Climate risk and real estate prices: what do we know?

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CLIMATE RISK AND REAL ESTATE PRICES: WHAT DO WE KNOW?

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CLIMATE RISK AND REAL ESTATE PRICES: WHAT DO WE KNOW?

Abstract

There is a growing international consensus that climate change represents one of the most important structural forces and risks that long-term investors need to proactively consider in building resilient portfolios. Many institutional real estate investors have significant exposure to cities and regions that are economically important, but increasingly susceptible to climate change impacts. In this paper the authors review and synthesize existing academic research on risk exposure to acute and chronic climate related events and forces and their impacts on property asset values and lending practices. Evidence to date is dominated by studies focused on residential property, although some recent research has begun to examine the commercial real estate sector in a more rigorous way. The authors draw inferences from the residential studies for how these findings might apply to commercial real estate and highlight the more recent studies focused on commercial property. Recent research is published within both real estate and broader economics and finance journals; these papers indicate that awareness of climate risks is starting to have a more sustained impact on pricing and on investor decision-making, although the channels though which impact occurs are generally opaque and warrant further research.

Key Takeaways

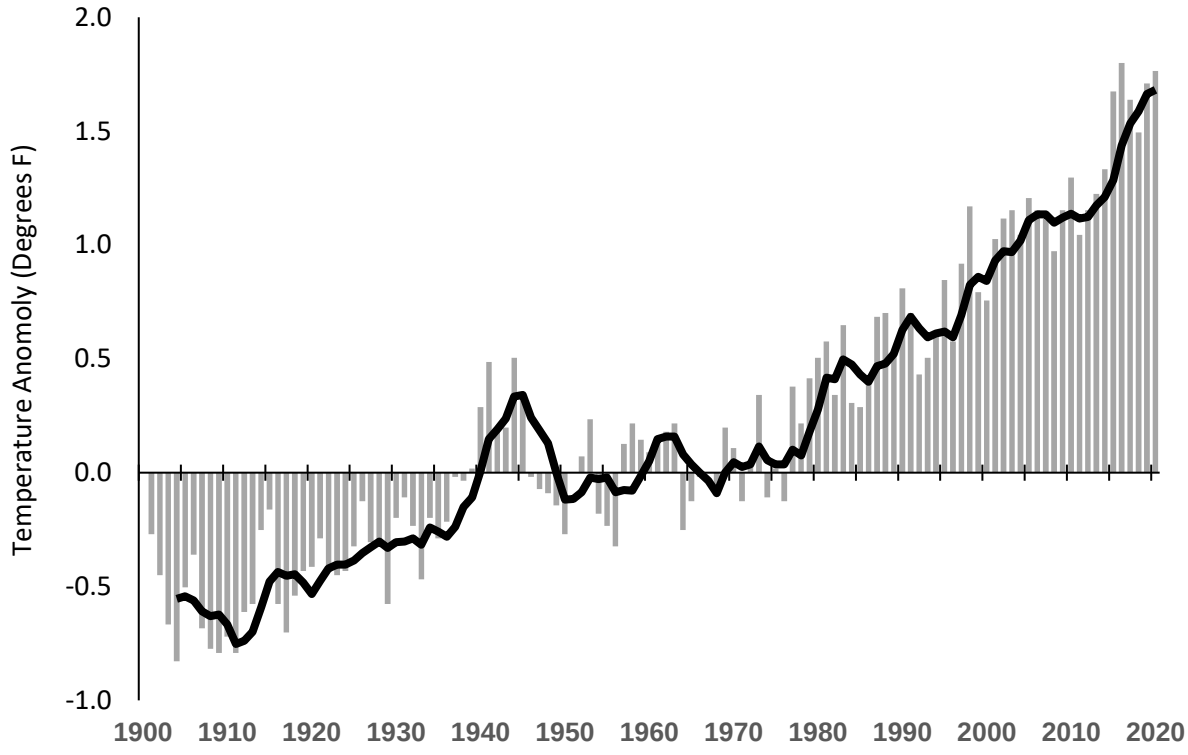
- Historically, property prices decline after climate events but tend to eventually recover. Recent evidence suggests that climate events in geographies that previously suffered little exposure to extreme weather can lead to a long-lasting decline in prices or liquidity.

- There is some evidence from residential markets that levels of belief in climate change and confidence in government-led mitigation of impacts may result in differing levels of price impacts where risks lie primarily in the future, such as sea level rise. In this respect the nature of the marginal investor is important.

- Commercial owners/investors in some geographies are placing a higher risk premium on all properties in metro areas affected by climate events, regardless of whether their individual properties have been directly affected.

Climate change is becoming one of the most important structural forces and risks that long-term investors need to proactively consider in building resilient portfolios. While there is uncertainty about future climate related risks, there is little question that global warming is a reality that has been building for decades, as highlighted by the trend and acceleration shown in Exhibit 1. Moreover, while climate events are not new, there is mounting evidence that the frequency, duration, intensity and geographic spread of extreme weather events have increased over recent decades as result of global climate change. The rise in potentially damaging acute events, such as flooding, wildfires, hurricanes and tornadoes coincides with a tipping point in the emergence of more chronic risks including sea level rise (SLR), temperature rise and drought that have the potential to transform economic and capital market environments around the world; recent analyses by McKinsey Global Institute (2020) and PGIM (2021) provide extensive insight into climate risks and these possibilities.

Exhibit 1. Earth's Surface Temperature (Land and Sea) Worldwide, 1901-2020



Temperature relative to baseline 1901 - 2000 average.

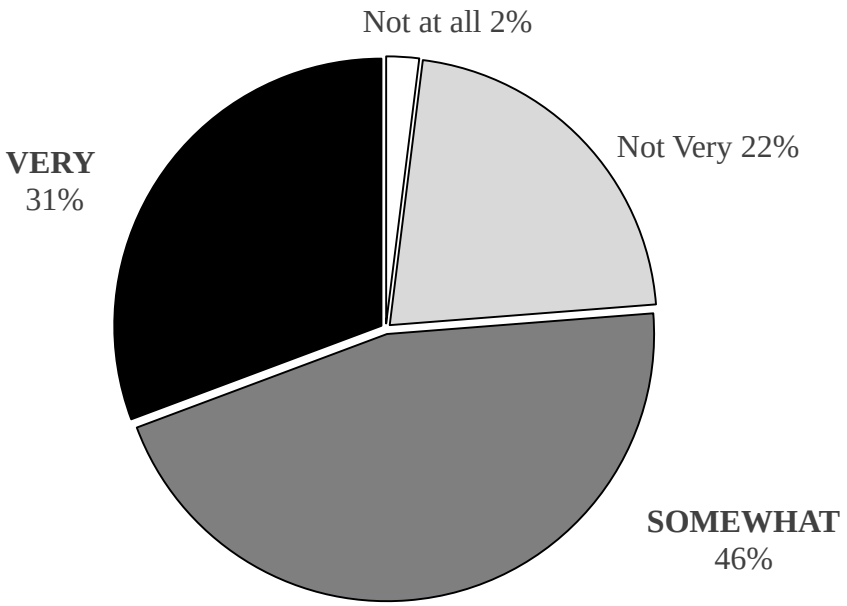
Source: United States Environmental Protection Agency (EPA) Climate Change Indicators in the United States: www.epa.gov/climate-indicators

Many institutional real estate investors have significant exposure to cities and regions that are economically important, but increasingly susceptible to climate change impacts. Fisher and Rutledge (2021) highlight the historical preference of U.S. investors for property investments in coastal, gateway markets for liquidity, demand density, and durable return motivations: locations that are increasingly susceptible to climate risk. An analysis of global property holdings of publicly listed real estate investment trusts (REITs) by real estate data analytics firm Geophy in partnership with climate risk assessment provider 427 (Four Twenty Seven) reveals a similar bias towards locations on a global basis, at the country level and within, that now face increased physical risk from both acute events and chronic forces.

Exhibit 2 provides recent survey evidence that illustrates industry awareness and concern amongst many, though certainly not all, global real estate investors. 77 percent of member responses to global real estate investor association AFIRE's annual survey indicated they are either "concerned" or "very concerned" about climate risks. The existence of climate risk does not necessarily mean that investors should avoid or withdraw from those places, but a reassessment of risks, allocations and potential mitigation actions is important to protect or limit impacts on performance. Krueger, Sautner and Sparks (2020) survey institutional equity investors about climate risk perceptions and find that the large majority believe climate risks have implications for companies in their portfolios. They also report that many of these investors, especially larger ones with a long-term view and well established environmental, social and governance (ESG) focus, consider risk management and engagement, rather than divestment, to be the better approach for addressing climate risks.

Exhibit 2. Global Real Estate Investor Opinion of Climate Risk

How concerned are you about the impact of climate change on your US real estate activity in 2021?



Source: Authors derived from the AFIRE International Investor Survey, 2021.

Recent industry commentary and analysis reveals the challenges associated with incorporating complex risk considerations into valuation and investment processes and decisions. Reports from the Urban Land Institute (ULI) in conjunction with real estate investment management firm Heitman (ULI/Heitman, 2019,2020) lay out many of the issues and explore current industry practice in surveys of industry participants. These reports, consistent with the AFIRE survey, find significant investor awareness. In going a step further to assess if awareness has led to action, the studies conclude that the industry is in the early stages of incorporating heightened climate risk into the investment and valuation process. Many investors are beginning to work with one or more of the growing roster of forward looking climate risk assessment firms to incorporate climate risk into investment and asset management decisions. However, connecting the perceived risk to valuation and pricing is more tenuous – a work in progress as highlighted in the overview of the approach developed by Dutch pension fund PGGM in Schlmetschek *et al.* (2020).

Rivera (2020) provides a call to action in the institutional valuation context, suggesting that commercial property valuations are not currently reflecting climate risks, owing in large part to a lack of global consensus on valuation/appraisal education and standards, relating specifically to climate risks . He emphasizes the crucial need for "*those of us in the real estate industry to work together to create industry-wide norms that contemplate and quantify climate risks in decision making and valuations*".

Understanding how property values could be materially affected by the physical impacts of climate change is of paramount importance to investors.[1] A major impediment to a rigorous forward-looking assessment of the financial impacts of climate risks on asset values is lack of knowledge and empirical evidence about how property markets have responded to past extreme weather events and how they are responding today to more chronic forces such as sea level rise. Without foundational understanding of the empirical evidence for how markets have responded to past extreme weather events, it is hard to make assertions on how modelling practices should be structured or investment / portfolio allocation decisions weighted to best balance risk and return.

The aim of this paper is help fill this gap through an analysis of relatively recent academic literature which addresses the link between climate hazard and financial materiality of climate impacts examining the following:

- What is known about the impacts of *past* but relatively recent and notable climate events on property prices and/or valuations?

[1] The terms "price" and "value" are being used rather loosely and somewhat interchangeably. However, it is important to distinguish between a valuation, a transaction price, and an assessment of investor worth. A valuation is the opinion by an expert as to a *likely* sales price, normally based on an analysis of past transactions; it is therefore essentially a *backward-looking* measure, although it should include a forward look based on an evidenced likelihood of future changes in market sentiments. Price, on the other hand, is what is achieved from sales in the market and, particularly in a residential context, may not have been influenced by professional valuations or advice unless borrowing was required. Finally, an investor's appraisal of worth is based on a forward projection of the likely income flows, capital appreciation and risks over a defined holding period. Clayton, Devaney, Sayce and Van der Wetering (2021) examine the role of valuations and valuation standards in an international context as they apply to climate risk considerations, as well as review the academic literature on the impact of climate risk on valuations.

- Have any proven impacts been short-term (bounce back) or long-term/value erosion? What are the channels of impact?

- Has there been any change in the way prices adjust to events as awareness and acceptance of climate risk has increased?

- What is known about the pricing or potential re-pricing of property assets in locations facing heighted risk of future climate events?

This review focuses on academic literature from the last decade, examining past 'acute' events (primarily flooding and hurricanes) and future' chronic events (notably SLR). It makes some reference also to wildfires but did not examine other chronic climate change impacts such as drought and extreme heat. The review found evidence more plentiful for residential than commercial real estate markets, although this is beginning to change as some recent research relating to the commercial real estate sector has been published. From the evidence on residential real estate, inferences were made for how these findings might apply to commercial real estate, noting that decisions by homeowners tend to be more subjective and less informed by professional advice than decisions taken by the real estate investment community who often adopt formal, rules-driven processes. While some literature was found on the response of commercial real estate owners, little literature was found on the response by tenants of commercial properties.

PAST EVENT IMPACT STUDIES: FLOODING AND HURRICANES

Flooding

There is an extensive body of empirical work that examines the impact of flooding on residential property prices. Findings vary greatly and many studies pre-date the recent focus on climate risks. The impact of flooding can vary significantly between areas given differences in meteorological factors, topography and geology. It also reflects differences in the nature and intensity of land use, the extent of local mitigation, and variations in the dynamics of real estate markets.

Beltrán, Madison and Elliott (2018) review and synthesize much of this literature and conduct a meta-analysis of the results of thirty-seven published studies on the impact of flooding on the prices of at risk residential properties in both U.S. and non-U.S. locations. They estimate that findings of previous studies indicate an average price discount of -4.6 percent for properties located in an officially designated 100-year floodplain. Their results also indicate that price discounts were larger immediately following a flood, but start to decay afterwards, a dynamic that is explored in more detail below.

Miller, Gabe and Sklarz (2019) undertake a comprehensive investigation of the impact of proximity to water on U.S. residential property prices. Referencing and building from a significant empirical literature on valuing the amenity (location and/or view) component of waterfront proximity, they investigate whether housing markets are adapting to heightened climate risks as climate change becomes more of a certainty. While many previous studies focus on locations in and around flood plains with a single metro area, this study utilizes a unique, large data set comprised of residential housing transactions in 19 states with waterfront locations over the 2000-2017 time period.

The authors confirm significant premiums for waterfront proximity, and that the positive amenity premium net of the negative impact associated with the potential risk of flood or other water related events that varies with location to the water. They also find that single-family home prices rebound quickly to prior macro trends after major storms, with little persistent negative impact on value; even with more recent events in the face of increased climate risk awareness.

One potential explanation is that insurance payouts could mitigate the impact on value. The authors suggest that federal flood insurance programs are underpriced and artificially prop up housing markets at higher risk of loss due to climate change. Only in extreme events large enough to displace employment, such as Hurricane Katrina in 2005, are longer-term depression of housing prices observed. The authors suggest that their results imply either a short-term horizon for buyers of coastal properties at risk, or a moral hazard problem whereby residential owners are dependent upon and subsidized by government and mispriced flood risk insurance.

Another part of the explanation could derive from a singular focus on the reaction of transaction prices and not the joint dynamic of liquidity and prices that characterise adjustment of private asset markets including real estate. Turnbull et al. (2013) argue that liquidity must be studied alongside prices to fully capture the effects of flood risk on housing markets. They found longer selling times as well as price discounts for houses in the highest risk areas of Baton Rouge, Louisiana.

Outside the US, there has been limited empirical research that has quantitatively modelled the value impacts of an acceleration in flood events. One interesting exception that provides insight into income-property impact is Hirsch and Hahn (2018) who analyzes the effects of flood risk on the rents and prices of residential properties in Regensburg, Germany. They found that the impact on both was negative, but with a smaller impact on rents than prices. They attributed this to the different commitments of tenants versus owners to specific properties.

In the absence of quantitative data in some markets, researchers have studied how perceptions of flood risk impacts on commercial property values. Bhattacharaya-Mis & Lamond (2015) found no clear evidence that property owners saw a direct link between flood risk and value and this is corroborated by interviews with built environment professionals reported in Lamond et al. (2019). They highlighted a temporal element, where a recent flood event can create a disproportionate reaction with impacts on value, property insurance and desirability of locations, but that people tend to forget over time. Lamond et al. (2019) also identified locational factors that could offset risk in the commercial sector. For instance, waterfront location could be seen as important in some commercial sectors and not just in residential markets.

Pottinger and Tanton (2014) found evidence of greater flood risk due diligence among major UK investors when making acquisitions, driven by tightening regulation and the occurrence of major flood events. The availability and accessibility of insurance were also identified as issues for occupiers. Yet, the authors found no evidence that valuers were making rent or yield adjustments to reflect changes in investor and occupier sentiment. Lamond et al. (2019) found that low perception or lack of awareness, as well as a lack of guidelines and common practices on the threat of flood risk explained why any discounts in market value were inconsistent. They identified that without reliable and accurate data and projections of risk, built environment professionals could not provide clear, fulsome advice in relation to flood risk to their clients.

Hurricanes

For coastal locations in several parts of the world, hurricanes are a fact of life and are anticipated based on historical patterns; but global climate change provides mounting evidence of increasing frequency, duration, and intensity of hurricanes. Indeed, 14 of the top 20 costliest mainland United States tropical storms have occurred since 2000 (Fisher and Rutledge, 2021). In addition, the geography of hurricane paths has changed over the past couple of decades, with locations further up the U.S. East Coast that were traditionally thought to be out of harm's way now affected.

Early studies of the impact of hurricanes on property prices focused on single-family homes and typically documented a temporary negative reaction that ultimately dissipated as the event became a distant memory. Below et al. (2017) conducted extensive analysis of house price reactions to hurricanes on the North Carolina coast over the period 1996-2012 and found a price discount of roughly 3.8% in the 60 days following a storm, but which became unobservable beyond 60 days post-storm. Severe storms do not seem to have a lasting impact on the prices of residential properties in this severely threatened subject area, perhaps because the threat was realized and hence risks were already being capitalized into prices of these properties.

Fisher and Rutledge (2021) provides one of a limited number of empirical studies focused on the commercial property sector. The authors investigate the impact on property values and returns from all the significant hurricanes that occurred during the past 30 years in the U.S. It finds on average an immediate price impact that worsens over time, taking three years to bottom out, before prices revert back to "normal". That is, there does not seem to be a permanent price discount, consistent with findings based on the residential/single-family sector.

A potential limitation with both the Below et al. (2017) and Fisher and Routledge (2021) studies is that that there is no consideration of the possibility that climate risk, and recognition of it, are increasing over time. The hurricanes and their associated time periods are grouped together in a single analysis, essentially forcing the adjustment coefficients to be time invariant. It would be fruitful to study the separate impact of some of the more recent hurricanes that are causing people to re-evaluate climate risk. Recent studies that focus on Hurricane Sandy, that hit land in October 2012 (the first major storm in recent times to impact New York City), do exactly this.

Ortega and Taspinar (2018) examine the reaction of house prices using an extensive property level dataset comprised of all New York City house sales from 2003-2017 combined with Federal Emergency Management Agency (FEMA) geo-coded data on building structure damage. They compared price trajectories of housing units impacted by Sandy to similar units not impacted but also in a flood zone, plus a "control" sample. They report that damaged properties suffered a large immediate drop in value following the storm (17–22%), followed by a partial recovery that likely reflects their gradual restoration. A key finding is the gradual emergence of a price penalty among flood zone properties that were not damaged by Sandy, reaching 8% in year 2017 and showing no signs of recovery, consistent with a learning mechanism related to heightened perceived risk of large-scale flooding episodes in the area, aka "belief updating".

Gibson and Mullins (2020) report that Hurricane Sandy flooding decreased home values by 3-5%, and inclusion of homes in the floodplain by new FEMA maps post-Sandy decreased sale

prices by 7-8%. However, the effect of new flood plain maps on properties flooded by Sandy was zero, while the effect on properties not flooded by Sandy, but now in the floodplain, was estimated to be between 12-23%. This implies that updated maps provide no new information for properties flooded by Sandy but led to reassessment of risk for homes previously outside of the floodplain. Cohen et al. (2021) show that the "surprise" of Sandy-induced flooding that extended beyond the FEMA flood zone at the time impacted house prices beyond but close to the area of flooding. They report a short-run negative effect on NYC housing prices of 6-7% for each mile difference between the property distance from the flood zone and the distance to actual flood locations. However, for homes outside the flooding area, the negative "surprise" effects on housing prices tended to disappear, as residents' memories of the incident faded.

Addoum et al (2021) is the second of only two academic papers on the impact of hurricanes on CRE, and the only one with a focus on the implications of increasing climate risk on CRE values. The authors examined the impact of Hurricane Sandy on property prices using CRE transactions from 2001-2017 (from CoStar) matched with flood risk data. The authors add controls by expanding their sample to include Boston (likely now higher perception of risk) and Chicago (as a placebo). Addoum et al. report a permanent price discount for impacted properties, with properties exposed to flood risk experiencing slower price appreciation after the storm than equivalent, but unexposed properties. Their analysis supports an impact channel primarily via an increased risk premium as opposed to revised downward strength of leasing fundamentals.

An important finding by Addoum et al. (2021) is that prices of commercial properties in Boston have been impacted by Hurricane Sandy, presumably as institutional investors, certain to have a broader geographic and portfolio view than more localized homeowners, have reassessed the risk of a hurricane hitting. It seems that investors are paying attention. But this is only one study of CRE values in response to a single event, so we are at the early stages of being able to say anything conclusive.

Temporary Discount or Permanent Re-Pricing?

A central theme that emerges from the academic literature is that historically, major weather events have had an immediate, sometimes prolonged, negative effect on property values in impacted areas, but that prices tend to eventually revert to trend. The short-term finding is particularly robust in studies for water-related hazards (flood and hurricane). There is evidence, albeit limited, though consistent across hazards, that repeated experience of hazard impact does impact risk assessment, but only for a time, unless the frequency remains high. In addition, recent studies provide results that, while based on specific localized events and so not necessarily generalizable, suggest that homebuyers, commercial property investors and lenders are increasingly paying attention to climate risk and that this is leading to an erosion in property values or has a real potential to – as evidenced by reduced liquidity and mortgage lender behaviour.

Below et al. (2017) and Miller et al. (2019) find that single-family home prices rebound quickly to prior trends after major storms, with little persistent negative impact on value. Fisher and Rutledge (2021) document a similar dynamic for institutional-owned commercial properties in the NCREIF Property Index (NPI), with prices declining for up to three years after major hurricanes before reverting to "normal". The transitory nature of pricing impacts in areas

known to be at risk likely implies that the threat is realized and hence the risks are to at least some extent being capitalized into prices of these properties. The storms are not a surprise per se. The question is, is this now changing and/or will it in the future as the risk of higher frequency and severity plus broader geographic impact?

Graham et al (2007) provide potential insight into the question of awareness and refined assessment of likelihood. They find a pattern of increasing home price declines in response to successive event hurricanes in their study of the impact of four successive major hurricanes on the North Carolina. However, this ultimately gives in to full price recovery and the return to pre-storm market stability over the following three years in the absence of another major hurricane landfall. Mueller et al. (2009) examine the impact of repeated wildfires and find that successive exposure to fires affects prices for proximate homes more than exposure to a single event or to no fire at all. Similar to the hurricane dynamic, recovery in real house prices is prolonged but does ultimately take place without continued events.

Consistent with this, in a commercial property context, Lamond et al (2019) receive consensus feedback that "*A flood event raises general awareness and, more importantly, perception that the risk is "real" and that the impacts can be severe*." But, also that in the absence of repeated events "people tend to forget" even if a property is located in a floodplain. One insightful response suggested that commercial property values could even increase in response to a severe flood if there is a high likelihood it could lead to increased mitigation spending by government.

The extent to which the empirical evidence demonstrates that the market has (or has not) in recent times priced in extreme weather and climate change is of paramount importance. An important finding in both in both Ortega and Taspinar (2018) and Addoum et al (2021) that tends to demonstrate this in the affirmative is that a post-event permanent price discount applies not only to properties impacted by Hurricane Sandy, but also by those that were not but could be in the future. McCoy and Walsh (2018) found a similar dynamic with wildfires. Prices in areas directly impacted fell in the year after a fire and only partially recovered. Prices in unaffected but high-risk areas also fell, though recovered in two to three years.

What can be concluded is that if the sustained uptick in frequency and severity of extreme weather events materialize as scientists forecast, then the awareness and recognition (i.e. more "believers") should heighten, spread and could certainly be reflected permanently in property prices in high risk areas.

Mortgage Lender Reaction

The real estate sector relies heavily on debt financing. As large scale, big ticket assets, property transactions often require significant debt financing – mortgage funding is part of the liquidity equation. Moreover, credit or debt markets are the largest component of the global financial system. Hence, it seems reasonable to assume that lenders, regulators and credit rating agencies may be even more in tune with potential new risks on the horizon, including physical climate risk.

In this context, it could be considered surprising that there is a lack of academic research on the impact of climate-related events on real estate debt markets or that focuses on commercial mortgage markets. However, the growing recognition of both the importance of climate risk to the financial system as a whole, and the large share of mortgage debt within it, is leading to

more attention in the mainstream finance field.[2] Moreover, major credit rating and mortgage analytic firms have all significant increased focus and analysis of physical climate risk on the mortgage sector, especially the mortgage-backed securities markets, and the municipal finance and infrastructure areas that could ultimately impact property pricing in higher risk locations.

Recent research targeting the U.S. Mortgage Backed Securities (MBS) market, which plays an outsized role in the U.S. compared to other mortgage systems around the world, has provided evidence of significant changes in lending behaviour following major hurricanes that is consistent with changing perceptions of risk in lending and also the shifting of it from lending institutions to U.S. GSEs. Ouazad and Kahn (2021) document that, in periods following major hurricanes, lenders are significantly more likely to approve mortgages that can be securitised - and therefore less likely to originate mortgage loans that cannot be sold to the GSEs Fannie Mae or Freddie Mac - thereby transferring climate risk.

While no academic publications were identified that examined commercial real estate debt markets, there has been an increase in research and analytic activity amongst investor, rating agency and mortgage analytics firms that suggests growing awareness of the seriousness of climate risk.[3] The applied research and shifts in underwriting and rating methodologies can be expected to have real impacts in the availability and pricing of commercial mortgage debt in at risk locations going forward.

A MORE FORWARD LOOK: PROPERTY PRICES AND SEA LEVEL RISE RISK

There has been a surge of academic research that attempts to quantify the potential price impacts of SLR predictions, though a clear gap in the literature is the lack of commercial real estate studies. The 15 papers identified that were published within the last five years are skewed towards the US, with only two being non-US based, both of which related to Australia (Warren-Myers *et al*. 2018; Fuerst and Warren-Myers, 2020).

It proved difficult to discern consensus findings from the literature. The range of estimates of SLR and the range of timescales over which it was expected that it would feed into purchase decisions clouded the ability to make meaningful comparisons (Bernstein *et al.,* 2019). Furthermore, a lack of knowledge as to the full (including indirect) costs, likely degree of inundation, and presence (now or in the future) of mitigation measures have been raised as issues that can influence results (Scott *et al.,* 2012; Conyers *et al.,* 2019; Warren-Myers *et al.,* 2018; Walsh *et al.,* 2019; Murfin and Spiegel, 2020). Further influences on the results may be the level of belief in climate change or expectation of state adaptation and mitigation actions

[2] See Hong, Karolyi and Scheinkman (2020), who suggest that "financial economists are late to the game" and need to better understand insurance loss distributions, divestment actions relating to potential stranding of assets, municipal mitigation and financing activities and financial innovation. Giglio, Kelly and Stroebel (2020) indicate that the academic profession is trying to make up for lost time with a surge in research activity that they label as the "rise in Climate Finance" research within their review of this nascent but growing literature.

[3] In July 2019, bond rating agency Moody's Investor Services acquired a major stake in climate risk analytics provider 427, and in August 2020 began including climate risk data analytics in commercial mortgage backed securities (CMBS) reports. In October 2020 CMBS information and analytics firm Trepp announced an integration with Risk Management Solutions (RMS) to provide climate risk scores for properties in CMBS pools. Smith (2021) provides a recent overview of climate risk assessment methodologies of 19 service providers, including 427 residential mortgages suppliers (RMS), for UNEP FI. Blackrock (2019) examined the impact of recent Hurricanes in Houston and Miami on property collateral for commercial mortgage backed securities (CMBS) and illustrate how a warming climate could lead to rising CMBS loan loss rates over time.

to provide protection or/and compensation. These views are developed further later in the paper.

Nonetheless, knowledge of the potential impacts from SLR is growing and with it, higher price discounting (Beck and Lin, 2020) or lower rates of price appreciation (Tyndall, 2020). This greater level of knowledge led McAlpine and Porter (2018) to conclude that some quantifiable level of price adjustment could be discerned in coastal Florida, although the adjustments were small.

Residential owner-occupiers may well not have access to, or consider, long-term impacts. This could be a matter of lack of knowledge or data, but beliefs as to whether SLR will/will not occur can influence whether, and by how much, prices are negatively affected (Bakkensen and Barrage, 2021; Baldauf *et al.*, 2020; Murfin and Spiegel 2020). In contrast, investor owners are more likely to factor in long-term impacts. They may discount long-term values in much the same way as, in non-risky locations, a long leasehold will command a lower value than a freehold (Bernstein *et al.,* 2019). Those with short-term interests, such as tenants (or older purchasing homeowners), will be less concerned with long-term risk altogether. Therefore, rental values are less likely to be impacted than capital values (Bernstein *et al.*, 2019; Miller *et al.,* 2019). A lack of liquidity can be an early sign that SLR is starting to impact on markets, before prices move negatively, but eventually a tipping point for prices will occur (Keys and Mulder, 2020).

Finally, the impact of SLR is only one risk among many climate risks and being 'chronic' (and in fact not presently 'realised' in most cases), other acute climate factors or positive factors such as amenity, may outweigh the risk, making isolation of SLR as a separate price influence difficult (Keenan et al., 2018). Indeed, Keenan et al, provide empirical evidence that the rate of appreciation of house prices since 2000 is negatively related to elevation; appreciation in the lowest elevation locations has not kept up with the rates of appreciation of higher areas. The authors conclude, albeit tentatively, that this shift of preferences and perceptions may be anticipatory of further climate change effects which will affect both marketability and valuation of properties where their resilience and exposure to SLR varies.

The still seemingly 'far off' nature (even if inevitable in scientific evidence), leads to a view that it is still too early to find evidence based on recent transaction prices (i.e. somewhat backward-looking literature). Nonetheless, for investors, there is some evidence of early price movement in high-risk areas where there is limited confidence in municipality ante-event mitigation schemes and insurance or public bail-out protection. The main inference that can be drawn from this is that value preservation moving forward is dependent on collective action by communities, individuals and government officials to reduce risks through reasonable adaptation measures.

Perceptions and beliefs

Several references have been made to the impact of perceptions and beliefs in climate change on observed prices. It is perhaps not surprising that a link should exist - after all, if there was no belief that climate change is happening, *ceteris paribus*, it would be reasonable to expect that markets would be unaffected. However, where belief exists, depending on the level and type of perceived risk presented by climate events, logic would suggest that price impacts should result. The evidence that perceptions and belief affect pricing mostly sits within the U.S. residential market literature and much of this relates to SLR.

Baldauf *et al*. (2020) undertook a large-scale quantitative study using Gallup poll results on beliefs in the risks of global warming to respondents' way of life. They then sought to establish whether these beliefs were revealed in the transaction prices of properties at high risk of *future* climate impacts (i.e., potential SLR inundation) rather than those properties that had seen value change as a result of *past* events, such as storm surge, wildfire or flood. The findings pointed to a variation of more than 7% between homes situated in 'believer' and 'denier' neighbourhoods but declined to conclude whether deniers *underplay* the risks or 'believers' over-estimate them.

Bernstein *et al*. (2019) found that investors, who they claimed were better risk-informed than owner-occupiers, discounted values to a greater extent in reflection of risk from SLR. They also suggested that greater information tended to lead to a greater belief in SLR. Meanwhile, Bakkensen and Barrage (2021) using a combination of hedonic analysis and door-to-door surveys in Rhode Island found that properties at risk of coastal flooding were overvalued, but the amount of overvaluation was sensitive not just to climate beliefs, but also to whether there was a perception among buyers that future policy measures might mitigate any impacts. This may point to trust in government action, and future insurability may also influence the perceived significance of the risk. These findings support those of Bhattacharya-Mis and Lamond (2015), who concluded that those with flood experience were more tolerant of the risk, but also had enhanced knowledge of, and belief in, the impact of mitigation activities.

The ability of events to change beliefs was also underscored by Ortega and Taspinar (2018) in their study of New York house sales both before and after storm Sandy. They concluded that, whilst increases in knowledge and information may lead to incremental behaviour change, a sudden extreme event can produce a more extensive and persistent change in beliefs, in this case with resultant negative price effects. Their findings pointed to how almost total denial of a risk can, when it materialises, create sudden and permanent change in attitudes.[4]

In contrast, when studying SLR price effects, Murfin and Spiegel (2020) found less clear evidence of impact. In seeking to explain this, they suggest that, if those at most risk generally are non-believers, whilst those who do believe choose to live in less exposed locations, then the price effect will not be found.

In summary, there is some evidence to support the view that pricing of residential properties subject to identifiable climate risks are influenced by beliefs; however, those beliefs are also a product of experience, knowledge of the scientific data and confidence in governments to mitigate future risks and insurers to compensate losses. While we found no studies of commercial properties that directly addressed the matter of belief, clearly where markets are well informed and confidence in governments is strong, pricing will most accurately price the risk.

[4] The findings are suggestive but not necessarily conclusive. The results are U.S. only and weighted towards one major hurricane episode hitting a major city (NYC) location for the first time. Miller et al (2019) suggest that Bernstein et al (2019) may overestimate the discount attributed to SLR due to inadequate detangling of property quality and waterfront location amenity. The lack of consensus or agreement is highlighted by the fact that Murfin & Speigel (2020), in the same journal issue as Bauldaf et al (2020), also tested whether house prices reflect differential SLR and find limited price effects; not statistically different from zero. Fuerst and Warren-Myers (2019) find no price effects of SLR in a study of Melbourne Australia residential property pricing.

Liquidity and Lender Behaviour

The influence of climate events and risks going forward on the beliefs and perceptions of market participants was considered above, largely in the context of impact on property pricing. However, private asset transaction markets adjust not only by price but jointly via changes in both price and liquidity. If the occurrence or risk of a climate event reduces the number of buyers relative to the number of existing owners, this should extend selling times and, in turn, reduce prices. Allied to this, if buyer valuations of properties in affected areas respond differently to owner valuations, say through a more rapid mark down in what buyers are prepared to pay, this will also affect prices and trading times. As sales must occur for price effects to be observed, indicators such as trading volumes or time on market may provide early signals of market reactions to climate events and risks.

Despite this, there have been very few analyses in the academic literature of how climate risks affect transaction activity. Keys and Mulder (2020) examined changes in house prices and sale volumes for coastal areas of Florida exposed to SLR. They found that sale volumes declined 16-20% relative to less exposed areas in 2013-2018, while prices continued to increase. From 2018-2020, however, relative prices in these at-risk markets declined by roughly 5% from their peak. They state that the results show how "*increasing salience of SLR risk can first result in a decline in market liquidity rather than… prices*" (Keys and Mulder, 2020: 6).

Keys and Mulder (2020) concluded that lower transaction volumes in areas more exposed to sea level rise reflected shifts in buyer demand and were not driven by changes in lender or insurer behaviour. The main justification for concluding that the decline in liquidity was not driven by reduced mortgage availability was the finding of the same liquidity change in both all cash transactions and those using mortgage financing.

While not directly impacting transactions, at least currently, Keenan and Bradt (2020) provide evidence of a shift in mortgage lender behavior in areas considered to be at higher risk of SLR. They provide evidence that concentrated local lenders are transferring risk in high-risk coastal geographies in the Southeast Atlantic and Gulf Coasts (U.S.) through increased securitization of mortgages, which is consistent with growing awareness that climate risk could impact defaults. The same behavioral dynamic as found by Ouazad and Kahn (2021) post-hurricane, but in response to a future risk and not an event—signaling that climate risk considerations are impacting mortgage default assessment and origination decisions by local lenders in high-risk areas of the U.S.

To our knowledge, there has not been similar liquidity focused research undertaken on CRE volumes or sale times, though there has been qualitative research and industry commentary on the growing influence of climate risk on stock selection and portfolio composition decisions. In ULI/Heitman (2019), concerns were noted about future liquidity for assets whose climate risk exposure was high, while investors interviewed a year later by ULI/Heitman (2020) cited instances where they claimed that climate risks were beginning to influence market selection. Kanne et al. (2017) also provided the specific example of South Florida, which they stated was excluded from investment in the case of National Real Estate Advisors. This implies that some real estate assets are becoming less liquid because of greater awareness of climate risks.

How soon any changes in liquidity occur will be influenced by investor behaviour and by how other stakeholders in real estate investment markets respond. For instance, how willing lenders will be to provide finance to potential purchasers (or refinance existing owners) and how willing insurers will be to cover potential losses from climate events. These are both factors that will influence investor interest in particular assets and locations.

SUMMARY OF KEY FINDINGS AND CONCLUSIONS

This paper has reviewed academic papers providing empirical evidence of the impact on real estate values and prices from some types of climate events and from greater awareness of climate risks. While the goal of this paper was to assess the effects for commercial real estate assets, much of the available evidence was for residential real estate and indicated that price impacts were relatively short-term in nature. The evidence is also skewed towards a handful of countries and regions (e.g., U.S., Australia, and Northern Europe)[5]. Many of the findings come with caveats to the analysis and are sometimes in conflict with similar research. For these reasons, the channels through which pricing and value are influenced by climate risks are unfortunately cloudy.

However, the review has shown that the breadth and depth of research has improved over time and it highlights more recent studies that have examined commercial real estate assets. This recent research is appearing both in real estate and in broader economics and finance journals and indicates that awareness of climate risks is starting to have a more sustained impact on pricing and on investor decision-making. The key takeaways or conclusions that commercial real estate investors can draw from this literature include the following:[6]

- ✓ Property prices decline after climate events, but historically the drop has generally been modest and short-lived in locations where there is strong awareness of, and experience with, extreme weather-related events.
- ✓ There is a small body of recent evidence that certain events can lead to a long-lasting decline in prices or liquidity in geographies that have historically been relatively unexposed to extreme weather or climate events, or where intensity and frequency have appreciably increased.
- ✓ Trading volumes or time on market may provide early signals of how markets are reacting to climate events and risks through lower liquidity that could ultimately feed into prices.
- ✓ Proactive public investment and strong governance as risk mitigating factors may contribute to the modest and short-term nature of pricing reductions.

[5] Noting that the literature search was limited to English language papers and publications and the results may have been narrowed as a result.

[6] This paper has focused primarily on empirical studies of the reaction of property transaction prices to flooding and hurricanes and the pricing of SLR at the asset level. Clayton, Devaney, Sayce and Van der Wetering (2021) provide a more extensive and comprehensive review of the academic literature that also includes coverage of wildfire events as well as exploration of the role played by additional external "Market Factors" in the impact of climate risk. Key factors explored include adjacency and amenities, governance, insurability, valuation practices and asset level investment in resilience.

- ✓ Commercial owners/investors in some geographies are placing a higher risk premium on all properties in metro areas affected by climate events, regardless of whether their individual properties have been directly affected.
- ✓ There is some evidence from residential markets that levels of belief in climate change and its impacts may result in differing levels of price impacts of climate risk.
- ✓ There is evidence in the U.S. context of lender concerns about climate risk being manifested through a shift in mortgage originations to loans that are able to be securitised.

This paper aimed to help address a perceived gap in market participants' in-depth understanding of pricing signals and value at risk from the physical impacts of climate change. Without a foundational understanding of the empirical evidence for how markets have responded to extreme weather events, it is hard to make assertions on how modelling practices should be structured or investment / portfolio allocation decisions weighted to best balance risk and return. The thinness of the empirical evidence base suggests further research is needed to better understand the transmission channels through which pricing and value impacts are revealed, and to inform policy makers, regulators and practitioners in their efforts to increase resilience and advance socially equitable markets.

The paucity of commercial-focused literature revealed by this review has affirmed the need for open, or shared, access to data to better enable rigorous academic investigation. Detailed property level data is crucial. Information in relation to asset-specific data, including for example capex and retrofit investment, transaction details that capture not only price but holding period and even identification of buyer and seller investor type, leasing agreements and insurance data would provide a platform to more extensively assess the impact of physical climate risk on investment performance.

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