STAFF
REPORTS

NO. 991
NOVEMBER 2021

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FEDERAL RESERVE BANK *of* NEW YORK

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Federal Reserve Bank of New York Staff Reports, no. 991
November 2021
JEL classification: Q54, Q58, D63

Abstract

We conduct a review of the existing academic literature to outline possible links between climate change and inequality in the United States. First, researchers have shown that the impact of both physical and transition risks may be uneven across location, income, race, and age. This is driven by a region's geography as well as its adaptation capabilities. Second, measures that individuals and governments take to adapt to climate change and transition to lower emissions risk increasing inequality. Finally, while federal aid and insurance coverage can mitigate the direct impact of physical risks, their structure may—inadvertently—sustain and entrench existing inequalities. We conclude by outlining some directions for future research on the nexus between inequality and climate change.

Key words: climate, natural disaster, inequality

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Introduction

Although the effects of climate change on economic output and financial stability have received considerable attention in public discourse, scholarly literature, and policy discussions, the interactions between climate change and income, wealth and health inequality[1] have received far less discussion. However, it is increasingly likely that climate change will not only have important effects on economic output, but that it will have profound effects on the geographic, socioeconomic, and demographic distribution of output. This paper presents a literature review of existing evidence on mechanisms by which climate change can affect economic inequality in the United States. First, we review whether risks from climate change affect populations and regions differently. Second, we consider whether institutions and policies around climate risk may have differential effects in different regions and on different communities. Finally, we identify open questions and gaps in the literature that could benefit from additional exploration and research.

Risks associated with climate change can be decomposed into two categories—physical risks and transition risks. Physical risks refer to the potential for losses as climate-related changes (storms, droughts, floods, sea level rises, etc.) disrupt business operations, destroy capital, and interrupt economic activity. Transition risks refer to the potential for losses resulting from a shift in policy (for example, moving toward a lower-carbon economy), consumer sentiment, technological innovation and many others that will affect the value of certain assets and liabilities. Transition risks can also take the form of personal adaptation mechanisms to combat climate change through migration or innovation. We discuss in sections below whether these physical and

[1] We interchangeably use "economic inequality" to describe these inequalities.

transition risks associated with climate change are uneven across geography, income, race, and age.[2]

We find multiple important channels, highlighted by various strands of literature, that point to the hypothesis that the heterogeneity in direct physical impacts of climate change, the differential adaptation capabilities of different regions, and the effects of climate policy and institutions may work to increase economic inequality. First, the literature on the geographic location of the direct physical impacts of climate change suggests that regions of the United States that are home to above-average shares of low-income and minority groups are likely to suffer the greatest meteorological effects of climate change. In particular, the U.S. South, with the lowest per capita income of the U.S. census regions, is predicted to experience the greatest level of total direct damages from climate change.

Second, a growing literature in household finance presents evidence that low-income and minority Americans are limited in how they may adapt to climate change because they have less access to insurance and are less likely to have access to credit when needed. Moreover, another growing body of work suggests that a major adaptation mechanism to climate change worldwide will be migration to the United States from low-income countries that will be even more affected by climate change. This migration is likely to mechanically increase inequality (the indirect effects through wage pressures are more mixed). The literature on the labor market effects of transition from high- to low-carbon technologies does not provide hard evidence that additional jobs will be created on net, and there may be some evidence that the jobs created will tend to require higher skills. On the other hand, there is a solid literature showing that adaptation to climate change in

[2] See Chakrabarti (2021).

the United States so far has improved health outcomes for low-income and minority populations in the U.S. Southeast.

Finally, a large literature documents that institutions (such as the Federal Emergency Management Agency (FEMA), banks and nonbank financial institutions and the National Flood Insurance Program) can play an important role in mitigating the impacts of risks, including climate risks, but often provide aid in ways that sustain existing inequalities, even if inadvertently. Such a pattern pertains to the disbursement of disaster insurance, as well as to public policy in urban design and the siting of environmentally hazardous facilities.

I. Do Physical Effects of Climate Change Increase Inequality?

In this section, we discuss whether physical risks from climate change affect geographies and populations differently. We start with the geographic distribution of climate risk and find that the incidence of the direct physical impacts of climate change is very heterogeneous across regions. We then discuss whether climate change and disasters affect mortality, location of residence, productivity, and conflict by demographics, socioeconomic characteristics, and geography.

A. *Differences in Regional Distribution of Climate Risk*

Regional disparities in climate risk and natural disasters are undeniable. The Fourth National Climate Assessment (Carter et al. 2018) highlights that the U.S. Southeast is expected to be especially exposed to climate change. That region is home to three of the nation's five large cities with intensifying heatwaves along multiple dimensions (including intensity, duration, etc.)—Birmingham, New Orleans, and Raleigh—and is also uniquely exposed to vector-borne diseases. The U.S. Southeast also has a long ocean coastline that is highly exposed to hurricanes. The National Climate Assessment states that "many Southern cities are particularly vulnerable to the

effects of climate change compared to cities in other regions" because Southern cities are disproportionately located in floodplains and have older infrastructure. The Southeast is not the only region expected to be affected by climate change. For example, the National Climate Assessment notes that the share of forest area burned by wildfires in the Southwest in 2015 would have been approximately half as large if not for the effects of climate change, while as recently as in 1995, climate change accounted for only a small fraction of this share.

There may be further inequality in the impact of physical risks from climate change within regions if individuals who live in the most detrimentally affected areas also tend to be disadvantaged ex ante. Buchanan et al. (2020) identify the coastal states and cities where affordable housing—both subsidized and market driven—is most at risk of future flooding and rising sea levels (Exhibit 1). They find that residents in low-lying affordable housing, who tend to have low-incomes and to live in old and poor-quality structures, are especially vulnerable to sea level rise and increased coastal flooding (see also Sisson 2020). The U.S. Southeast has a longer coastline—from the Chesapeake Bay to the mouth of the Rio Grande—than any other region in the continental United States, making it particularly exposed to coastal flooding. In contrast, California and the Mid-Atlantic region—New York, New Jersey, and Connecticut—have shorter coastlines but more dense economic activity on their coastlines.

Evidence also indicates that already disadvantaged neighborhoods are particularly affected by the direct impacts of climate change. Bleemer and van der Klaauw (2017) find that after Hurricane Katrina, declines in homeownership of affected households were markedly smaller for individuals from predominantly white neighborhoods than for households from minority neighborhoods and also, for individuals with high credit scores than those with low credit scores. A number of studies have also documented that homes in areas of higher flood risk are often

discounted aggressively as a direct consequence of being exposed to this flood risk (see Bin and Polasky, 2004; Bin et al., 2008; Kousky, 2010; and Atreya et al., 2013).

Lin, Ma and Phan (2021) provide survey evidence that minorities are also disproportionately likely to be located near environmentally hazardous sites despite being more worried about pollution. Multiple journalistic investigations (see for example, Plumer and Popovich (2020)) document that low-income and minority areas of many U.S. cities have considerably fewer green spaces and considerably more concrete paving than do more affluent and non-minority areas, and that these areas are also considerably hotter. Given that the climate damage function is likely convex (Hsiang et al. 2019), similar increases in temperature in warmer localities in cities are likely to lead to greater damages to productivity and health than they would in cooler areas. In particular, Heilmann and Kahn (2019) document that the increased urban heat island effect in minority areas contributes to higher rates of violence in these areas.

Gillingham and Huang (2021) find that air pollution from maritime ports has uneven effects on health outcomes across racial groups. Increases in air pollution stemming from weather-driven vessel stays in port have lead to three times as many hospital visits per capita among Black individuals in nearby communities as among white individuals. As climate change has increased the forest area consumed by wildfires in the West (Abatzoglou and Williams 2016), and as forest combustion generates particulate matter that pollutes the air, the health damages from climate-change driven air pollution will be distributed unevenly across regions. Pollution from forest fires can affect regions far away from the location of the original fire, for example, pollution from the Bootleg Fire in Oregon reached Chicago and New York in July 2021 (Schwartz 2021), implying that Western wildfires will continue to affect not just the Pacific west and the Northwest, but also areas far away from this region.

B. Distribution of Mortality Risks

Human beings are optimized for relatively mild temperatures, so extreme heat or cold tends to result in excess deaths. Climate change may affect mortality through increasing the prevalence of extreme heat, decreasing the prevalence of extreme cold, or increasing the prevalence of extreme temperatures through greater variance in the weather. Hsiang et. al. (2017) look at the spatial difference in all-cause mortality rates across the United States. They find that warming reduces mortality in cold northern counties while it increases mortality in hot southern counties (Exhibit 2).[3] The resulting pattern induces substantial increases in mortality (up to 80 per 100,000) in the U.S. Southeast as well as parts of the Southwest (for example, southern Arizona), smaller mortality increases (20 per 100,000) at the latitudes of Maryland and Missouri, and mortality *decreases* in most of the Northeast, the northern part of the Midwest, some areas of the Plains and Mountain states and in the Pacific Northwest.

C. Differential Productivity Shocks by Sector

Another way in which climate change could increase inequality is by directly lowering productivity in certain industries that employ the poor and on which the poor rely, for example agriculture. Declining agricultural yields may result in increased food prices (Crane-Droesch et al. 2019) and given that low-income communities spend a higher proportion of their budget on food, this can have disproportionate effects on them. However, Deschenes and Greenstone (2006) argue that, on average, the effects of climate change on U.S. agricultural productivity are ambiguous, with the best evidence (based on panel data associations between weather and agricultural

[3] These estimates include not only the direct effects of changing temperatures but the indirect effects of unequal adaptation capabilities.

outcomes) being consistent with very modest declines. Such an average result is reassuring from the point of view of food prices (which, in a frictionless market, should depend only on average agricultural productivity). Nevertheless, the effects of climate change on the agricultural sector may influence inequality through other channels. The Fourth National Climate Assessment (Carter et al. 2018) states that counties in the Southeast will lose the greatest number of labor hours, on average, relative to counties in other U.S. regions, largely because they disproportionately rely on rural economic activity that is particularly sensitive to changes in heat and humidity. More generally, Hsiang et. al. (2017) show that climate change will generate agricultural productivity improvements at higher latitudes and agricultural productivity declines at lower ones. Exhbit 3 depicts the redistribution in agricultural yields across the United States, where the most negative impact is seen in predominantly lower-income counties in the South.

Like food, energy is an important component of the budget of the poor. Hsiang et al. (2017) provides evidence that energy expenditures are likely to disproportionately rise in the Southeast as a consequence of climate change, which may disproportionately affect low-income individuals.

It is worth considering the direct effects of climate change on economic activity more generally. Roth-Tran and Wilson (2020) investigate the effect of natural disasters and find evidence of increases in per capita personal income over the long run, although they find considerable heterogeneity in impacts by pre-disaster county income. Differentiating by quartiles of pre-disaster county income, they find that counties with below-median pre-disaster income per capita did not see an increase until six years after the disaster while above-median counties saw an increase one year after the disaster. Therefore, climate change may make the distribution of economic activity more unequal even without affecting it on average.

D. Distribution of Climate Effects on Conflict

Additionally, there is research showing that extreme climate conditions increase conflict and crime. Burke et. al. (2015), in a meta-analysis of fifty-five studies encompassing developed and developing countries, including the United States. They show that deviations from moderate temperatures and precipitation patterns systematically increase conflict risk, with contemporaneous temperatures having the largest average impact on interpersonal and intergroup conflict. They also find that in low-income settings, extreme rainfall events—too much or too little rain—that adversely affect agricultural income are associated with higher rates of personal violence and property crime. Relatedly, Hsiang et. al. (2017) present the spatial distribution of the expected effect of climate change on property crime and violent crime rates across the United States (Exhibits 4-A and 4-B). They find that effects on violent crimes is uniform across locations while the effects on property crimes are more concentrated in the North. Hence, rising crime is likely to work *against* the tendency for regional inequality to increase, which we observe from the other channels considered.

E. Summary

The literature we reviewed shows that physical risks from climate change exacerbate inequality by income, race and geography, with the U.S. Southeast experiencing more direct physical risks than other parts of the country. These physical risks from climate change take the form of differences in effects on mortality, housing, consumer finance, conflict, and geography. Taking into account a large number of factors including agricultural yields, mortality, energy expenditures, risks to labor, coastal damage, property crime, and violent crime, Hsiang et al. (2017) computes a measure of total direct damages from climate change for U.S. counties, which is illustrated in Exhibit 5. Warming due to climate change results in a net transfer of value from Southern, Central, and Mid-Atlantic regions towards the Pacific Northwest, the Great Lakes

region, and New England. This echoes the consensus that damages from climate change will be distributed very unevenly across different parts of the United States. The preexisting inequality between the U.S. Southeast and the rest of the country will possibly be exacerbated by climate change. We next turn to transition risks and review whether they have unequal effects across populations and geography.

II. Do Adaptations to Climate Change Increase Inequality?

Adaptation, according to the Intergovernmental Panel on Climate Change (IPCC), is defined as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Parry et al. 2007). This could be understood as adjustments done in terms of changes to existing technologies or innovating new technologies, or as a decision to migrate away from areas with higher climate risk.

Besides the unequal distribution of the direct physical impacts of climate change, unequal reaction to these impacts plays at least as large a role in shaping the way in which climate change may affect inequality. In fact, Dell, Jones, and Olken (2012) find that the magnitude of short-run effects of temperature on economic activity is so large that absent adaptation, just eight years of temperature differences across countries would be sufficient to explain present-day cross-country income differences. Dell, Jones, and Olken (2008) find that countries with higher GDP experience very little sensitivity of economic activity to temperature and precipitation changes because of better adaptation (such as, potentially, air conditioning and other infrastructure to reduce exposure to extreme heat), while poorer countries see considerably larger effects, both to the level of output and to their long-run growth rate. The findings of these studies have implications for the U.S.

regions, suggesting that poorer regions in the United States—specifically, the South—may see larger level and growth effects from climate change than would richer U.S. regions.

A. Innovation

There is evidence that some adaptation to climate change has proceeded in ways that reduced inequality. Barreca et. al. (2016) focus attention on the spread of health-related innovations: residential electricity and residential air conditioning. These innovations have helped mitigate the health consequences of hot temperatures, especially for populations that are more vulnerable, for example, individuals aged 65 or above and Black residents relative to white residents (Barreca et al. (2016)). Electrification has enabled a wide variety of innovations including fans, refrigeration, and air conditioning. Air conditioning has made it possible to reduce the stress on health during periods of extreme heat.

Apart from this, increased access to health care has enabled both preventive treatment and emergency intervention, such as the intravenous administration of fluids in response to dehydration. Another innovation that has garnered attention is elevating homes in flood-prone areas to reduce potential damage. However, access to some of these adaptations is likely not equally distributed, rather they tend to vary markedly by income (for example, it costs nearly $50,000 to elevate an average house (Fixr 2021), a substantial fraction of median household income).

B. Labor Market Effects

As the U.S. transitions from a high-carbon to a low-carbon economy, changes in the labor market become an important channel through which adaptation to climate change may affect inequality. Acemoglu et al. (2012) and Cruz-Alvarez and Rossi-Hansberg (2021) document that

such a transition is expected to take place to avoid an environmental disaster or energy resource depletion. Metcalf and Stock (2020) use variation in European carbon price adoption across space and time to conclude that the effects of plausible carbon price increases in the United States on employment should be minor, while Hafstead and Williams (2018) reach a similar conclusion using a computable general equilibrium model. However, the aggregate result masks considerable variation in job destruction and job creation across industries. Greenstone et al. (2002) and Castellanos and Heutel (2019) show that jobs in fossil-fuel industries are likely to bear the brunt of the job destruction, requiring substantial reallocation of workers if employment overall is to remain steady. Vona et al. (2015) document that environmental regulation will reward "green skills," among which are "high-level analytical and technical know-how related to the design, production, management and monitoring of technology," which likely may increase inequality by rewarding already highly valued and expensive-to-obtain skills. Popp et al. (2020) consider the impact of the green component of spending under the American Recovery and Reinvestment Act, finding that it created fewer jobs than similar non-green components of the act, and that while the jobs were mostly in manual labor, they still required some college education and did not change equilibrium wages. Therefore, the literature seems to provide evidence for only marginal changes to aggregate employment, with gross jobs created likely to require higher skills.

C. Effects of Climate-Change-Induced Migration on Inequality

Another important factor to consider is migration, and how uneven migration patterns following a disaster may be across different social groups. Individuals from high-income areas are more likely to move following a disaster, just as households in predominantly white neighborhoods are more likely to migrate after a disaster (Bleemer and van der Klaauw (2017); Roth-Tran and Lynn-Sheldon (2020)). Interestingly, Fussell, Sastry, and Van Landingham (2010) actually show

that after Hurricane Katrina, Black residents returned to New Orleans at a much slower pace than white residents. The delayed return was driven by the more severe housing damage that Black residents had faced because they tended to live in areas that experienced greater flooding. Moreover, climate change may be leading formerly minority communities to gentrify at a more rapid rate. For example, due to their relatively high elevation for the Miami-Dade metro area, traditionally minority neighborhoods, such as Liberty City and Little Haiti, are seeing rising property values that are making homes unaffordable for residents, reflecting the new preference of high elevation (see Harris 2018). This combination of rising prices in higher elevation neighborhoods and declining property values in more exposed coastal areas may further contribute to the cycle of disproportionate exposures to rising sea levels in low- and moderate-income communities. Bakkensen and Ma (2020) also find clear evidence that low income and minority residents are more likely to move into high-risk flood zones. These findings highlight the difference by income and race in both the ability to migrate to better outcomes after a negative disaster shock and also in being pushed out to locations more susceptible to climate risk.

More generally, migration is likely to be key to mitigating the direct impacts of climate change, so it is important to consider the broad implications of migration for inequality. Alvarez and Rossi-Hansberg (2021) find that optimal migration responses to climate change would entail large population flows from the global South to the global North (including to the United States) and would halve the decline in economic activity that would be caused by climate change in the absence of migration. Therefore, it is possible that the United States would receive substantially more immigrants from poorer countries because of climate change, with the U.S. Southwest a likely initial destination for many of them as it is geographically closest to the U.S. land border with Mexico. Mechanically, an inflow of individuals considerably poorer than the average of the

receiving population should increase inequality, and Card (2009) suggests that these mechanical effects create small but positive increases in inequality in general equilibrium. However, there is debate on whether low-skill immigration lowers wages in low-skill occupations, with, for example, Borjas (2017) and Peri and Yasenov (2015) taking opposing views. Nevertheless, the mechanical effects of immigration alone should contribute to higher inequality within U.S. borders, though likely lower inequality in the world taken as a whole.

D. Summary

Societal and economic adaptations to climate change will take many forms. Although technological innovations and adaptations may improve some communities' resilience to heat and disease, it is the higher-income communities and populations that are more likely to benefit. Many regions of the United States are likely to face labor market disruptions as the economy adapts to new climate and regulatory challenges. While small in the aggregate, these labor market disruptions are likely to primarily impact poorer households and communities throughout the South. Moreover, as people leave areas in Central and South America that suffer particularly large damages from climate change, large scale migration to the United States is likely to place pressure on—and adversely affect inequality in—the South, which is the region closest to the U.S.-Mexican land border.

III. Do Institutions Tackling Climate Change Increase Inequality?

Along with the gaps created between different communities due to the direct loss from climate change, the ability to migrate, and access to mitigating technology, another important factor to consider is the role of institutions and policies. The most prominent institution is insurance—both individual and federal disaster insurance. The provision and take-up of both types of insurance,

along with the provision of credit is often correlated with the pre-existing wealth and regional racial composition. This means that the uneven distribution has potential to create further imbalance, especially in areas that are ex-ante economically depressed.

A. Insurance

The availabilityof private insurance significantly affects the long-term economic costs of natural disasters for individual households. Uninsured losses are a primary driver of the adverse macroeconomic consequences that follow a disaster (Von Peter, Von Dahlen, and Saxena 2012). In the United States, mortgage lenders are able to requireflood insurance in regions designated "flood zones" by FEMA as part of the mortgage contract[4]. However, as Kousky (2018) finds, natural disasters have recently flooded historically safe areas, leading to uninsured household losses. Chart 1 shows that uninsured losses have been rising globally in recent years as disasters become more frequent and severe. This increase has been most severe in less developed countries, where insurance penetration remains much lower than in, for instance, the United States (Chart 2).

Even within the United States, the take-up of insurance varies a great deal and insurance penetration remains relatively low. Atreya et al. (2014) analyze flood insurance purchasing behavior using data for Georgia from the National Flood Insurance Program (NFIP), which provides federally subsidized flood insurance to property owners and renters. Atreya et al. find that education plays a significant role in a person's willingness to purchase flood insurance. Households with more education are more likely to purchase flood insurance. Additionally, in the sample of people studied, individuals over the age of forty-five and African Americans are, all else equal, more likely to purchase insurance. Another reason for low NFIP take-up may be its pricing.

[4] Note that only about half of the owner-occupied homes are mortgaged.

As Kousky (2018) points out, given minimum insurance thresholds, the NFIP is disproportionately overpriced for people insuring low-value properties, inadvertently making such insurance relatively unattractive.

The NFIP helps the households that are able to make use of it rebuild after a disaster. Unfortunately, this tends to prevent some lower-income households that would wish to relocate to a safer area from doing so. As a consequence, the NFIP frequently rebuilds the same properties several times— although it would have been far cheaper to help the insured family relocate (see National Resource Defense Council (NRDC 2017) for a discussion). As such, it inadvertently traps some low-income households unable to move away from areas of risk to natural disasters (NRDC (2017)).

A study by Knighton et al. (2021)[5] examines differences in flood-risk mitigating behavior by race. Using data on flood insurance loss claims and active insurance policy records from fifty U.S. metropolitan areas, they identify two types of communities: "risk-enduring" with lower flood defenses and "risk-averse" with higher defenses. They find that behaviors relate strongly to composition of cities by race. Risk-averse patterns are found in areas with larger dams and a higher proportion of white residents while the opposite is true in risk-enduring metro areas. In risk-enduring cities, a steep rise in the purchase of flood insurance policies is seen after flooding, which then declines quickly. In risk-averse cities, the number of flood insurance policies tends to be more stable with few fluctuations. Major floods lead to a slight increase in insurance uptake, and the level does not drop off again over time.

[5] Also see Hancock (2021).

It seems natural that the desire to purchase insurance is correlated with risk awareness, which is itself of course affected by the occurrence of recent disasters. Ganderton (2000) as well as Petrolia, Landry, and Coble (2013) show that demand for insurance grows as disasters become more likely. They further show that insurance take-up rises as the cost of insurance falls (relative to the underlying risks), with the price acting as an important determinant of actual insurance take-up. Pricing, however, may be affected by increased risk. Tesselaar et al. (2020) model the uptake—and profitability—of general disaster insurance under various theoretical future climate paths. They find that, as climate risks increase and disaster insurance is priced to reflect these risks accurately, insurance will likely become unaffordable for large groups of people without subsidies.

The state can also help guarantee the provision of private insurance to a limited degree. For example, California prevented insurers from cancelling or aggressively repricing fire insurance policies in zip codes surrounding the areas affected by the Kincade fire. This primarily affected residents of Sonoma County and prevented insurers from cancelling maturing insurance contracts during or directly following the fires. State governments recognize, however, the limited efficacy of such policies in providing long-term insurance coverage for residents and investors in high-risk areas.[6]

Insurance is an integral mechanism through which communities recover from and adapt to climate change. However, in some communities insurance take-up is low and too often occurs after a disaster has struck. Overall, it appears that due to pricing, already disadvantaged groups—

[6] See: Swindell, 2019 at https://www.petaluma360.com/article/news/state-insurance-chief-bans-insurers-from-dropping-coverage-of-homeowners-ne/.
Silvy, 2021: https://www.northbaybusinessjournal.com/article/news/california-seeks-to-establish-new-fire-safe-standards-for-homes-insurers/.

particularly low-income individuals—may be less able to take advantage of the possibilities that insurance offers.

B. Financial Intermediation and Consumer Credit

A number of studies have found correlations between increased disaster risk and lending. It appears, however, that these correlations are further affected by the race and wealth of the individuals and communities affected by climate change. Disasters are usually followed by an increase in the demand for credit. However, insurance market imperfections with incomplete coverage of catastrophic events can restrict supply of post-disaster credit as banks become less willing to finance ventures in high-risk areas (see Garmaise and Moskowitz, 2009). The authors show that higher earthquake risk in California actually led to a *decrease* in commercial real estate bank loans in the 1990s. Importantly, the authors show that this effect of credit rationing was more severe for Black communities where insurance provision was less prevalent.

Cortés and Strahan (2017) show that banks use their internal capital markets to reallocate mortgage credit to areas affected by disasters. Banks primarily do this in support of their core markets, withdrawing funds from regions in which they have a smaller or no presence to fund these rebuilding efforts. While long-term effects may depend on the provision of credit by other entities, it is nevertheless evidence of existing bank-funding reallocation following a disaster.[7] Ivanov, Machiavelli, and Santos (2020) document that a similar reallocation takes place for corporate credit. They also present evidence that the shadow banking system may attenuate this mechanism. Nevertheless, such a reallocation of credit may exacerbate the tendency of economically

[7] Further evidence of such reallocation of funds is also presented by Mahmoudi (2021).

underdeveloped regions to be under-banked as credit is directed to markets or customers considered “key” for a bank. These effects are not limited to the United States.

Another phenomenon of adverse lending responses to climate change is a practice known as “blue lining,” which refers to banks refusing to make loans in areas that they deem susceptible to flooding or being submerged. Blue lining results in degradation of neighborhoods in flood plains, as poor infrastructure begets more flooding, which begets worse flood scores and zoning, further resulting in less investment and housing opportunities (see Kaufman 2020). Having federal rebuilding assistance funds be linked to the value of the house, as they typically are, further disadvantages low-income communities.

The impacts of increased disaster risk on financial intermediation are not unique to households; entire regions can be negatively affected. Painter (2018) shows that poorer communities with lower credit ratings, which face long-term flood risk, pay more in terms of underwriting fees and initial yields to issue long-term municipal bonds than comparable but more affluent communities. This negatively affects the ability of such communities to issue bonds and hence finance important long-term projects (such as infrastructure development). The phenomenon reflects the market’s expectation that some, wealthier, communities will be better placed to deal with the impact of climate disasters.

Having access to credit is particularly valuable in the wake of a natural disaster. A number of papers document that credit card utilization rises after a natural disaster as households attempt to smooth the financial shock through borrowing (Gallagher and Hartley 2017, Roth-Tran and Lynn-Sheldon 2017). However, access to this adaptation mechanism is not uniform across demographic and socioeconomic characteristics. Banked households have better credit access and minority and low-income households are more likely to be unbanked (FDIC 2020). For example,

14 percent of households with income less than $40,000 are unbanked compared to 2 percent of households between $40,000 and $100,000 and 1 percent of households above $100,000. Disparities prevail by race as well. While 4 percent of whites are unbanked, these numbers are 14 percent and 11 percent respectively for Blacks and Hispanics (Morgan 2021). The most important reason cited by respondents for not having a bank account is that they do not have enough money to meet minimum balance requirements (FDIC 2020).

Lack of access to the financial system may lead low-income individuals and people of color to be less equipped to combat the direct physical impacts of climate change. The existing gaps in access to credit can be exacerbated following a natural disaster. Roth-Tran and Lynn-Sheldon (2017) also find a higher incidence of adverse credit conditions following disasters, such as bankruptcies, for low-income households.

Matching FEMA data to the New York Fed Consumer Credit Panel and using a distributed lag model, Chakrabarti and van der Klaauw (2021) study the effect of three types of disasters—hurricanes, floods, and severe storms—on consumer credit outcomes and investigate whether these outcomes vary by income and race. Their preliminary findings indicate that despite increases in credit card balances following hurricanes, credit card delinquency decreases between one to five years after the disaster. No such pattern is found for the other two disaster types. Further, they find that borrowers from low-income, predominantly Black, predominantly Hispanic and majority minority[8] neighborhoods experience an even greater decline in credit card delinquencies in the aftermath of hurricanes and floods. No such evidence is found in the aftermath of severe storms

[8] Majority-minority neighborhoods are defined as counties in which at least half the population is Hispanic, and/or non-Hispanic Black. Predominantly Black (Hispanic) neighborhoods are counties that fall in the top quartile in the population-weighted distribution of non-Hispanic Black (Hispanic). Low-income neighborhoods are counties that fall in the lowest quartile of the population-weighted distribution of median household income.

with the exception that borrowers from predominantly Black neighborhoods again experience a higher decline in credit card delinquency. These findings suggest that access to FEMA aid can benefit borrowers from minority and low-income neighborhoods, despite negative shocks from disasters.

Relatedly, Ratcliffe et al. (2019) find that the effects of natural disasters on inequality in credit outcomes are heterogeneous by disaster size because access to FEMA aid is often contingent on disaster size and associated losses. They find that medium-sized disasters are considerably more likely to widen inequalities compared to large disasters. Specifically, they show that people living in majority-minority communities that are hit by medium-sized disasters experienced an on average 31-point decline in credit scores four years after the disaster compared with a 4-point decline for affected people in majority white communities (Chart 3). In contrast, credit scores in majority-minority communities four years after Hurricane Sandy declined *less* in comparison to that in majority-white communities (10 points versus 11 points).

To summarize, the financial system provides an essential service by reallocating credit to areas experiencing natural disasters. However, the way in which it does so tends to be uneven, with already less affluent, minority-heavy, and underbanked communities benefiting less. The financial system may also disproportionately withdraw credit from such communities unaffected by disasters when a strong need for liquidity arises in a core banking market. Additionally, the literature uncovers substantial inequalities in access to credit, which appear to be softened by disaster relief insurance, such as FEMA aid. The existence of federally provided aid appears to reduce post-disaster inequality considerably relative to the baseline of no aid being distributed. However, this does not imply that the process through which FEMA aid is distributed is equitable, which will be discussed in the next section.

C. Policy

State aid constitutes an important factor in how regions and individuals rebuild after natural disasters. In the United States, FEMA can compensate even uninsured households after certain disasters. FEMA disasters are declared by the President after a natural disaster at the request of the governor(s) of the state(s) in which the disaster takes place. FEMA can then help small businesses and individuals through direct payments and typically allocates funds in accordance with needs.[9] FEMA payouts have, however, been found to be unequal across regions. For example, Billings et al. (2020), studying the effects of Hurricane Harvey, find that residents of poorer neighborhoods received 5 percent less in FEMA assistance, after controlling for damages, than residents of wealthier neighborhoods. The authors find that this effect may be exacerbated by race. A one standard deviation increase in the share of minority home owners is associated with a 14.4 percent decline in the probability that the registrant is approved for FEMA assistance. Willison et al. (2019) find that disaster relief aid, as measured by all federal funds allocated to an area, was greater and timelier after hurricanes affecting Florida and Texas than after hurricanes that hit Puerto Rico. This difference is more pronounced after controlling for the damage and death toll of the disasters.

Howell and Elliot (2018, 2019) analyze the long-term wealth implications of natural disasters and their heterogeneity by income and race. They find that FEMA aid may have played a role in widening wealth gaps between white families and families of color. White households living in counties that experienced significant disasters and received substantial FEMA aid accumulated more wealth than their counterparts in counties that received very little FEMA aid. However, Black respondents living in counties that received substantial FEMA aid accumulated

[9] Individuals with insurance will likely have to repay FEMA funds after an insurance payout while uninsured individuals can, depending on conditions, receive a reprieve from repaying funds.

less wealth than their counterparts living in unaffected counties. The authors suggest that disaster relief aid, if not implemented with awareness of existing inequalities, can exacerbate inequalities at increasing marginal levels of aid.

In summary, FEMA payouts or similar state aid may be a crucial way for communities and individuals to recover from a natural disaster. However, the above studies make it apparent that significant disparities exist in FEMA aid across different communities, even conditioning on the level of damages. The disparities in payout may inadvertently widen existing inequalities.

Another channel through which climate change may affect inequality is the measures that national, state, and local governments take to decrease carbon emissions. Fullerton (2011) lists six potential effects of a carbon permit system that could potentially have regressive effects on the income distribution, including higher relative prices of carbon-intensive goods, allocations of scarcity rents from permits, and changes in the relative returns to assets in which the rich and the poor invest. Although climate policy need not necessarily be regressive (Pizer and Sexton 2017), some important existing policies, such as clean energy tax credits, appear to be (Borenstein and Davis 2016). It may also be likely that when choosing between different policy responses to climate change, such policies may give greater weight to the preferences of higher-income individuals than lower-income individuals (Bartels 2018) and follow a direction that places the burdens of transitioning to cleaner energy disproportionately on the poor.

Government-sponsored enterprises often provide mortgage forbearance in the wake of natural and other disasters and federal agencies often encourage mortgage servicers to provide relief to struggling homeowners (see Sorohan 2018, Coloretti 2012, Board of Governors of Federal Reserve System 2020). However, mortgage forbearance can increase inequality. Mortgagors are typically wealthier, and wealthier households usually have larger mortgage balances. As a result,

mortgage forbearance can provide a relatively greater benefit to wealthier households (Chakrabarti et al. 2020).

D. Summary

There are a number of ways in which institutions attempt to alleviate the impact of climate change. However, these measures can inadvertently increase inequality. Insurance payouts, for instance, help a region recover, though private insurance may be too expensive for some households. Subsidized national insurance suffers from low take-up among the most vulnerable. In part, this may lie in the relative mispricing of low-value property insurance. Disaster payouts from organizations like FEMA have a large impact. However, FEMA payouts have been shown to exacerbate existing inequalities. Similarly, bank lending is crucial to enable regions to recover after a natural disaster, though banks have been shown to prioritize core markets. Entire low-income communities at risk of climate change, as a whole, have even found it difficult to raise funds. Finally, critical public policies for mitigating climate change may be implemented in ways that miss the groups that are particularly affected by its damages. In order to avoid exacerbating existing inequalities, programs and public policy that govern payouts and lending incentivization may have to be amended to better respond to the combined challenges of climate change and existing structural issues.

IV. Directions for Future Research

The different strands of literature that we cite provide evidence that climate change is likely to increase inequality, but more research is needed into the precise pathways by which it might do so. Below are several follow-ups that we have identified on the basis of what the most current work in the literature does not yet address.

A. Indirect Effects of Credit Chains

The literature in Section III.B. documents that banks reallocate credit toward areas that suffer natural disasters and away from the rest of their network. It would be important to understand the distributional consequence of these reallocations. Do consumer loans or small business loans shrink in relative terms when another area in the bank network experiences a natural disaster? How is the decline in lending distributed across demographic groups? It is important to understand whether the indirect effects of the rerouting of credit are substantial and whether focusing on areas that experience natural disasters may hide important channels through which climate change affects inequality elsewhere.

B. Financial Markets, Climate Risk and Inequality

There are concerns that climate change may cause a rapid change in asset valuations that may destabilize the financial system (Carney 2015). Hong et al. (2016) present evidence that asset markets, including in the United States, inefficiently price drought risk in agriculture, relating their findings explicitly to these policy concerns. However, Schenkler and Taylor (2019), present evidence of markets incorporating temperature risk into asset prices, concluding: "When money is at stake, agents are accurately anticipating warming trends in line with the scientific consensus of climate models." Although the literature on market efficiency (and inefficiency) is voluminous, the application of this literature to the possibility of systematic underpricing of climate risk is scant. Clearly, if such systemic underpricing were rapidly reversed, this would have important implications for inequality as well as for aggregate growth. On the other hand, establishing that markets efficiently incorporate climate risk would provide important clarity.

C. Heterogeneous Impacts of Disaster Aid Award Mechanisms

Section III. C. discusses evidence that there may be disparities in the way that disaster aid agencies, such as FEMA, allocate funds to individuals affected by climate change. It would be useful to analyze the sources of these disparities, drawing on the literature for the sources of demographic disparities in bank lending, such as Bhutta, Hizmo, and Ringo (2021) and the articles cited therein. It would be useful to distinguish, as the above article does, between disparities created as a function of disparate covariates that enter into algorithms, disparities created through program officer discretion, and disparities created through differential ability and willingness to disclose information by the aid applicants.

As discussed in section II.A., elevating homes in flood-prone areas is key to protecting the property against future disaster damage (Fixr 2021). Such innovations guard against future flooding, and additionally, reduce flood insurance costs. However, there are bureaucratic barriers to obtaining aid approvals and building permit applications and these may prove more costly for low- and medium-income families who often hold hourly jobs without flexibility and also may not be informed about the various options. It would be important to understand these frictions and whether they affect LMI communities differentially.

D. Federal Reserve Policies

Turning to the Federal Reserve Board policy areas, in October 2020 the Fed released an Advance Notice of Proposed Rulemaking (ANPR) on modernizing the supervisory and regulatory framework relating to the Community Reinvestment Act (CRA).[10] This is part of an attempt to get feedback on different approaches in order to more effectively meet the needs of low- and moderate-income (LMI) communities. Among the questions in the ANPR, one asked

[10] Call for proposed rule: https://www.federalregister.gov/documents/2020/10/19/2020-21227/community-reinvestment-act.

for ideas on whether disaster preparedness and climate resilience investments should qualify as CRA activities in target areas. This is consistent with key connections between climate adaptation and the CRA, within the context of disaster provisions guiding pre- and post-disaster investments, unveiled by Keenan and Mattiuzzi (2019). Some CRA qualified projects to support LMI communities are: development and construction of energy efficient and climate resilient affordable housing, installation of energy efficiency improvements in homes and buildings, creation and expansion of green jobs with family-sustaining wages and in small businesses, deployment of community solar projects, and creation of additional green infrastructure, including parks and green spaces (Willingham and Zonta (2020)). Causal research aiming to understand the potential impacts of inclusion of climate resilient investments on economic inequality and equitable growth would be valuable and could guide policy.

D. Comparing the Size of Physical Versus Transition Risks

Our review of the literature suggests that not only can the direct effects of climate change exacerbate inequality, but the process of transition to a low-carbon economy can do the same. Although the literature has not yet tried to compare the differential effects of physical and transition risks on inequality, such an analysis could inform our understanding of the costs and benefits of transition to a low-carbon economy and can potentially also inform policy. A related promising avenue of research is to investigate whether design changes in policies can reduce disparities in exposures to such transition risks. Such an understanding can provide useful information for policy and can go a long way toward alleviating inequalities during the transition to an environmentally more sustainable economy

V. Conclusion

We have considered three pathways through which climate change may affect inequality. They are (1) the unequal impact of direct physical risks, (2) the unequal capacity of different regions to adapt, and (3) the unequal impact of the responses of existing institutions. We reviewed mechanisms through which climate change may exacerbate existing income and racial inequality as well as other types of inequality, such as inequality by age, education, and health. For both the physical and transition risks of climate change, we summarized potential differential impacts that may arise by numerous factors, including race, gender, age, geography, income, education, among others. We reviewed evidence showing how climate risks pose uneven effects on mortality, housing, consumer finance, social and labor markets, crime and conflict. These disparate effects were found to aggravate economic inequality by income and race and disadvantage the U.S. Southeast relative to other regions, thus further exacerbating already existing geographical and socioeconomic inequality. These unequal effects are further exacerbated by the uneven adaptations to climate change, driven by differential abilities to migrate, adapt, or innovate to protect against climate risk. Disparate access to institutions, such as insurance and the financial system, result in even more negative effects for households. Additionally, public policy may allocate resources like federal disaster assistance and use urban planning regulations in ways that accentuate these gaps.

With the growing acceptance and understanding of how big a risk climate change poses to our community and society, we already see new structures and ideas being put into place. The Federal Reserve Board joined the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) in December 2020,[11] to be a part of the exchange of ideas, research and best practices on the development of environment and climate risk management for the financial sector.

[11] See Press Release from Board of Governors here: https://www.federalreserve.gov/newsevents/pressreleases/bcreg20201215a.htm.

Not only that, but the Fed is moving to incorporate climate risk into its microprudential oversight of banks and oversight of stability of the financial system. Even as the Fed is collecting insight on modernizing the framework relating to CRA, the Fed's current guidance[12] provides credit for financing renewable energy, energy-efficient and water conservation equipment, or projects that support the development, rehabilitation, improvement, or maintenance of affordable housing or community facilities, such as a health clinic that provides services for LMI individuals. Moreover, the state of New York has recently issued guidance[13] that banking institutions subject to the New York CRA may receive credit for financing activities that support climate resiliency of LMI and underserved communities. The current administration also has already prioritized actions on climate change and is sharpening focus on climate policy through multiple measures.[14]

As rapid changes continue to happen that are bound to have implications on inequality, potentially reducing inequalities and bridging gaps, it will be important to understand and continue to monitor how developments unfold. Needless to say, more innovative research using more comprehensive data are essential to understanding the impacts on different communities across the United States and the globe as new policies and practices are unveiled.

[12]See: CRA Interagency Questions and Answers Regarding Community Reinvestment: Guidance.
[13] See DFS Press Release here: https://www.dfs.ny.gov/reports_and_publications/press_releases/pr202102092.
[14]See Executive Order on Climate-Related Financial Risk | The White House.

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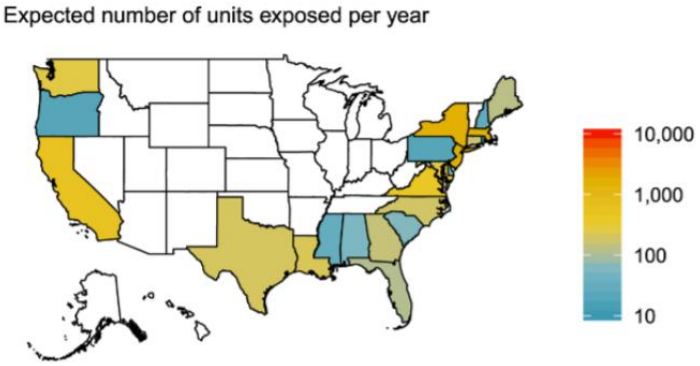
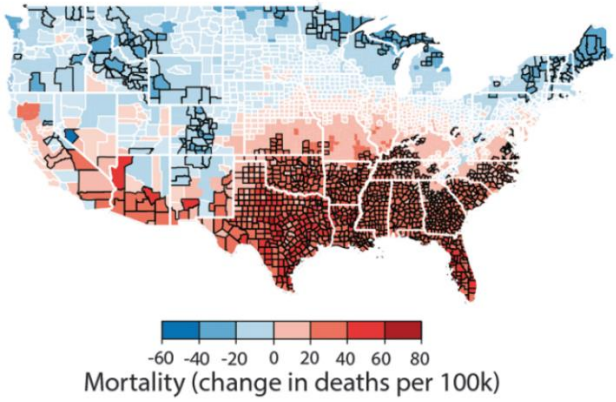
Exhibits

Exhibit 1 Regions Most at Risk of Flooding and Sea Level Rises



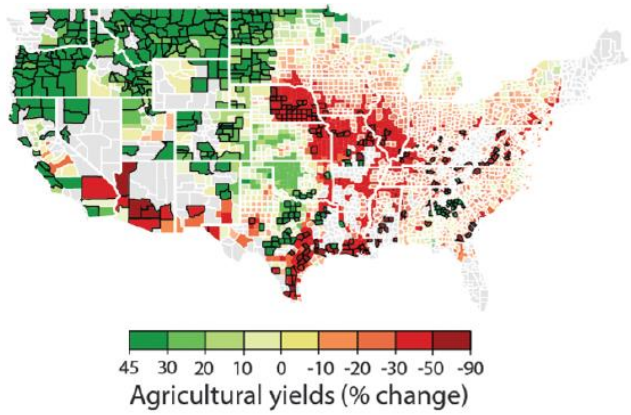
Source: Buchanan et al. (2020)

Exhibit 2 Geographic Distribution of Effect of Warming on Mortality



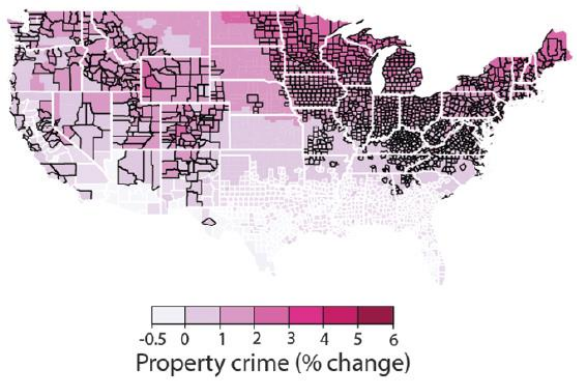
Source: Hsiang et al. (2017)

Fig 3 Redistribution in Agricultural Yields Across the US



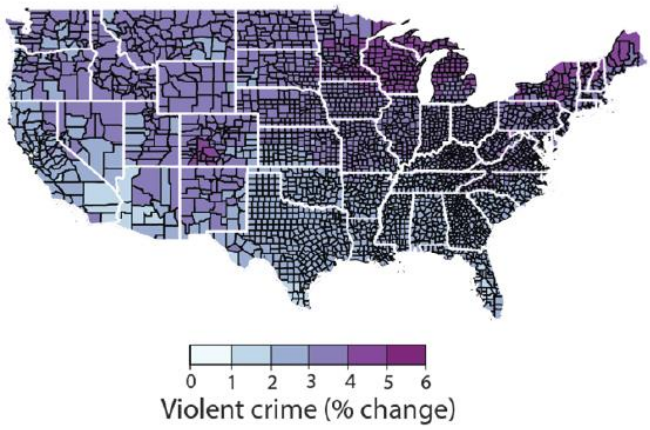
Source: Hsiang et al. (2017)

Exhibit 4-A Spatial Distribution of the Expected Effect of Climate Change on Property Crime



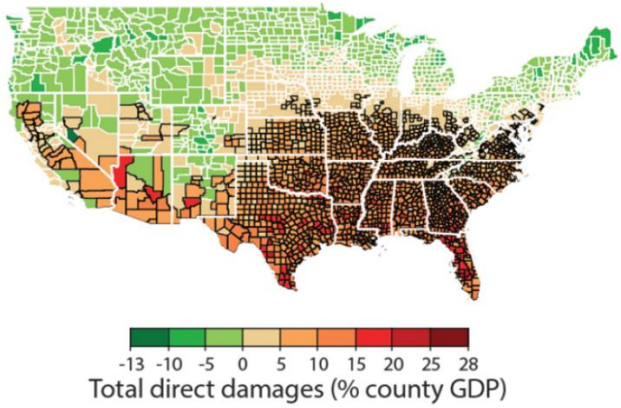
Source: Hsiang et al. (2017)

Exhibit 4-B Spatial Distribution of the Expected Effect of Climate Change on Violent Crime Rates



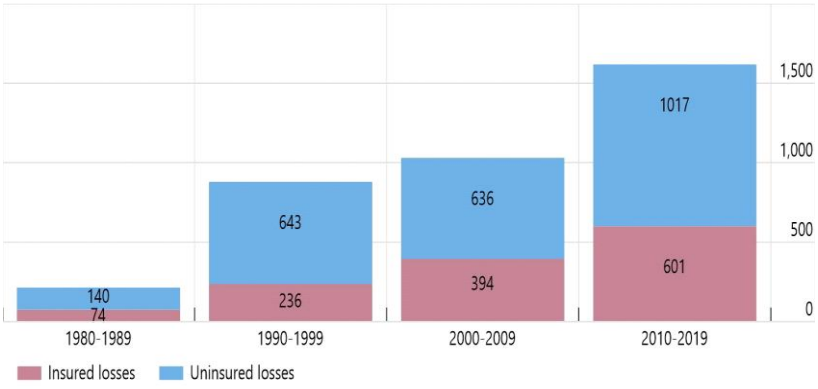
Source: Hsiang et al. (2017)

Exhibit 5 Total Direct Damages from Climate Change for U.S. Counties



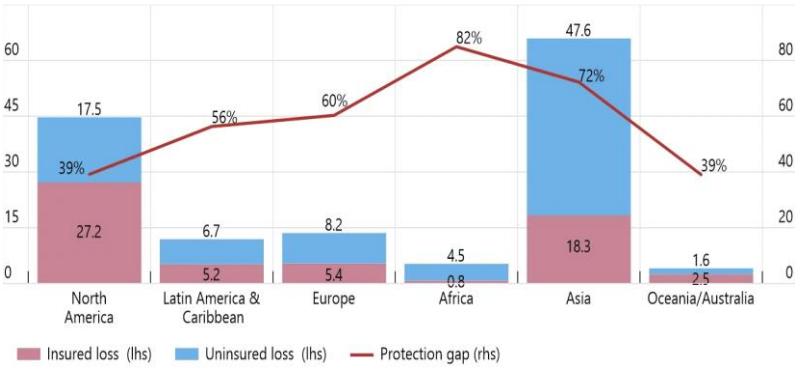
Source: Hsiang et al. (2017)

Chart 1 Uninsured Losses over Time Resulting from Natural Disasters



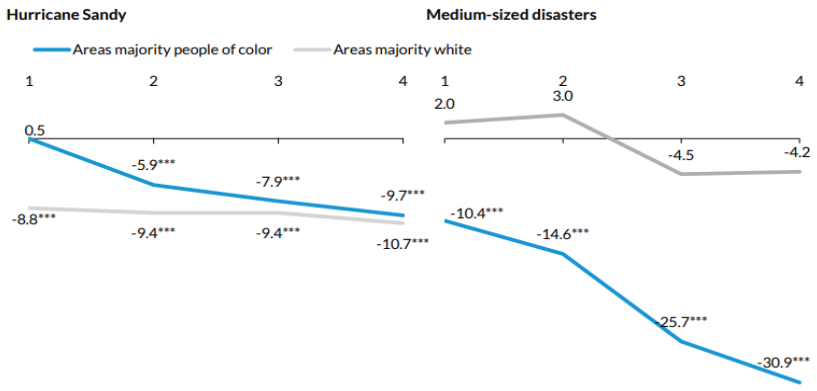
Source: AGV Report (2020)

Chart 2 Global Comparison of Uninsured Losses Resulting from Natural Disasters



Source: AGV Report (2020)

Chart 3 Change in Credit Score due to Different Sized Disasters



Source: Ratcliffe et al. (2019)