



Who Owns Climate Risk in the U.S. Real Estate Market?

Jamie Woodwell, Mike Fratantoni, and Edward Seiler
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AUTHORS

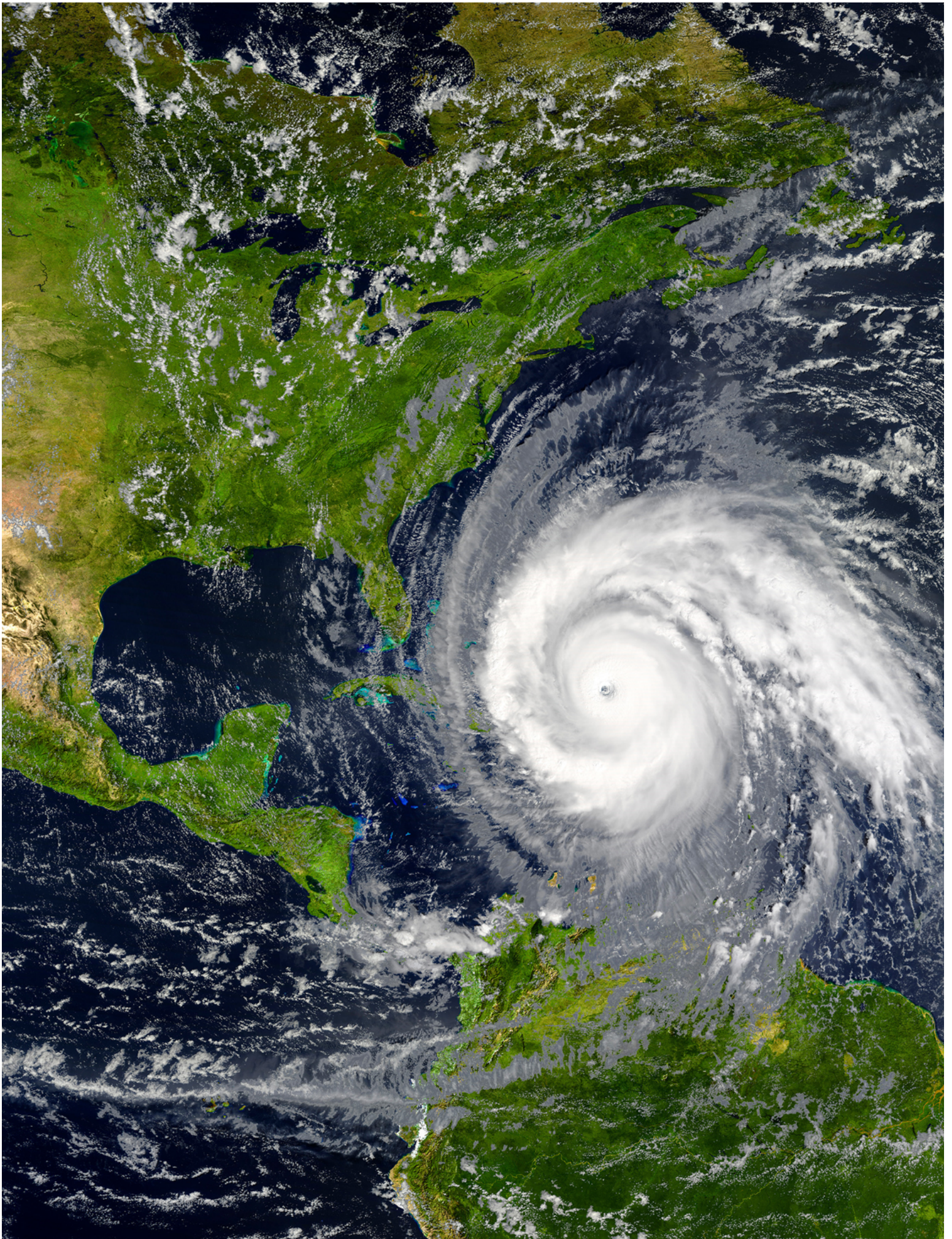
Jamie Woodwell, jwoodwell@mba.org, 1919 M St, NW, 5th Floor, Washington, DC 20036.

Mike Fratantoni, mfratantoni@mba.org, 1919 M St, NW, 5th Floor, Washington, DC 20036.

Edward Seiler, eseiler@mba.org, 1919 M St, NW, 5th Floor, Washington, DC 20036.

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Abstract

Physical, economic, and social changes associated with a changing climate will directly affect the \$50 trillion single-family residential real estate and \$25 trillion commercial real estate markets in the United States. Because real estate owners and other real estate market participants keenly focus on the identification, assessment, mitigation, underwriting, insurance, and pricing of risk, they create a unique case study for understanding the ways in which climate-related risks are likely to impact individual actors and the market ecosystem as a whole. The real estate market also provides key insights into where regulators will need to pay increased attention — to identify changes in the composition or concentration of risk in existing risk structures, and in relationships that are already undertaking risk management associated with climate change. Modeling the “ownership” of risks illuminates under which circumstances homeowners, insurance providers, lenders, investors, and others do and do not take on physical, transition and other risks, and the level of risk “owned” by each. We find that owners bear the burden of paying for the risks, in some circumstances through explicit or implicit insurance, but that the ways in which responsibility for climate risk is distributed among the various market players is heavily dependent on whether the property owner does or does not have a mortgage in place and whether that mortgage is held in a lender’s portfolio or sold into the secondary market. The results have broad implications for where risk management and regulation can have the most significant impacts.

Introduction — The Changing Climate and Its Impacts on the Financial System

Beckett (2021) starts his Research Institute for Housing America (RIHA) report on climate change with a simple, albeit loaded, five-word sentence: “The Earth’s climate is changing.”¹ Indeed, the concentration of greenhouse gases in the atmosphere has increased by about 55 percent since the preindustrial era, and consequently, the Earth’s temperature has increased by around one degree Celsius over the last hundred years. Beckett continues to write that while we know that the changing climate will affect housing and the housing finance industry, there are many unknowns. For example, the precise links between global warming and specific extreme events are open to debate, as is the future path of global warming and its impacts on the U.S. financial system. In other words, the risks that homeowners, insurers, mortgage industry participants, investors, and regulators (among other players) will need to recognize and navigate as the climate changes remain uncertain.

To illustrate the uncertainty regarding the future path of global warming, the Intergovernmental Panel on Climate Change’s (IPCC) Fifth Assessment Report (AR5), that includes an accessible summary for policymakers, does not contain a single future climate change projection, but considers temperature change and sea level rise projections for four alternative pathway scenarios, labeled as Representative Concentration Pathways (RCPs).² The RCPs, which describe four different 21st century pathways for greenhouse gas emissions and atmospheric concentrations, air pollutant emissions and land use, are summarized in Table 1.

However, the reality is even more involved than the table implies, as these four divergent paths are not definitive. Koonin (2021)³ points to the complexities of how humans will influence the ongoing changes (through a host of actions that can be taken by governments, firms, and individuals), and in turn, the ambiguities of how the climate will respond to the human (and natural) influences. This means that there are not only four scenarios that we need to navigate, but a bewildering choice of pathways that we may face in the coming years.⁴

1 Beckett, Sean. 2021. “The Impact of Climate Change on Housing and Housing Finance,” Special Report, [Research Institute for Housing America](#).

2 Intergovernmental Panel on Climate Change’s (IPCC) Fifth Assessment Report (AR5). 2015. “Summary for Policymakers.” (Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_SPM.pdf).

3 Koonin, Steven. 2021. “Unsettled: What Climate Science Tells Us, What it Doesn’t, and Why it Matters,” BenBella Press.

4 A further illustration of the evolving nature of the IPCC’s projections can be seen in the August 2021 “Climate Change 2021: The Physical Science Basis” that is the first in a series of reports that will lead to the AR6 report in September 2022. The August 2021 report shows that the pace of climate change has exceeded previous expectations and that the changes over the upcoming decades will probably be greater than those projected in AR5.

TABLE 1: CLIMATE CHANGE RELATIVE TO THE 1986–2005 PERIOD

SCENARIO	REPRESENTATIVE CONCENTRATION PATHWAY (RCP)	TEMPERATURE CHANGE		SEA LEVEL RISE	
		2046–2065	2081–2100	2046–2065	2081–2100
High GHG Emissions	RCP8.5	2.0	3.7	0.30	0.63
Intermediate Scenario	RCP6.0	1.3	2.2	0.25	0.48
Intermediate Scenario	RCP4.5	1.4	1.8	0.26	0.47
Stringent Mitigation Scenario	RCP2.6	1.0	1.0	0.24	0.40

Notes: Table replicated from Beckett (2021). Global mean surface temperature change in degrees Celsius; global mean sea level rise in meters.

Furthermore, the complexity does not end with human influence and the climate’s response — we also need to take into account how the climate’s response will impact ecosystems and societies.⁵

That is, there are multiple complex layers of uncertainty that need to be considered in order to understand how changing climate may affect the U.S. financial system, and more specifically, the ways in which complex climate-related risks are likely to be absorbed (or not) by participants in the real estate and mortgage finance ecosystem.

The climate-related risks facing the U.S. financial system are discussed in an influential (and stark) 2020 report from the Commodity Futures Trading Commission (CFTC).⁶ This report also recognizes that the emerging risks we face are complex in nature, and it further argues that they may well induce disruption of the proper functioning of financial markets that may, in turn, provoke disruptions in economic activity.

While our understanding about how different types of climate risk could interact remains in an incipient stage, there is a growing view that we should act despite this uncertainty. For example, in a February 2021 speech, Federal Reserve Governor Lael Brainard cautioned that “Climate change and the transition to a low-carbon economy create both risks and opportunities for the financial sector,” and that “robust risk management, scenario analysis, and forward planning can help ensure financial institutions are resilient to climate-related risks and well-positioned to support the transition to a more sustainable economy.”⁷



5 The above narrative reflects Koonin’s three core questions of climate science: How have humans influenced the climate, how the climate will respond, and how the climate’s response will impact ecosystems and societies. He notes that “since the answer to each question depends upon the answer to the one before it, we can expect that the answers to the final — and perhaps the most significant — question will be the most uncertain.”

6 Climate-Related Market Risk Subcommittee. 2020. “Managing Climate Risk in the U.S. Financial System.” U.S. Commodity Futures Trading Commission, Market Risk Advisory Committee.

7 Brainard, Lael. 2021. “The Role of Financial Institutions in Tackling the Challenges of Climate Change,” Board of Governors of the Federal Reserve System. Available at: <https://www.federalreserve.gov/newsevents/speech/brainard20210218a.htm>.



This message is also evident in the CFTC report that urges U.S. financial regulators to “move urgently and decisively to measure, understand, and address these risks.”⁸ The CFTC report argues that policy and regulatory choices should be flexible, open-ended, and adaptable to new information about climate change and its risks, based on close and iterative dialogue with the private sector, and it encourages the private sector to be proactive and invest in innovations that can help the U.S. economy better manage climate risk and channel more capital into technologies essential for the transition.

In this paper we examine where regulators of the mortgage finance system will need to pay increased attention to identify changes in the composition or concentration of climate-related risk. Despite the uncertainty of how climate risk may

evolve—especially at a granular geographic level⁹ — we believe that existing risk management practices, structures, and relationships are already capturing potential risks from climate change, and that by better understanding the distribution of climate risks to different actors in the market, regulators — and the players themselves — will be better able to react appropriately.¹⁰

In the next section we expand on the risks facing the housing and mortgage finance system and discuss who the stakeholders are. We then delve deeper into the ownership of the risks and how mortgage markets distribute the risk among the stakeholders.

⁸ Indeed, regulators are moving forward, as demonstrated by the Office of the Comptroller of the Currency’s (OCC) 2021 “Principles for Climate-Related Financial Risk Management for Large Banks,” and the Federal Housing Finance Agency’s (FHFA) January 2021 request for input on climate and natural disaster risk management at the regulated entities. The Mortgage Bankers Association’s (MBA) response to FHFA provides a framework for moving forward on many of the main issues. See: “MBA Response to FHFA’s Climate and Natural Disaster Risk Management RFI,” April 2021, at [MBA Letters and Testimony](#).

⁹ The uncertainty at more granular geographic levels leads to the question of whether climate related risks can be diversified across locations. At a global level, selected older climate models (published between 1970 and 2007) were able to project future global mean surface temperature that were relatively consistent with observations (see: Hausfather, Z., Drake, H. F., Abbott, T., & Schmidt, G. A. 2020. “Evaluating the performance of past climate model projections,” *Geophysical Research Letters*, 47. <https://doi.org/10.1029/2019GL085378>). However, as described above, when it comes to the real estate adage of “location, location, location,” uncertainty abounds.

¹⁰ This is summarized in MBA’s April 2021 response to FHFA’s RFI: “In MBA’s view, managing climate risk may require FHFA to further focus supervision on the regulated entities’ risk management capabilities, although the overall process of such supervision may not necessarily change.”

Building a Climate Risk Framework for the Housing and Mortgage Markets

The frequency and scope of natural disasters impacting owners of real estate, insurance providers, lenders and servicers, the Government Sponsored Enterprises (GSEs), investors, as well as other participants in the mortgage finance system have increased in recent decades. Moreover, the trend in these acute climate-related events is predicted to continue.¹¹

Beyond these acute event-driven risks (comprising, among other events, hurricanes, wildfires, floods, and heatwaves), longer-term chronic shifts in climate patterns — including higher average temperatures, sea level rise, changes in precipitation patterns and ocean acidification — are also predicted to pose net risks to the housing system. While warmer temperatures may be beneficial for real estate values in some geographies, the higher volatility and increased natural disaster risk are likely to offset any benefits. In a June 2017 report, the Financial Stability Board’s Task Force on Climate-related Financial Disclosures (TCFD) included the acute event-driven and the chronic risks in a broad “physical risk” category.¹² The TCFD also defines the more-novel “transition risk” of moving to a lower-carbon economy and the multitude of associated risks involved.¹³

For physical risks TCFD states,

“Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for organizations, such as direct damage to assets and indirect impacts from supply chain disruption. Organizations’ financial performance may also be affected

by changes in water availability, sourcing, and quality; food security; and extreme temperature changes affecting organizations’ premises, operations, supply chain, transport needs, and employee safety.”¹⁴

Regarding transition risks, TCFD notes,

“Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organizations.”¹⁵

From a real estate perspective, one might consider physical risks to be those which cause physical damage to a property or changes physical conditions in such a way that a property’s economic viability is diminished. Think of wind damage, wildfire, flooding, drought, or other such changes. Transition risk is best thought of as changes caused by climate-change that don’t physically affect the property but do change the condi-

¹¹ See MBA’s April 2021 response to FHFA’s RFI.

¹² Financial Stability Board. 2017. “Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures.” Available at: <https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf>.

¹³ We will delve into these risks in the next section.

¹⁴ <https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf>

¹⁵ <https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf>

TABLE 2: CLIMATE RISK AND SELECTED REGULATORY RISK FRAMEWORKS

CLIMATE RISKS ^a		FHFA RISK FRAMEWORK ^b	OCC FRAMEWORK ^c	DIRECT HOUSING-RELATED CLIMATE RISK	
Physical	Transition	Credit Risk	Credit Risk	Physical	Transition
		Operational Risk	Operational Risk	Physical	Transition
		Market Risk	Other Financial Risk		Transition
		Business Risk			
		Liquidity Risk	Liquidity Risk		
			Legal/Compliance Risk		
			Other Nonfinancial Risk		

a. <https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf>

b. <https://www.law.cornell.edu/cfr/text/12/1239.11>

c. <https://www.occ.treas.gov/news-issuances/news-releases/2021/nr-occ-2021-138.html>

tions in which the property operates. Think here of changes in insurance costs or availability, tax rates, land use restrictions, building code requirements, and associated property value declines.

In their recent request for feedback on principles for climate-related financial risk management for large banks, the OCC laid out its proposed risk assessment principals across a broad framework that includes:

- **Credit Risk:** “Effective credit risk management practices could include monitoring climate-related credit risks through sectoral, geographic, and single-name concentration analyses, including credit risk concentrations stemming from physical and transition risks.”
- **Liquidity Risk:** “[T]he board and management should assess whether climate-related financial risks could affect liquidity buffers and, if so, incorporate those risks into their liquidity risk management and liquidity buffers.”
- **Other Financial Risk:** “Management should monitor interest rate risk and other model inputs for greater volatility or less predictability due to climate-related financial risks. Where appropriate, management should include corresponding measures of conservatism in their risk measurements and controls. The board and management should monitor how climate-related financial risks affect the bank’s exposure to risk related to changing prices.”

- **Operational Risk:** “The board and management should consider how climate-related financial risk exposures may adversely impact a bank’s operations, control environment, and operational resilience.”
- **Legal/Compliance Risk:** “The board and management should consider how climate-related financial risks and risk mitigation measures affect the legal and regulatory landscape in which the bank operates.”
- **Other Non-financial Risk:** “Consistent with sound oversight, the board and management should monitor how the execution of strategic decisions and the operating environment affect the bank’s financial condition and operational resilience as discussed in the strategic planning section.”¹⁶

This framework is similar to, but slightly different than, the more mortgage-centric model put forth by the Federal Housing Finance Agency (FHFA) in their oversight of the Government Sponsored Enterprises. In defining risk management for the Enterprises, FHFA focuses on:

- Credit Risk
- Market Risk
- Liquidity Risk
- Business Risk and
- Operational Risk¹⁷

¹⁶ <https://www.occ.treas.gov/news-issuances/news-releases/2021/nr-occ-2021-138a.pdf>

¹⁷ <https://www.law.cornell.edu/cfr/text/12/1239.11>



For the purposes of our analysis, we focus on the first-order climate-related risks to the housing and mortgage market — credit, operational and market risk — and address each through the physical- and transition-risks that climate may bring (Table 2). We leave aside the second-order business, liquidity, legal/compliance, and other nonfinancial risks that may be affected by those first-order risks. It is not that we do not consider these important considerations for regulators. Rather they are only indirectly affected by the risks adopted through exposure to the housing market.

Note that in this analysis we are using the risk framework terms from the perspective of the financial institution, in particular a mortgage lender/servicer. For example, if a property loses value as a result of climate-related changes, that may be seen by the property owner as a market risk but would be seen by the financial institution as credit risk. If a set of mortgage

assets or securities lose value because of investors’ general concerns about climate-risk, that would be considered market risk for the asset holder.

Examples of different climate-related risks for the real estate market and the financial-framework categories into which they fall can be seen in Table 3.

From a real estate perspective, some chronic physical risks may be better thought of as transition risks. For example, the decline in value of a property because of changes in the availability of water might, in some contexts, be viewed as a form of physical risk, because it is the result of physical environmental changes, even though the property itself was not physically damaged and any financial risk to the property stems from a social/economic transition of demand away from that property/area.

TABLE 3: REAL ESTATE MARKET RISKS BY RISK CATEGORY

	CREDIT	OPERATIONAL	MARKET
Physical	<ul style="list-style-type: none"> • Wind damage • Wildfire damage • Flood damage 	<ul style="list-style-type: none"> • Servicing operations are halted by flooding • Insurance coverage lapses lead to losses 	<ul style="list-style-type: none"> • N.A.
Transition	<ul style="list-style-type: none"> • Increased insurance costs • Loss of insurance coverage • Increasing property taxes • Change in building codes • Loss of property value 	<ul style="list-style-type: none"> • Increased insurance monitoring raises costs and risks 	<ul style="list-style-type: none"> • Mortgage assets lose value due to rising investor general concerns about climate change



Application of Existing Risk Management Regime to Climate Change-Related Risks

To better understand the potential impacts of climate change on risks to different actors in the \$75 trillion real estate markets, and to serve as a framework for understanding how climate change may affect property owners, insurance providers, portfolio lenders/servicers, securitizers and other players, we consider the exposure to different climate-related risks among different market participants.

The distribution of risk is heavily dependent on whether and to what degree a property (or group of properties) is insured and mortgaged and the degree to which mortgages are or are not included in a GSE, FHA or private label securitization structure. The mortgage market serves as a de facto insurance coverage for climate-related transition risk.

WHO OWNS RISK

To model the distribution of climate risk, we divide the U.S. real estate market into four groups:

A. Properties without a mortgage

- A1. Without insurance
- A2. With Insurance

B. Properties with a mortgage

- B1. Held in portfolio
- B2. Securitized by GSEs, FHA or Private Label MBS

Each category distributes the physical and transition risks of climate change — and therefore climate change's impact on



CHART 1. CLIMATE RISK OWNERSHIP

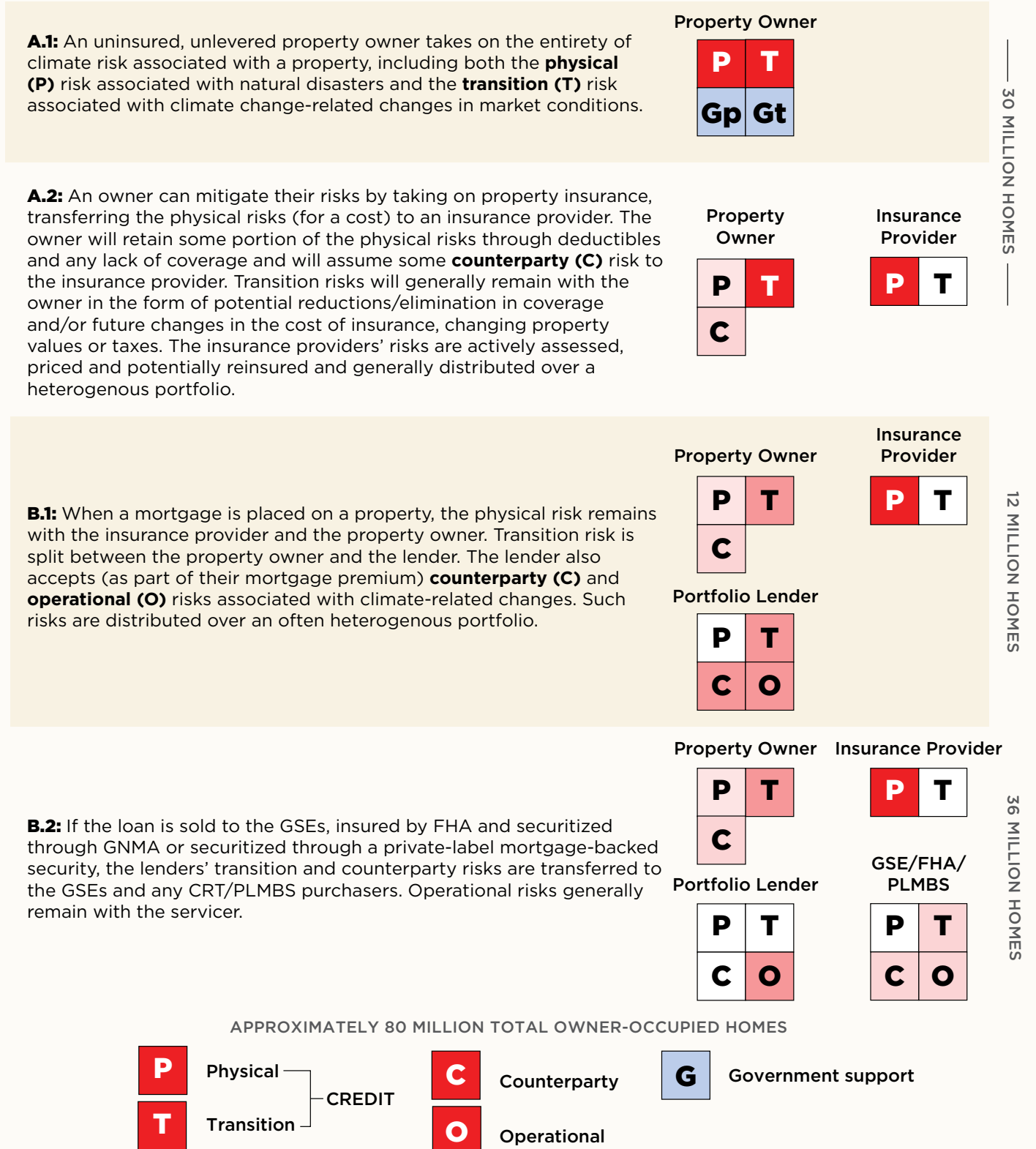


TABLE 4, PANEL 1: WHICH MARKET PARTICIPANTS ASSUME RISK FOR WHICH CLIMATE-RELATED RISKS? PROPERTY OWNED FREE-AND-CLEAR WITHOUT INSURANCE

	PHYSICAL RISK	TRANSITION RISK	COUNTERPARTY RISK	OPERATIONAL RISK
a. Property Owner	P(1:V)	T(1:V)	0	0
b. Insurance Provider	0	0	0	0
c. Mortgage Lender/Servicer	0	0	0	0
d. GSE/FHA/PLMBS Market	0	0	0	0

Note: The costs of Physical risks (P) and Transition risks (T) are reduced across all players to the degree governments provide grants, loans and/or other relief.

credit, counterparty, and operational risks at financial institutions — to different players in different amounts. These are demonstrated in Chart 1.

A. Properties without a mortgage

Out of some 80 million owner-occupied properties in the United States, 30 million are owned free-and-clear, without a mortgage.¹⁸ Without the requirements with respect to insurance coverage that a mortgage typically brings, it is up to the owners of these homes to decide whether or not to purchase protection. “Insurance” can include typical homeowner’s coverage as well as insurance for flood (either through the National Flood Insurance Program (NFIP) or private providers), wind, earthquake, wildfire and more. If the homeowner has a mortgage, the lender will ensure that coverage is in place to at least cover the mortgage amount. Homeowners without a mortgage will make their own choices about which coverages to purchase and in what amounts.

A.1: Properties without a mortgage and without insurance

In the case of a **property owner who owns their property free and clear and has not purchased property insurance**, that owner retains the climate-related physical (P) and transition (T) risks associated with their property. Should the property experience physical losses stemming from storms, rising waters, wildfire or other climate-related events, the property owner will bear those losses. Similarly, if transitions related to climate change — increased tax burdens, regulatory changes, or something else affect the property, the owner alone will bear the risks associated with those changes. (See the top panel in Chart 1).

The one qualification to these owners bearing the full effects of climate risks is the degree to which governments (federal, state or local) step in to absorb some of the losses/costs in the event of natural disasters. This is a regular element of many disaster responses by FEMA and other government agencies and can include grants, loans, subsidized insurance programs and other supports. The potential for a government rescue beyond a property owner’s explicit insurance coverage provides implicit but very important support for owners. Of course, these government supports are ultimately paid for through progressive taxes on the broader population, which might well be an acceptable form of distributing risk in some instances. This same qualification applies to all the distributions of climate-related risk detailed below.

We summarize the distribution of risk and the attachment and detachment points among different players in Table 4.¹⁹

Where the values in the table are defined:

- P(A:B) indicates that that player holds the physical risk associated with climate change from attachment point A to detachment point B,
- T(A:B) indicates that that player holds the transition risk from attachment point A to detachment point B, and
- V represents the property value.

As shown in row a of Table 4, Panel 1, without property insurance or a mortgage, the property owner retains climate-related physical and transition risk for the full value of the property — from attachment point 1 to a detachment point of the full property value, V.

¹⁸ Throughout this paper when we highlight the size of the market through references to estimates of the number of owner-occupied homes in certain categories, the numbers are from a 2020 estimate by the Urban Institute (<https://www.urban.org/urban-wire/price-tag-keeping-29-million-families-their-homes-162-billion>.)

¹⁹ Note that Table 4 is presented in four panels corresponding to the four cases presented in Chart 1.

**TABLE 4, PANEL 2: WHICH MARKET PARTICIPANTS ASSUME RISK FOR WHICH CLIMATE-RELATED RISKS?
PROPERTY OWNED FREE-AND-CLEAR AND WITH INSURANCE**

	PHYSICAL RISK	TRANSITION RISK	COUNTERPARTY RISK	OPERATIONAL RISK
a. Property Owner	P(1:D); P(C:V)	T(1:V)	CP(D:C)	0
b. Insurance Provider	P(D:C)	0	0	0
c. Mortgage Lender/Servicer	0	0	0	0
d. GSE/FHA/PLMBS Market	0	0	0	0

In summary, for properties without a mortgage and without insurance,

- The owner bears all the Physical (P) and Transition (T) Risk related to climate change, less any government intervention.

A.2: Properties without a mortgage and with insurance

As mentioned above, property owners without a mortgage may choose to purchase insurance of their own accord. In the case of **property owners who own their property free and clear and have purchased insurance**, they transfer the bulk of the climate-related physical (P) risk to an insurance provider but retain transition (T) risk (See Chart 1).

PHYSICAL: Through insurance, the property owner formally transfers the physical risks associated with their property to a third party in exchange for insurance premiums. The property owner retains some portion of the physical (P) risk in the form of a deductible (D) as well as the responsibility to pay for the remainder of average expected physical risk through an insurance premium, but the variability and uncertainty of that physical (P) risk from the deductible (D) up through the coverage level (C) is now borne by the insurance provider. Through their reliance on the insurance provider, the property owner has also adopted a (generally small) element of counterparty (CP) risk, in the case that a physical loss is experienced and the insurance provider either cannot or does not fulfill their responsibilities.

TRANSITION: A homeowner who purchases insurance retains climate-related transition (T) risk associated with their property. The insurance provider generally retains the right to cancel and/or change pricing for coverage as conditions change and other transition-related risks — such as increased tax rates, changes in the availability of property insurance, changes in a home’s value related to changing conditions or tastes and any costs related to increased resilience or other needs — remain with the property owner. To reduce some of the transition risk

related to changes in insurance coverage or costs, many states have stepped in to provide a government insurance alternative when private insurers have pulled out of some coverage.

Where (in addition to the values defined in Table 4, Panel 1):

- CP(A:B) indicates that that player holds the counterparty risk associated with physical risk from attachment point A to detachment point B,
- D represents the deductible for an insurance policy, and
- C represents the insurance policy coverage amount.

The attachment and detachment points are an important consideration, as risk is concentrated among those market participants taking on a first-loss position. If, for example, a property owner has a \$5,000 deductible on an insurance policy for a \$205,000 home and the property sustains \$10,000 worth of insured damage, that property owner experiences losses on their full exposure (attachment point \$1 to detachment point \$5,000) while the insurance provider experiences losses on only 2.5% on their exposure (a \$5,000 loss on their exposure of \$200,000 from attachment point \$5,000 to detachment point \$205,000).

As shown in row a of Table 4, Panel 2, for homes with property insurance but without a mortgage, the homeowner retains the physical (P) risk from an attachment point 1 to a detachment point of the deductible (D) and, should the insurance coverage be less than the full value of the property, any residual amount from the coverage level (C) to the full property value (V). The property owner also retains climate-related transition (T) risk for the full value of the property — from attachment point 1 to a detachment point of the full value (V). In purchasing an insurance policy, they also take on physical-related counterparty (CP) risk to the insurance provider with attachment/detachment points of the deductible amount and the property’s coverage level (C).



Looking at row b, the insurance provider takes on the physical (P) risk from an attachment point of the deductible (D) to a detachment point of the coverage level (C) of the insurance policy.

In summary, for properties without a mortgage and with insurance,

- The owner retains all Transition (T) Risk as well as a portion of the Physical (P) risk and (generally small) Counterparty (CP) risk to the insurance provider.
- The insurance provider adopts the bulk of the Physical (P) risk associated with climate change but is generally protected from Transition (T) risk.

B. Properties with a mortgage

Out of roughly 80 million owner-occupied properties in the United States, 48 million have some form of mortgage. As a condition to making a loan, a lender will typically require insurance coverage be in place on the property. Should a policy lapse, the lender has the authority to “force-place” such coverage to ensure the loan amount is secured against physical risks to the property. Even with the insurance coverage, the extension and ownership of a loan transfers some climate-related risks from the homeowner to the owner of the loan.

Of the 48 million home loans in the United States, approximately 12 million mortgages are held in the portfolios of banks, credit unions and other lenders while 36 million have been

sold to and/or securitized by Fannie Mae, Freddie Mac, FHA/Ginnie Mae, private-label securitizers or others (which we will refer to as “investors”). Within the commercial and multifamily mortgage market, depositories hold roughly half (48%) of total outstanding commercial and multifamily mortgage balances — \$2.4 trillion out of \$5.0 trillion — with life insurance companies holding an additional \$600 billion. One quarter of outstanding commercial/multifamily mortgage debt (\$1.3 trillion) is held in Agency, GSE and private-label mortgage-backed securities or in the GSE portfolios.²⁰

B.1: Properties with a mortgage held in portfolio

When a property loan is made, it is often sold into the secondary mortgage market. Roughly one-in-five home loans and more than half of the balance of commercial and multifamily mortgages, however, is held in portfolio by a bank or other lender. In the case of **property owners who take out a mortgage which is held in the lender’s portfolio**, the lender absorbs some level of transition risk but little in the way of physical risks.

PHYSICAL: The distribution of physical risks is little changed through the extension of a mortgage, except in the fact that the mortgage lender will generally require that insurance for physical risks is in place at levels that cover the property’s mortgage amount. As a result, and as is the case in situations in which a property owner does not have a mortgage and does take out insurance, the property owner retains a portion of the physical (P) risk in the form of a deductible (D). The insurance

²⁰ Federal Reserve Board, Financial Accounts of the United States. Note that these figures include mortgage debt on both income-producing and owner-occupied properties but does not include properties that may be supported by an owner’s debt if the borrower did not pledge the property as collateral for the loan. Beckett, Sean. 2021. “The Impact of Climate Change on Housing and Housing Finance,” Special Report, [Research Institute for Housing America](#).

TABLE 4, PANEL 3: WHICH MARKET PARTICIPANTS ASSUME RISK FOR WHICH CLIMATE-RELATED RISKS? PROPERTY MORTGAGED AND HELD IN PORTFOLIO

	PHYSICAL RISK	TRANSITION RISK	COUNTERPARTY RISK	OPERATIONAL RISK
a. Property Owner	P(1:D); P(C:V)	T(1:(V-UPB))	CP(D:C)	0
b. Insurance Provider	P(D:C)	0	0	0
c. Mortgage Lender/Servicer	0	T((V-UPB):V)	CP(1:D); CP(D:UPB)	OP(1:UPB); OT(1:UPB)
d. GSE/FHA/PLMBS Market	0	0	0	0

provider bears the physical (P) risk from the deductible (D) up through the coverage level (C) and the property owner bears any risks from the coverage level (C) through the property value (V). Through their reliance on the insurance provider, the property owner has adopted a (generally small) element of counterparty (CP) risk. With requirements that insurance be in place on a mortgaged property, a lender’s exposure to physical (P) risk is typically covered by the property owner and insurance provider, so the lender’s (generally small) physical risk is in the form of counterparty risk (CP) to the property owner for the deductible amount (D) and to the insurance provider for the remaining amount up to the loan’s unpaid principal balance (UPB).

TRANSITION: When a homeowner takes out a mortgage, they are also taking-out de facto insurance against transition risks associated with climate change. Should a property face transition-related risks or losses — increased tax burdens, reduction in property value, increased property insurance rates or a loss of coverage or something else — the mortgage now extends a portion of those risks (equal to the loan amount) to the lender in a second-loss position. The property owner will bear transition risks (T) in the amount of the equity they hold in the house. For example, should a property’s value decline as a result of climate change, the owner can lose their equity. But should the value decline in an amount greater than the owner’s equity, the owner may default on the mortgage, leaving the remaining risk to lender. As a result, in a mortgaged property held in portfolio by the lender, the property owner retains the first-loss transition (T) risk from \$1 to their equity in the home (Value (V) — unpaid principal balance (UPB)). The lender then bears the transition related risk from that point (V-UPB) to the property value (V).

The mortgage transfers a large portion of the aggregate transition risk from the property owner to the lender,²¹ but, because the risk is concentrated in the first loss portion, the homeowner retains a significant share of the concentrated risk.

OPERATIONAL: In addition to the risks outlined above, the lender/servicer’s reliance on the counterparties and insurance policies to cover portions of the physical and transition risks introduces new operational risks. To ensure that policies are in place and that coverage levels are adequate, the portfolio lender/servicers must establish policies and procedures to monitor and act on slippages in coverage or other misalignments. These requirements mean that should a lender’s/servicer’s operations not work as intended; they could experience losses that should be borne by others. In this instance, portfolio lenders/servicers face operational risks associated with the entire amount of the mortgage, although this overstates the situation because it double counts the risks they are already taking on.

Where (in addition to the values defined in Panels 1 and 2):

- OP(A:B) indicates that that player holds the operational risk associated with physical risk from attachment point A to detachment point B,
- OT(A:B) indicates that that player holds the operational risk associated with transition risk from attachment point A to detachment point B, and
- UPB represents the current mortgage unpaid principal balance.

Looking at the distribution of risks by market player, as shown in row a of Panel 3, for homes with a mortgage that is held in portfolio, the homeowner retains the physical (P) risk from an attachment point 1 to a detachment point of the deductible (D) and, should the insurance coverage be less than the full value of the property, any residual amount from the coverage level (C) to the full property value (V). Similarly, the property owner retains climate-related transition (T) risk for the equity they hold in the property — from attachment point 1 to a detachment point of the value of the property less the loan balance

²¹ The academic literature on mortgage default looks at default events through the lens of option theory, and often models default as a put option (as first described in Foster, Charles, and Robert Van Order. 1984. “An Option-Based Model of Mortgage Default,” Housing Finance Review 3(4): 351-372). That is, a homeowner can extinguish some or all his/her mortgage obligation by putting a house back to the lender. That is, (s)he has a put option as well as equity in the house. Following

Hurricane Katrina, Fannie Mae modelers adopted the put option theory to estimate losses on its book-of-business by assuming that homeowners would strategically default if they owed more than the net value of the home (including damage and insurance). Interestingly, for the case of New Orleans, this was often not the case—homeowners showed deep attachment to their homes and did not strategically default in the numbers that option theory may have predicted.

TABLE 4, PANEL 4: WHICH MARKET PARTICIPANTS ASSUME RISK FOR WHICH CLIMATE-RELATED RISKS? PROPERTY MORTGAGED AND SOLD TO INVESTORS OR SECURITIZED

	PHYSICAL RISK	TRANSITION RISK	COUNTERPARTY RISK	OPERATIONAL RISK
a. Property Owner	P(1:D); P(C:V)	T(1:(V-UPB))	CP(D:C)	0
b. Insurance Provider	P(D:C)	0	0	0
c. Mortgage Lender/Servicer	0	0	0	OP(1:UPB); OT(1:UPB)
d. GSE/FHA/PLMBS Market	0	T((V-UPB):V)	CP(1:D); CP(D:UPB)	OP(1:UPB); OT(1:UPB)

outstanding (V-UPB). In purchasing an insurance policy, they also take on physical-related counterparty (CP) risk to the insurance provider with attachment/detachment points of the deductible (D) amount and the property’s coverage level (C).

Looking at row b, the insurance provider takes on the physical (P) risk with an attachment point of the deductible (D) and a detachment point of the coverage level (C) of the insurance policy.

In row c of Panel 3, the lender takes on the transition risk of the property from an attachment point of the value of the property less the loan amount (V-UPB), which is equivalent to the owner’s equity in the property, to a detachment point of the value (V) of the property. The portfolio lender also takes on counterparty risk associated with the physical risk borne by the borrower (from 1 to D) as well as counterparty risk associated with the physical risk borne by the insurance provide (D to UPB). The lender/servicer also takes on operational (OP and OT) risks associated with monitoring and managing the risks taken on by others. The lender’s risk is often diversified

In summary, for properties with a mortgage held in portfolio,

- The owner retains direct physical (P) risk up to their insurance deductible amount (\$1 to D), counterparty risk to the insurance provider from the deductible amount up to the insurance coverage level (D to C) and direct physical risk for any uncovered value (C to V). They also hold first-loss transition risk from \$1 up to their equity in the property (V-UPB).
- As in previous cases, the insurance provider adopts the bulk of the Physical (P) risk associated with climate change but is generally protected from Transition (T) risk.

- The portfolio lender/servicer bears little to no direct physical risk, instead being exposed to physical risk only indirectly through counterparty and operational risk. They take on a portion of transition risk — the second-loss levels above the owner’s equity. They also take on operational risk as they monitor and manage the risks taken on by the borrower and insurance providers.

B.2. Properties with a mortgage sold/secured by GSEs, FHA or Private Label MBS

The majority of home loans made in the United States, some 36 million outstanding, are sold/secured through Fannie Mae, Freddie Mac, FHA/Ginnie Mae or private label securitizers (investors).²² One quarter of outstanding commercial/multifamily mortgage debt (\$1.3 trillion) is also held in Agency, GSE and private-label mortgage-backed securities or in the GSE portfolios. In the case of **property owners who take out a mortgage which is sold to investors**, the securitization process does not affect the risks taken-on/shed by homeowners and/or insurance providers but does significantly impact the risks held by individual lenders and servicers.

PHYSICAL: When a property’s mortgage is sold to an investor, the distribution of the physical risks related to climate change generally do not change. The property owner and insurer hold the same risks they would if the loan were held in portfolio. The only change is that the investors in mortgage assets take on physical-related counterparty risk that the portfolio lender would have borne. Should there be losses that the property owner or insurance company should bear but can’t or don’t, those counterparty risks are transferred from the lender/servicer to the investors.

TRANSITION: Similar to the physical risks, when a property’s mortgage is sold to investors, the transition risks related to

²² Ouazad and Kahn (2022) provide evidence that in the aftermath of natural disasters, lenders are more likely to approve mortgages that can be securitized, thereby transferring climate risk, and adversely selecting the government-sponsored enterprises (GSEs). While this does not alter our framework, it is of interest when comparing the loans that are in cases B.1 and B.2. Note, however, that Ouazad and Kahn’s findings may be restrictive since the GSEs are much more likely to have an informational advantage (with superior data on climate projections) that many of their sellers — especially smaller institutions like community banks. That is, the GSEs may well be more than capable of protecting against adverse selection as climate-change risks evolve.

climate change do not change for the property owner. The transition (T) risks which otherwise would be borne by the portfolio lender — from an attachment point of the borrower's equity (V-UPB) to the detachment point of the property value — are now borne by the investors.

OPERATIONAL: In this situation, both the servicer and the investors will bear some level of operational risk related to the monitoring and management of both physical and transition risks.

Looking at the distribution of risks by market player, as shown in row a of Table 4, Panel 4, and unchanged from the example above Panel 3 (row a), for homes with a mortgage that is sold/secured by GSEs, FHA or Private Label MBS, the homeowner retains the physical (P) risk from an attachment point 1 to a detachment point of the deductible (D) and, should the insurance coverage be less than the full value of the property, any residual amount from the coverage level (C) to the full property value (V). Similarly, the property owner retains climate-related transition (T) risk for the equity they hold in the property — from attachment point 1 to a detachment point of the value of the property less the loan balance outstanding (V-UPB). In purchasing an insurance policy, they also take on physical-related counterparty (CP) risk to the insurance provider with attachment/detachment points of the deductible (D) amount and the property's coverage level (C).

Looking at row b, (which is similarly identical row b in Panel 3) the insurance provider takes on the physical (P) risk from an attachment point of the deductible (D) and a detachment point of the coverage level (C) of the insurance policy.

In row c, the lender/servicer in this situation sheds their direct transition risk as well as their counterparty risks, as these are now taken on by the investors. The servicer does continue to bear some operational (OP and OT) risks associated with monitoring and managing the risks taken on by others.

In row d, the investors take on the risks that had been borne by the lender in the case of a mortgage held in portfolio. This includes transition (T) risk of the property from an attachment point of the value of the property less the loan amount (V-UPB), which is equivalent to the owner's equity in the property, to a detachment point of the value (V) of the property, as well as counterparty (CP) risk associated with the physical risk borne by the borrower (from 1 to D) counterparty (CP) risk associated with the physical risk borne by the insurance provider (D to UPB). The investors also take on operational (OP and OT) risks associated with monitoring and managing the risks taken on by others.

In summary, for properties with a mortgage sold and held-by/secured by the GSEs, FHA or the private label securitization market,

- The owner retains direct physical (P) risk up to their insurance deductible amount (1 to D), counterparty risk to the insurance provider from the deductible amount up to the insurance coverage level (D to C) and direct physical risk for any uncovered value (C to V). They also hold first-loss transition risk from 1 up to their equity in the property (V-UPB).
- As in previous cases, the insurance provider adopts the bulk of the Physical (P) risk associated with climate change but is generally protected from Transition (T) risk.
- The servicer bears no direct physical or transition risk. They do take on operational risk as they monitor and manage the risks taken on by the borrower and insurance providers.
- The investors in mortgage assets bear little to no direct physical risk, instead being exposed to physical risk only indirectly through counterparty and operational risk. They take on a portion of transition risk — the second-loss levels above the owner's equity. They also take on operational risk as they monitor and manage the risks taken on by the borrower and insurance providers.

Key Takeaways

Among the key findings are:

- Climate-related housing risks are distributed among a wide range of market actors, with “ownership” of the risk heavily dependent on the degree to which a property is insured, mortgaged and, if mortgaged, by the form of mortgage ownership.
- Even with the distribution of risks, property owners continue to bear the first-loss risk for both physical and transition risks related to climate change.
- The insurance market is a key piece of the system for physical risks. Other players are dependent on its resilience and stability and the mortgage market promotes the use of the P&C and other markets for physical risks. The insurance market is generally built to avoid transition risks.
- The mortgage market acts a de facto form of insurance for climate-related transition risks, taking on the risk from an attachment point of the owner’s equity in the property through to a detachment point of the property’s value. The amount of risk/coverage homeowner experience depends on the loan loan-to-value ratio.
- As the market prices climate-related risks, property owners will bear the costs for the explicit or implicit insurance that others in the market provide.
- Portfolio lenders’ greatest exposures to climate-related risk in the housing market are through transition risk on the loans they hold in portfolio and through counterparty and operational risks.
- A portfolio lender’s risk is diversified to the degree it has a diversified portfolio.
- Lenders and servicers bear no direct physical or transition risk for loans that are sold/ securitized, although servicers bear some operational risk for such loans.
- Investors in mortgage assets take on climate-related risks from the initial lender and distribute them into heterogeneous pools and more risk-absorbing pockets



Policy Questions and Implications

The framework shows that the regulatory community, recognizing that the traditional approach in real estate finance the past several decades has been to distribute risk across multiple parties, should lean into this approach.

First, regulators need to embrace the fact that at this point there are substantial uncertainties regarding the climate and hence economic paths that we are on. Acknowledging that uncertainty does not mean refraining from action, but it does mean expressing a reasonable humility regarding next steps.

Second, given that uncertainty, as was highlighted throughout our analysis, the model suggests that regulators' efforts may be most productive in seeking to capitalize on the risk management processes, procedures, and strengths already inherent in the real estate finance system.

With respect to credit risk, regulators best approach may simply be to ensure that lenders are doing the blocking and tackling that their businesses require. The right level of insurance coverage must be in place. Lenders must monitor concentrations of credit risk with respect to geography and other key factors. Beyond fundamental credit risk measurement, modeling, and management, lenders and their examiners likely need to take closer looks at counterparty credit risk and think through the implications of a counterparty failure in one or many parts of the system. While credit losses from natural disasters may well have been minimal in the past, lenders and other market participants need to carefully think through the impact and potential chain of events that could flow from the failure of any counterparty who holds substantial risk from property damage or destruction.

On market risk, there is clearly the potential for policy to be a source of transition risk. In addition to natural market reactions to climate change, a new law, regulation, zoning ordinance, election, or public campaign may suddenly impair the value of a property or related loan or security. While the potential for such a change certainly appears elevated in the climate risk context, it is not different in kind from the risk that lenders have always faced, even if it has not been labeled as such. Regulators, with the humility noted above, can certainly require lenders to work through the implications of a sudden drop in the value of their portfolios, and help industry develop the

intellectual muscles to think through both how to respond to such a development, and how to diversify, hedge, or otherwise protect their portfolios against the impact of such a change.

With respect to increasing operational risk from more frequent and more severe natural disasters, regulators should review servicer performance in prior episodes and help to lead industry-wide discussions regarding how to optimize relief efforts for borrowers following such an event. Much has been learned in recent years regarding the appropriate types of relief that can lead to retention of homes and return to performance on loans in a manner which is sustainable for the system over time. Given that such approaches are likely to become even more widespread, there likely need to be careful attention paid with respect to the staffing, technology, and other inputs required in certain key servicing functions, and regulators can work with servicers to ensure that they are prepared before the next disaster strikes.

Beyond pushing lenders to strengthen their capabilities to manage the fundamental risks of lending, regulators also have the unique ability to push efforts that benefit the resilience of the system, and to be a central source of information regarding both the risks and potential mitigants. Again, highlighting the uncertainties associated with this topic, it is going to be impossible to stop every "shot on goal" that could be coming from a changing climate. Rather, regulators should push for efforts that will help the system as whole become more resilient in the face of disasters. For example, encouraging lending for activities that help reduce flood risk through various abatement measures in advance of disasters would be preferred to requiring additional capital against the threat of flood risk.

Additionally, regulators have a unique ability to be an informational resource for the market, particularly information regarding lender performance, lending activity, and practices and processes used by market participants to manage climate risk. Regulators also have the ability to inform the public regarding the roles that each participant in the market is playing. As noted above, borrowers, lenders, insurers, and capital market

participants all have important risk management roles to play as climate risk is managed in the years ahead. No one should be surprised at the exposures they have to shifting tides, and no one should necessarily expect that another participant will take on a heavier load than they signed up for. Clear communication regarding the risks and rewards associated with each position would be welcome.

Finally, this framework shows that the regulatory community, recognizing that the traditional approach in real estate finance the past several decades has been to distribute risk across multiple parties, should lean into this approach.²³ The biggest risk to individual market participants and key counterparties will come from concentration of risk, whether that be operational, credit, or market risk. Regulators should monitor for such concentrations, but even more than had been the case

in the past, they should also facilitate the true distribution of these risks that effectively reduce these concentrations. As noted above, this is standard blocking and tackling both with respect to risk management within institutions and examination and supervision by regulatory personnel. However, the big picture in this case is that such skills and practices are more important than ever.

Understanding who owns climate-related risk in the US real estate markets is an essential building-block for market participants, policymakers, regulators and others to prepare for the impacts of coming climate change. It also establishes a framework that can be extended to other markets and other players. The fact that it reinforces the utility and value of many existing risk-management activities is generally positive news for the US real estate and finance markets.

²³ U.S. Department of the Treasury Housing Reform Plan, 2019. (Available at: [Treasury-Housing-Finance-Reform-Plan.pdf](#)).

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1919 M STREET NW, 5th FLOOR
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