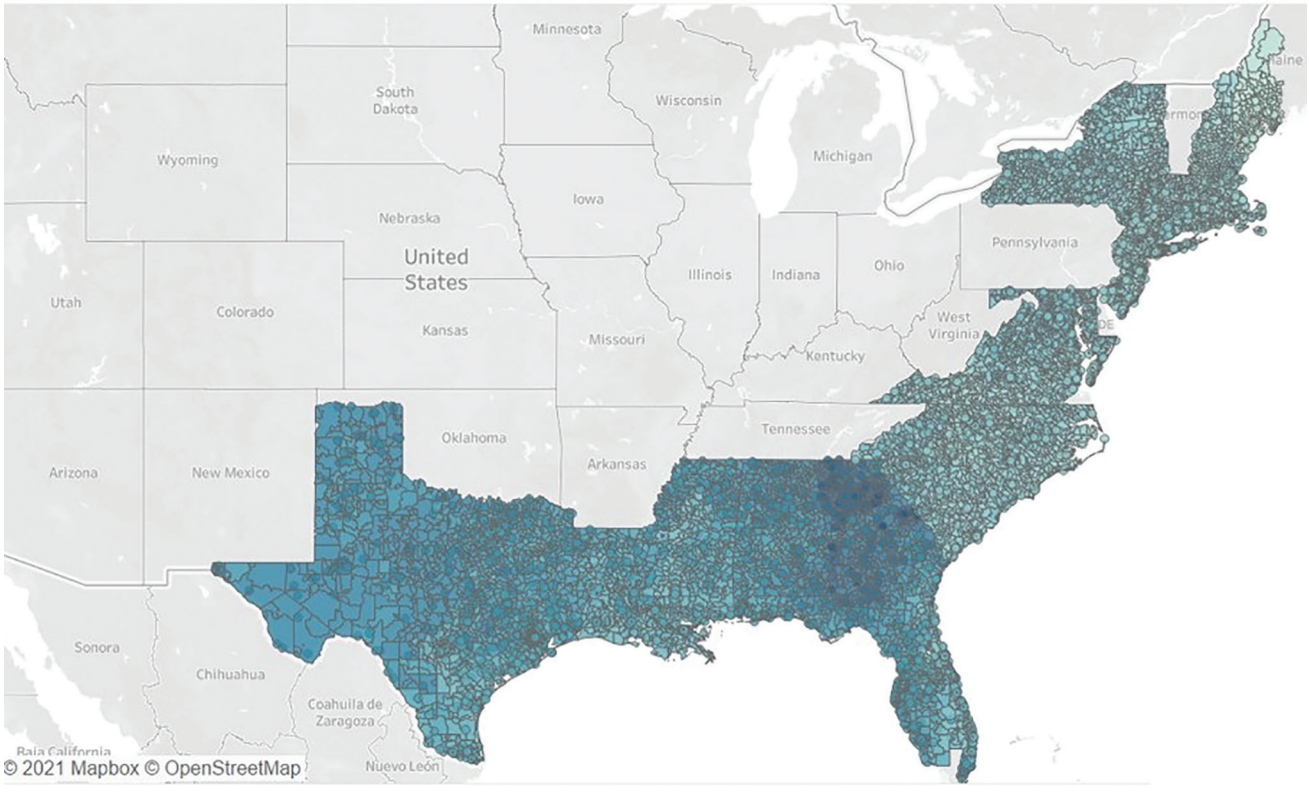

Figure 4: Number of hurricanes of Freddie Mac sample loans originated 1999–2015 by county

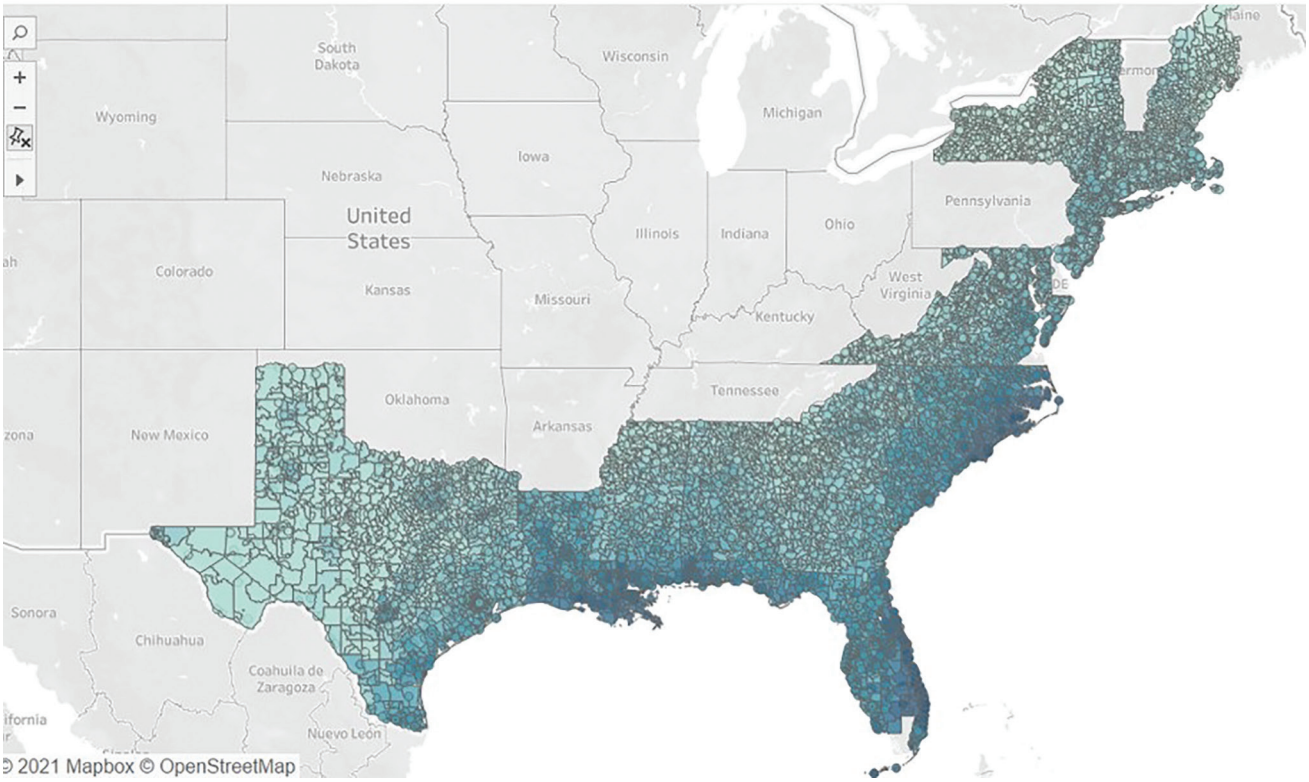

Figure 5: Average hurricane ratings of Freddie Mac sample loans originated 1999–2015 by county

each property in the sample and D90+ rate. The uncontrolled bivariate results show a monotonic increase in both D90+ rates.

METHODOLOGY AND EMPIRICAL APPROACH

To analyse the impact of hurricane intensity and frequency on mortgage delinquency, a standard logistic regression model applied in underwriting borrowers was estimated with the binary choice dependent variable defined as whether a D90+ delinquency event occurred (=1) or not (=0). This ensures the estimated probabilities are confined to the 0–1 domain. Following the theoretical model of mortgage default presented earlier, mortgage default in both models is a function of borrower, product, property and hurricane risk factors. The general form of the regression models is presented in Equations 3 and 4:

$$P_{Default} = \frac{1}{1+e^{-Z}} \tag{3}$$

$$Z = f(\text{FICO, CLTV, LTV, DTI, NUMUNIT, OCC, CHANNEL, PROPTYPE, PURPOSE, NUMBORR, FTHB, HURNUM, HURINT, AGE}) \tag{4}$$

To gain a sense of the relative importance of these candidate variables, a machine learning analysis was performed. Specifically, a form of gradient boosted decision trees (XGBoost) was applied to predict a D90+ event. In that analysis, candidate variables were tested in terms of their importance score which reflects a variable's decision tree split contribution to a metric of performance such as a Gini coefficient. The top ten candidate variables by their feature importance are shown in Table 15. Note that among the top three variables in feature importance are the average number and ratings of hurricanes.

Table 15: Top ten candidate variables feature importance

Candidate variable	F score
Current LTV	6,176
Average number of hurricanes	6,079
Average hurricane rating	5,980
FICO	5,078
Relative median UPB	4,136
DTI	3,972
Number of borrowers	512
Purchase-only mortgage	481
Broker channel originated	454
Correspondent channel originated	390

DTI, Debt-To-Income ratio; FICO, Fair, Isaac and Company score; LTV, Loan to Value; UPB, Unpaid Principal Balance.
Note: The F score reflects the number of times the variable (feature) is split on the analysis.

A description of the candidate variables for analysis is found in Tables 16 and 17. Several transformations of key variables were made prior to modelling. Due to inherent nonlinearities in FICO and credit score, a set of splined variables were created and tested with different knot points. The general form of each spline is shown in Equation 5.

$$\beta_i VAR_i + \sum_{m=1} \beta\left(Max\left(VAR_i - KP_m, 0\right)\right) \quad (5)$$

where VARi is variable i to be splined, and KPm is the mth knot point chosen. For FICO, a set of knot points consistent with industry practice were tested at 620, 660, 700, 720 and 750. For CLTV, candidate knot points tested included 50 per cent, 80 per cent, 85 per cent, 90 per cent and 95 per cent. Final estimates for the number of splines and knot point settings were based on the statistical significance of each spline and contribution to model performance.

Table 16: Candidate variable description

Risk Factor	Variable Name	Definition	Type
Borrower	FICO	Credit score	Continuous
	CLTV	Current LTV	Continuous
	DTI	Debt-to-income ratio	Continuous
	OCC	Occupancy type	Categorical
	NUMBORR	Number of borrowers	Categorical
	FTHB	First-time homebuyer	Categorical
Property			
	NUMUNIT	Number of property units	Categorical
	PROPTYPE	Property type	Categorical
Product/Channel			
	PURPOSE	Loan purpose	Categorical
	RUPB	Relative median UPB	Continuous
	CHANNEL	Origination channel	Categorical
Hurricane			
	HURNUM	Average number of hurricanes	Categorical
	HURINT	Average hurricane rating	Categorical

LTV, Loan To Value; UPB, Unpaid Principal Balance.

Table 17: Categorical variable description

Variable name	Category name	Description
OCC	Primary	Primary residence
	Investor	Investor owned
	Second home	Second or vacation home
NUMBORR	1	1 borrower
	2+	2 or more borrowers
FTHB	1	First-time homebuyer
	0	Non-FTHB
NUMUNIT	1	1 unit property
	2–4	2–4-unit property
PROPTYPE	SF	Single family
	PUD	Planned unit development
	Condo/Coop	Condominium or Coop
PURPOSE	Purchase	Purchase-only mortgage
	Cash-out	Cash-out refinance mortgage
	R&T	Rate and term refinance
CHANNEL	R	Retail originated
	B	Broker originated
	C	Correspondent originated
	TPO	Third party originated
HURINT	1	Loan's average hurricane rating <3
	0	Loan's average hurricane rating ≥3–5

A variable, AGE, was included to control for the number of months after origination for each loan. AGE, along with the intercept term, is not reported among the estimated coefficients in Table 18 for ease of exposition but is available from the author upon request.

The average of the Saffir–Simpson hurricane category of all hurricanes generating a FEMA disaster declaration experienced during the life of each loan in the county where a loan's property was located was used to measure the impact of hurricane intensity on delinquency.

Table 18: D90+ logistic regression results

	Coefficient	Standard error
FICO*	–.0087	.000018
FICO660*	–.0068	.000583
CLTV*	.0873	.00103
CLTV80*	.0515	.0132
CLTV95**	2.7719	1.1933
DTI**	.0064	.00269
DTI43*	.0312	.00722
NUMUNIT2+**	.4159	.1289
PUD*	–.6584	.0564
Cash-out*	.5172	.0468
Channel B or C*	.9307	.0610
Channel TPO*	.9923	.0482
NUMBORR2*	–.4633	.0425
HURINT*	.6335	.0436
KS	.52	
AUC	.83	

Note: Parameters designated * or ** are statistically significant at the 1 per cent and >1 to 10 per cent levels, respectively.

RESULTS

The results from the final set of estimations for the D90+ model are presented in Table 18. To compare alternative specifications when determining the 'best' D90+ model, the Kolmogorov–Smirnov (KS) test and the area under the curve (AOC) were used as model performance criteria. A separate holdout sample of 100,000 Freddie Mac loans not used in estimating the model over the same origination period was used to generate the KS and AUC statistics. Specific attention is paid to these measures used to assess the model's discriminatory power between default and nondefault loans. On this basis, the splined effects for FICO and CLTV resulted in a single knot point for FICO at 660 along with two knot points; 80 per cent and 95 per cent for CLTV and a single knot point at 43 per cent for DTI. Some candidate variables such as relative median UPB and first-time homebuyer were not statistically

significant and thus were removed from the models. In the final specifications, all estimated coefficients carry the expected signs and are all are statistically significant at the 10 per cent level or lower. The majority of parameters were significant at the 1 per cent level. The model performance statistics are robust as shown in Table 18.

To understand the relative impact of the categorical variables, most notably the hurricane intensity effect, odds ratios were computed and shown in Table 19 along with the reference category for each variable. For example, holding all else constant, the odds ratio for cash-out refinance loans indicates that the incidence of default is 1.68 times that of a purchase-only loan. The other categorical variables have comparable interpretations relative to the reference category indicated in Table 19. Of interest, among these effects is the hurricane intensity variable. The results indicate that controlling for all other factors, delinquency risk is 1.88 times higher for loans experiencing an average hurricane rating 3 and greater than loans experiencing an average rating lower than 3. This result is consistent with the historical meteorological data showing that hurricanes rated 3–5 are associated with greater wind and flooding damage.

These findings have important implications for mortgage investors now and in the future. If the meteorological research cited earlier bears out that the frequency of major storms rated 3–5 would increase over the next century, the analysis just presented suggests that mortgage delinquency rates in hurricane-affected areas of the country would rise considerably from where they are today. To better understand the sensitivity of mortgage delinquency rates under various assumptions on hurricane frequency and intensity, the estimated model was run to generate predicted delinquency rates for each loan in the sample. The loans were reweighted in the sample reflecting different proportions of borrowers with average hurricane ratings of 3 or greater to reflect the range of potential changes in frequency of major hurricanes from long-range hurricane projections described earlier. The results from this sensitivity analysis are presented in Table 20. In one test, the proportion of borrowers in the sample experiencing an average hurricane rating of 3 and greater was raised 10–100 per cent in the increments shown in Table 20 while reducing the proportion of other borrowers accordingly. The increments provide a reasonable range of long-term hurricane intensity outcomes that are consistent with those reported by Bender et al. and Knutson et.al.[23,24]

The results suggest that increasing the proportion of borrowers experiencing major hurricanes and more hurricanes overall has a moderate effect on raising delinquency rates. For example, if the proportion of borrowers experiencing major hurricanes and more hurricanes in general doubled, that would raise the D90+ rate more than 17 per cent above baseline rates (ie sample D90+ rates). These results reflect the fact that the size of the borrower cohorts with average ratings at or above 3 are relatively small (6.8 per cent of the sample). In other words, the incremental effects of more severe hurricanes may

Table 19: Categorical variable odds ratios

Variable	Odds ratio	Reference group
NUMUNIT	1.52	1 unit
PUD	.52	Single family
Cash-out	1.68	Purchase only
Channel B or C	2.54	Retail
Channel TPO	2.70	Retail
NUMBORR2	.63	1 borrower
HURINT	1.88	Average hurricane rating <3

Note: *Odds Ratio* = e^{β}

Table 20: Sensitivity of D90+ rates to increased hurricane intensity and frequency

Percentage increase in intensity	Average D90+ rate (%)	Percentage change from baseline	Basis points change from baseline
Baseline	5.14		
10	5.23	1.75	9
25	5.37	4.36	23
50	5.59	8.72	45
75	5.81	13.08	67
100	6.04	17.44	90

be substantial as shown in Table 20 but are muted to some degree by the larger proportion of borrowers experiencing less severe hurricanes.

CONCLUSIONS AND IMPLICATIONS

The results from this analysis have several implications for borrowers and investors in mortgage credit risk. First, if hurricane frequency and intensity for major Atlantic hurricanes rise over the next decades as some meteorological research suggests, more borrowers will be affected, and the resulting wind and flood damage on communities, businesses and residential properties appears likely to lead to much higher delinquency rates in the future. This potential increase in delinquency rates from hurricane events could leave investors in mortgage credit risk exposed unless that risk is appropriately priced into guarantee fees in the case of the GSEs or tranche pricing of CRT transactions.

More intense and frequent hurricanes could likewise reduce market liquidity in CRT transactions if private investors are not able to assess the impact of hurricane risk in these transactions. There is some evidence that hurricane events in recent years have exposed the CRT market to some volatility. The CRT market was temporarily roiled starting after Hurricane Harvey in August 2017 and Hurricane Irma in September 2017 as yields on subordinate (B1) CRT tranches widened by 125 bps over a 5-week period.[25] Consistent with this result, Gete, Tsouderou and Wachter found significant increases in spreads on junior CRT tranches associated with loans affected by Hurricanes Irma and Harvey.[26] By contrast, spreads on mezzanine tranches appeared unaffected by these events as indicated in Figure 6 and was also confirmed in the Gete et al. analysis. Nonetheless, the apparent transitory effect on subordinate tranche spreads could become more pronounced if long-term hurricane forecasts prove out over time.

These back-to-back major hurricanes nevertheless caught investors off-guard and eventually led the Association of Mortgage Investors (AMI) to request

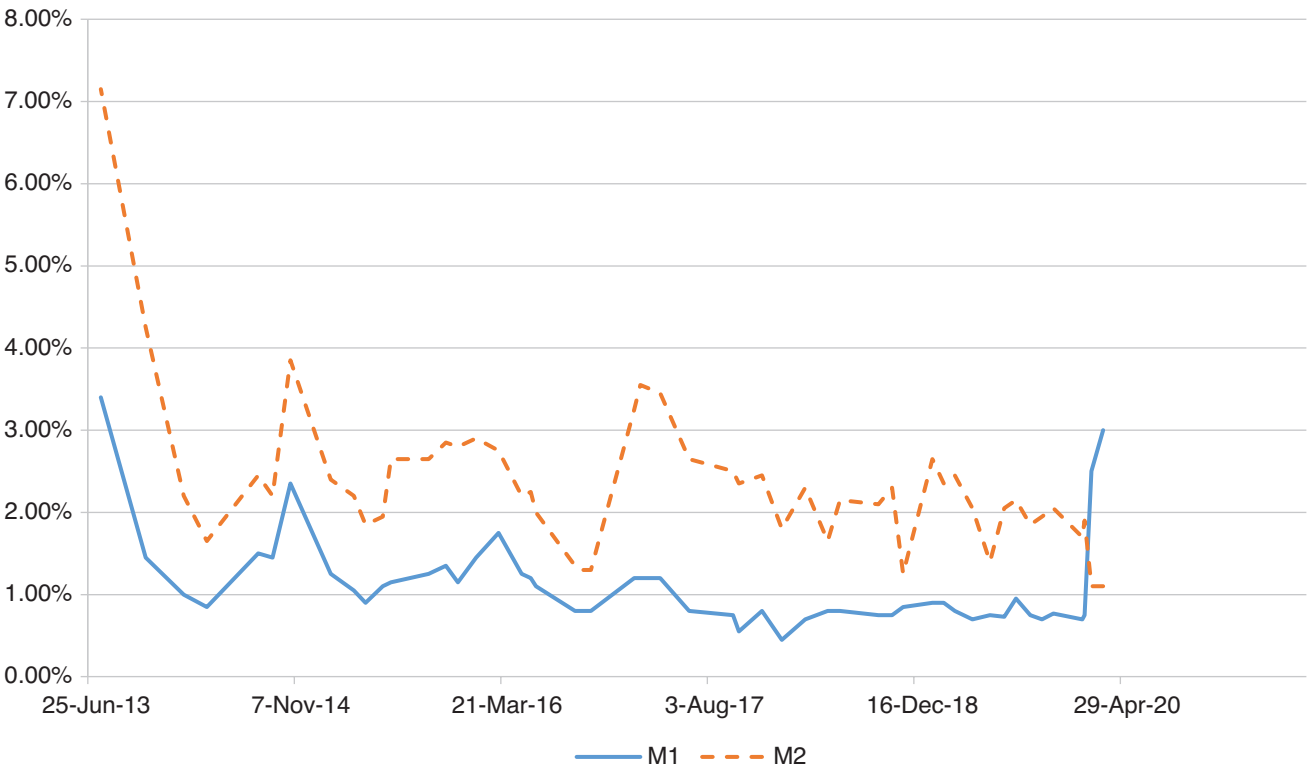

Figure 6: Spreads for M1 and M2 Freddie Mac STACR CRT transactions[27]

that Fannie Mae and Fannie Mae exclude such loans from CRT pools as they contended that catastrophic risk from natural disasters is a risk that investors do not know how to effectively analyse or price. The GSEs have taken steps since then to moderate the effect of hurricanes in CRT transactions by such actions as no longer counting loans in forbearance as a credit event; an alternative strategy in the future, however, might be to create a separate 'clean-up' or residual tranche in individual or multiple CRT transactions that provides cat risk protection to CRT tranche investors for hurricane risk. While removing loans from CRT deals by the GSEs is a viable alternative to addressing investors' concerns about absorbing cat risk in CRT transactions, it may not be a satisfactory outcome unless the GSEs obtain some form of reinsurance of the cat risk they hold. The GSEs are not a natural entity to price or take on natural disaster risk and so should hurricane risk rise in the future, finding alternatives to transfer cat risk from the GSEs to other investors could remedy this exposure the GSEs have retained. As CRT transactions have attracted reinsurance companies as investors over the years, a cat risk carve-out structure in CRT deals involving reinsurers could be possible.

The future risk to the mortgage market from hurricane risk appears to be on the upswing according to the consensus of scientific research on hurricane intensity and frequency. Prospective homeowners when shopping for a new home should become more informed on where their property is located in terms of flood and hurricane risk before deciding where to buy. Traditional investors in mortgage credit such as the GSEs and private mortgage insurance companies are not well equipped to assess and price for cat risk, particularly if that risk is rising over time. Instead, alternative financial structures such as cat risk tranches of CRT deals may be a more appropriate way of distributing this risk in the future.

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