



# Long-run net distributionary effects of federal disaster insurance: The case of Hurricane Katrina<sup>☆</sup>

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## ABSTRACT

Federal disaster insurance—in the form of national flood insurance, the Federal Emergency Management Agency (FEMA), and other programs—is designed to nationally-distribute large geography-specific shocks like earthquakes and hurricanes. This study examines the local long-run distributionary effects of Hurricane Katrina and the subsequent policy response on impacted residents. Using a unique fifteen-year panel of five percent of adult Americans' credit reports, we find persistently-higher rates of insolvency and lower homeownership among inundated residents of New Orleans ten years after the storm, relative to their non-flooded neighbors. Residents of mostly-white and mostly-black neighborhoods are similarly-impacted in the short and long run, though residents of white neighborhoods are more likely to migrate out of the city. However, residents of the large Gulf Opportunity (GO) Zone surrounding New Orleans, who were also eligible for various federal programs, obtained net financial benefits in the years following Katrina; a decade later, those residents have higher rates of consumption and homeownership, are more likely to have paid off their mortgages, and have lower rates of bankruptcy and foreclosure than residents outside the GO Zone. These net subsidies are found to be progressive—favoring young and low-income residents of the counties surrounding New Orleans—and are broadly similar across black and white neighborhoods.

## 1. Introduction

In 2017, the southeastern United States experienced three massive hurricane disasters, together killing 217 people and causing tens of billions of dollars in economic damages. While these storms were particularly damaging, they were not without precedent: More than two hundred natural disasters with losses exceeding one billion 2016 dollars have occurred in the United States between 1980 and 2016. Six of the ten costliest disasters were hurricanes, causing over \$345 billion in total damages and more than 2000 deaths (Smith and Katz, 2013). The most deadly and damaging of these storms was Hurricane Katrina, which struck the Gulf coast in August 2005. Hurricanes' economic cost is immediately experienced by the impacted communities through damaged infrastructure and disrupted economic activity, but large federal and private insurance programs spread those costs across the country in the long-run. Federal emergency insurance programs often provide additional resources to residents of impacted regions for years

following the disaster.<sup>1</sup> In this study, we examine the short- and long-term net aggregate effect of Hurricane Katrina and those insurance programs on the consumption, financial health, homeownership, mobility, and household composition of individuals whose residences were impacted by the storm.

Because many residents of hurricane-impacted regions relocate in the years after the storm, and may continue receiving federal support following their relocation, it is challenging to conduct representative follow-up surveys of impacted residents. As a result, most studies of post-Katrina outcomes have focused on short run effects one or two years

<sup>1</sup> For example, the Federal Emergency Management Agency (FEMA) maintained temporary housing units in the Gulf Region for more than six years following Hurricane Katrina. The Department of Housing and Urban Development's Katrina-related Community Development Block Grant housing programs had expended \$8.2 billion by Dec. 2008 on a variety of rebuilding activities, but expended an additional \$2.6 billion from Jan. 2009 to March 2012.

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after the storm (e.g. Fussell et al., 2010; Zissimopoulos and Karoly, 2010; Sastry and Gregory, 2014), and most studies of natural disasters' long-run impacts ignore post-storm migration by treating regions, not individuals, as the units of analysis (e.g. Cavallo et al., 2013; Barone and Mocetti, 2014). In this study, we analyze credit report data from the Federal Reserve Bank of New York's Consumer Credit Panel (CCP), a quarterly representative panel of most US residents, to follow residents of Katrina-impacted regions from the time of the storm until 2016, over ten years later. Individuals randomly drawn into the CCP remain indefinitely, enabling representative analysis of hurricane-impacted residents a decade after Hurricane Katrina. Our focus on the micro-level impact of the storm allows us to analyze the storm's distributional impacts *within region*, assigning treatment to individuals based on their pre-storm residential location.

Rather than assessing the aggregate effectiveness of post-Katrina policies in promoting New Orleans' recovery (see Deryugina et al., 2018), we focus on heterogeneity in long-term net impacts across geographic areas that were differentially impacted by the storm. Using a methodology similar in spirit to a spatial regression-discontinuity design, we analyze four distributional outcomes of natural disasters and related federal policies. First, extending previous work by Gallagher and Hartley (2017), we examine outcomes within the city of New Orleans, comparing residents that experienced sustained flooding to those whose homes were outside the most severely flooded area. This analysis tests the degree to which federal policies mitigate welfare gaps between those most damaged by the disaster and less-affected residents living in the same region; we call this the policies' *intensive* effectiveness. Rather than explicitly parameterizing welfare, we present effects on a variety of economic and social outcomes which are themselves components of individuals' broader welfare.

Second, in contrast to earlier Katrina impact studies, we compare the outcomes of residents of the Gulf Opportunity (GO) Zone—a hurricane-impacted region designated by the federal government in order to target substantial tax incentives to promote economic recovery—to those living in the five states surrounding the GO Zone.<sup>2</sup> The GO Zone encompassed six million residents, or 2.03 percent of the US population. We match GO Zone residents to observably-similar residents of nearby counties and estimate the degree to which they were impacted by Hurricane Katrina and the subsequent policy response. These residents faced a wide range of flooding and wind damage (with many residents actually experiencing little or no damage), but were safeguarded by private insurance and substantial emergency aid from the federal government. In our GO Zone analysis we first exclude New Orleans, comparing residents of less severely impacted areas closer to the border to residents living outside the GO Zone. This analysis represents a test of federal policies' *extensive* effectiveness, or the degree to which they 'normalize' outcomes for residents of less-damaged communities relative to residents outside the disaster's geographic scope. We then repeat the analysis for the entire GO Zone area, providing an assessment of how *all* impacted communities in the greater GO zone area fared compared to those outside the impacted region.

Third, we test the *breadth* of the policies' effectiveness by estimating heterogeneous outcomes across three demographic divisions which may have been importantly and differentially affected by the storm: Age, race, and income.<sup>3</sup> Finally, we examine post-Katrina migration from New Orleans and assess the effectiveness of federal policies in limit-

ing long-term population losses and in reversing short-run population outflows from the area hit hardest by Hurricane Katrina. In addition to mapping the long-term destinations of former New Orleans residents, we compare inundated and non-inundated residents to estimate migration patterns specific to inundated residents.

The region affected by Hurricane Katrina was non-randomly selected, determined by the geographical path of the storm and by topological and engineering features of New Orleans. To evaluate distributional impacts, for each subpopulation of interest we use difference-in-differences event study analysis to control for individual- and time-specific variation in characteristics and outcomes. Following (Hirano et al., 2003), we apply propensity score weighting estimated from three years of residents' pre-Katrina socioeconomic characteristics to account for regional differences in those characteristics, and show that nearly all of our weighted outcomes of interest are balanced across treatment group for five years before the hurricane.

Our analysis of the impact of Hurricane Katrina on household finance is related to that of Gallagher and Hartley (2017), who also use the FRBNY Consumer Credit Panel for their analysis, while our analysis of the storm's impact on mobility and household composition is related to Deryugina et al. (2018), who use tax return data from the Internal Revenue Service. Our study, which in part confirms those earlier papers' findings, augments them in two important ways. First, the previous studies only examined short- and medium-term effects of the storm and policies (3 and 8 years, respectively), whereas we find important dynamics in impact magnitude up to 11 years after the storm, and especially around the Great Recession. These differential effects are particularly important for policy analysis given the lengthy federal presence in the Gulf Coast area, with Katrina-related programs continuing to provide more than \$300 million dollars of local expenditure per year until at least 2012.<sup>4</sup> Second, both of these previous studies focus exclusively on outcomes for the city of New Orleans (where the hurricane was particularly damaging) as a case study of the impact of natural disasters in the United States; the former compares more- and less-flooded areas of the city, while the latter compares the outcomes of New Orleans residents to those of 10 demographically-similar American cities. Our study analyzes the impact on the most storm-impacted parts of the city, but also examines the broader effect of storm policies on the large Gulf Opportunity Zone that was affected by the storm, finding that these more-peripheral residents—who vastly outnumber those impacted by New Orleans' failed levees—actually obtained some long-run benefits from the storm's policy response relative to comparable residents just outside the Zone.<sup>5</sup> Other complementary work includes Groen et al. (2016), who study labor market outcomes in the coastal region surrounding New Orleans and find evidence of net increases in average earnings among impacted residents over seven years following Katrina.

Note that regional heterogeneity in the net impact of the hurricane not only captures differences in insurance coverage but also differences in economic damages, which themselves reflect differences in the storm's intensity and impact, as well as exposure and vulnerability to risk (including quality of construction and damage abatement activity) which vary with the average income of the local population (see Kellenberg and Mobarak, 2008 in a cross-country context). Strobl (2011) similarly showed the importance of measuring impacts at the local level, finding that hurricanes have an annual negative impact at the county level, but no effect at the state or national level. Evidence of geographic heterogeneity in impacts have been found for other natural

<sup>2</sup> The Hurricane Katrina GO Zone was designated by the federal Gulf Opportunity Zone Act of 2005. The Act also designated GO Zones for Hurricanes Rita and Wilma, but all references to the 'GO Zone' below refer to the Katrina GO Zone. Individuals living outside the GO Zone may still have been eligible for additional hurricane-related relief, which may attenuate our findings.

<sup>3</sup> While we do not directly observe race or income, we proxy income by pre-Katrina credit scores (which are highly correlated with income; see Albanesi and Nosal, 2015) and infer black and white residents from the racial distribution of their residential neighborhoods. More details are provided below.

<sup>4</sup> This study also presents a broader selection of New Orleans outcomes than either of the previous studies, and the focuses on racial heterogeneity and mobility are unique.

<sup>5</sup> Like Deryugina, Kawano, and Levitt, our empirical specification controls for sample selection using propensity scores estimated on a large set of pre-Katrina socioeconomic characteristics, and includes individual and time fixed effects. Gallagher and Hartley control for pre-Katrina socioeconomic characteristics in post-Katrina periods and directly control for adverse sample selection.

disasters as well. Instead of inundation level and FEMA disaster designation, Elliott et al. (2015) combine actual typhoon track data with a wind field model to derive an index of potential damage to evaluate the economic effects of tropical storms on coastal China. Using panel data they find evidence of large negative short-term effects on local economic activity when measured locally (using night-light intensity data), but not at more aggregated geographic levels. Siodla (2015) exploits variation (and boundaries) across city blocks in fire damage associated with the 1906 San Francisco fire to study post-fire location-specific changes in land use and residential density.

In New Orleans, we define ‘inundation’ as experiencing at least four feet of flood water, following (McCarthy et al., 2006) definition of “Severe Damage” following Hurricane Katrina, although we find similar impact estimates based on alternative flooding thresholds.<sup>6</sup> We find modest but persistent effects on inundated residents’ use of auto and consumer debt, bankruptcy behavior, and credit scores; inundated residents’ credit scores immediately and persistently dropped about six points, or 0.05 standard deviations, and consumer debt declined by \$150 per quarter (persisting until at least 2013). On the other hand, we find large persistent increases in migration and declines in homeownership rates; a decade after the storm, inundated homeowners remained ten percentage points less likely to own a home and seven percentage points less likely to reside in New Orleans. The estimates show that many inundated homeowners who moved out of New Orleans became renters. Furthermore, inundated residents remained more likely to have recently changed residences (in the past three years) as late as 2011, after which their mobility behavior reverted to that of the non-flooded control group. Household size immediately declined (by about 0.15 adults per household), with a marked transition from large extended-family households to single-adult residences (see Rendall, 2011), but the gap had largely disappeared a decade after the storm.

Among the inundated, older, higher-income, and white residents were more likely than their respective counterparts to evacuate New Orleans immediately after Hurricane Katrina, but we find little additional evidence of heterogeneous impacts across demographic group. In particular, we find no evidence that residents of mostly-black flooded neighborhoods faced more negative consumption, delinquency, homeownership, or partnership outcomes than residents of mostly-white flooded neighborhoods, despite our study’s sufficient power to identify such differences.<sup>7</sup>

Seven percent of New Orleans residents evacuated the city after Hurricane Katrina and had not returned to the city ten years later, with 13 different US states each still hosting over 500 adult evacuees in 2016. The storm’s long-term impact on out-migration contributed to large and persistent declines in the city’s population and economy. A controlled post-treatment comparison suggests that inundated New Orleans resi-

dents were more likely to move to neighboring and nearby states than their non-inundated neighbors in the year after the storm, and ten years later were more than 60 percent more likely to have migrated to Georgia and other parts of Louisiana, but they were more than 40 percent less likely to have moved north to states like North Carolina and New York; indeed they were 33 percent less likely to have moved to any Mid-Atlantic or New England state. This storm-induced change in destinations with dissimilar economic conditions in turn played a role in mediating the overall impact of the storm on the displaced and affected.

Overall, our New Orleans findings suggest a partial success of insurance and government programs in minimizing long-term intensive-margin gaps in consumption behavior and financial health outcomes, as well as those programs’ success in distributing funding across demographic groups, but suggest a failure to redress the long-term decline in homeownership that remains more than ten years after the storm.

In the expansive GO Zone, from which we initially exclude New Orleans, we find that Hurricane Katrina had immediate, substantial, and statistically-significant negative effects on consumption and homeownership. However, these declines were short-lived; by 2015, GO Zone residents were two percentage points *more* likely to own a home than non-residents. This increase in homeownership was similar for pre-storm renters and owners. Interestingly, a much greater share of pre-storm homeowners paid off their mortgage on their house after the storm, compared to unaffected pre-storm homeowners, presumably using insurance payouts. The impact also marked the beginning of a medium-term increase in residents’ credit scores along with decreased prevalence of delinquency, foreclosure, and bankruptcy. Moreover, by 2013 those who resided in the GO Zone at the time of the storm tended to have higher average consumer debt (mostly credit card)—by as much as \$160 (4 percent)—than those who lived outside the GO Zone before the storm. Given their lower delinquency rate, these trends suggest that the aftermath of the hurricane provided long-term net consumption benefits for GO Zone residents.

Given the relatively small size of New Orleans relative to the expansive GO Zone area, it is perhaps unsurprising that the findings for the GO Zone residents overall do not materially change when New Orleans residents are included. While seeing slightly larger short- and medium-term negative effects, we find larger longer-term positive effects on consumption. As expected, we also find much larger increases in relocation rates relative to those living in the “unaffected” area outside the GO Zone.

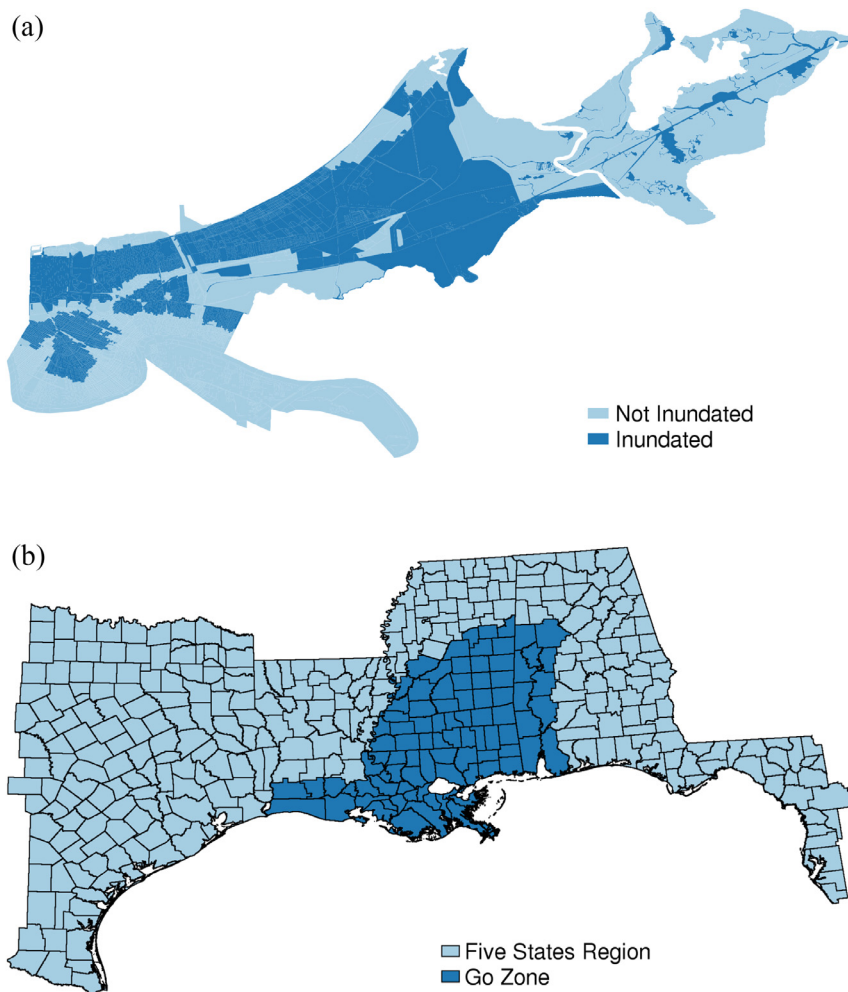
These results provide some support for the theory that post-storm insurance policies were more spatially diffuse than the storm’s economic damage, providing some GO Zone residents with long-run net subsidies relative to residents of neighboring counties.<sup>8</sup> Moreover, we find that these net subsidies were progressive—somewhat larger for young and low-income residents—and appear broadly similar for residents of black and white GO Zone neighborhoods. Restricting our analysis to counties within 25 miles of the GO Zone border (with similar results for 15 and 35 mile bands), we find that these net subsidies cannot be explained by the Zone’s peripheral residents, suggesting that residents of counties closer to (but not including) New Orleans, where flooding and high winds would have been non-negligible but limited, benefited the most from post-storm policies relative to their storm impact.

In Section 2 we provide some background on Hurricane Katrina and the various governmental programs implemented to insure residents against its associated damage. We introduce our dataset, the Consumer Credit Panel, in Section 3 and discuss our empirical approach in Section 4. Section 5–7 present our baseline results for each part of our analysis—the impact on inundated residents within the city of New Orleans, the storm’s impact on migration from New Orleans, and the impact on residents of the GO Zone within the Five States region—along with results by age, race, and income level Section 8 concludes.

<sup>8</sup> Our findings are restricted to financial compensation, not compensation in an overall welfare sense.

<sup>6</sup> While (McCarthy et al., 2006) note that “housing units in locations with 2–4 feet of standing water ... would have irreparably damaged floors and the lower portion of the interior walls”, along with damage to furniture and appliances, owners of “housing in locations with more than 4 feet of flooding ... would have to hire a contractor to manage partial or complete demolition and reconstruction or rebuilding”, citing a U.S. Army Corps of Engineers report (Pace 1988) to motivate their use of 4 feet of flooding as an appropriate severe inundation threshold.

<sup>7</sup> A number of academic Henderson (2015), private foundation (Hamel et al., 2015), and newspaper (e.g. Rivlin 2015 in the NYT Magazine and Philip (2015) in the Washington Post) reports have found that black New Orleans residents are far less likely to report post-Katrina economic recovery than white New Orleans residents. These reports all rely on current residents’ beliefs as reported in surveys and interviews instead of actual outcomes, and fail to directly account for large differences in both post-Katrina immigration and emigration by race. While we find no evidence of differential impacts resulting from inundation *within* the white and black populations of New Orleans, we are unable to test whether *all* black residents of New Orleans fared worse after Katrina than *all* white residents, independent of hurricane inundation (and pre-hurricane characteristics).



**Fig. 1.** (a) Inundation Region of Orleans Parish, by Census Tract. For reference, the most-populous area of Orleans Parish is the western portion of the city, directly below Lake Pontchartrain and above the Mississippi River. In 2005, there were about 7200 Census Blocks in New Orleans, half of which were inundated. *Source:* GCR and Associates, Inc.; available from RAND. (b) GO Zone in the Five States Region, by County The 'Five States' region includes the portions of Texas, Louisiana, Mississippi, Alabama, and Florida within four degrees longitude of the Gulf Opportunity (GO) Zone defined by the GO Zone Act of 2005. The region includes 401 counties, about 20 percent of which were in the GO Zone. *Source:* The Gulf Opportunity Zone Act of 2005.

## 2. Background

Hurricane Katrina formed as a tropical storm in the Caribbean Sea on August 23rd, 2005. By August 28th, Mississippi, Alabama, Louisiana, and Florida had been declared in states of emergency by President George W. Bush and their respective governors, while Mayor Ray Nagin of New Orleans had ordered the first mandatory evacuation in that city's history. The hurricane made landfall near New Orleans on August 29th as a Category 3 hurricane (sustained winds between 111 and 129 miles per hour) with a storm radius of over 100 miles. New Orleans experienced 14 in. of rain and a series of levee failures that flooded most of the city at depths of up to 16 feet (Kates et al., 2006). Fig. 1(a) shows a map of Census Blocks in Orleans Parish that were inundated (with at least four feet of water) by Hurricane Katrina, while Fig. 1(b) shows a map of counties and parishes in the GO Zone area that were designated by the federal government as eligible for various assistance programs. In the broader affected GO Zone region, large portions of Louisiana and Mississippi experienced wind speeds above fifty miles per hour; Katrina rendered 300,000 houses uninhabitable and left at least 2.5 million residents without electricity (Townsend, 2006).

According to the National Weather Service (NWS), Hurricane Katrina was the third most intense (as measured by barometric pressure), third most deadly, and second most costly hurricane to strike the United States between 1851, when reliable record-keeping commenced, and 2016 (Blake and Gibney, 2011). It ranked first in all three of those categories among hurricanes since 1970, and is estimated by NWS to have

caused almost \$108 billion in damages (\$129 billion in 2015 dollars).<sup>9</sup> In short, Hurricane Katrina was highly disruptive to residents of the Gulf Coast, particularly those who lived in New Orleans, and there is ample reason to expect it to constitute a substantial shock to every facet of those residents' lives.

As visualized in Fig. 1(a) and (b), not all residents of New Orleans and of the Five States Region experienced the same level of damage which instead varied greatly by geographic location. As discussed in more detail below, residents of flooded areas in New Orleans were economically worse off pre-storm (as captured by lower credit scores and homeownership rates, and higher debt delinquency and foreclosure rates) than those in other parts of New Orleans prior to the storm. Similar, though quantitatively smaller differences apply to those living in the affected GO Zone area compared to those living just outside the area. A key challenge in identifying the storm's impact will be to properly account for these pre-storm differences.

Insurance for damage caused by Hurricane Katrina came in the form of direct aid, disbursements, tax breaks, tax credits, and subsidies from the public and private sectors, but was imperfectly targeted toward residents who faced the most significant damage from the storm.

<sup>9</sup> See (Elliott et al., 2015) for a discussion of the challenges in estimating hurricane damages. This paper focuses on the distribution of individuals who face these economic costs. Hurricane Katrina is estimated to have caused four times more economic damage than all cyclones that hit coastal China between 1992 and 2010.



According to a 2010 report by the Insurance Information Institute, an industry group, private insurance payouts totaled \$41.1 billion towards more than 1.7 million claims in six states, with residents of Louisiana receiving more than \$25 billion (III, 2010). Claims were evenly split between individuals (49 percent, for homes and cars) and firms (51 percent, not including an additional \$2 billion for offshore energy and marine losses). According to the Foundation Center, as much as \$6.5 billion was also made available through private individual and corporate philanthropy, though this includes aid for other 2005 Gulf Coast hurricanes (Atienza et al., 2007).

The response of the federal government to Hurricane Katrina was manifold. In addition to the typical federal response to natural disasters, including insurance payouts through the National Flood Insurance Program totaling more than \$16 billion, the federal government implemented three large-scale programs designed to mitigate the long-term socioeconomic impact of the storm. About \$20 billion was dispersed through the Department of Housing and Urban Development's Community Development Block Grant (CDBG) program, which targeted infrastructure reconstruction focusing on affordable rental housing, federally assisted housing, and public housing (Boyd, 2011). An additional \$20 billion was dispersed through the Department of Homeland Security's Federal Emergency Management Agency, which provided short-term relief like replacement housing and furniture as well as long-term repair of public infrastructure (FEMA, 2013). These programs also funded most state responses to the storm, like the initiatives of Louisiana's Economic Development Department; for this reason, we hold the federal governments' policies comprehensively responsible for the public insurance portion of the shock caused by Hurricane Katrina.

Finally, the Internal Revenue Service offered substantial tax breaks and subsidies to individuals living or working within a federally-designated three-state Gulf Opportunity (GO) Zone. In addition to tax breaks for GO Zone businesses, GO Zone residents were permitted to use their 2004 income for 2005 EITC calculations; received doubled Hope or Lifelong Learning Credits (to \$3,300 and \$4,000, respectively) if they attended an eligible educational institution in 2005 or 2006; could make tax-free withdrawals up to \$100,000 from IRAs and other retirement plans through 2007; and received housing tax breaks if they resided in employer-provided housing or housed Katrina evacuees (IRS, 2006). These provisions were available to GO Zone residents whether or not they experienced flooding or other storm damage. The Joint Committee on Taxation estimated the cost of these tax breaks to be \$10.8 billion, including \$6.3 billion in the first year.<sup>10</sup>

While the CDBG and FEMA funding could have been legally allocated outside the GO Zone, nearly all of it was likely targeted within the Zone. Moreover, the Gulf Opportunity Act of 2005 also authorized Mississippi, Alabama, and Louisiana to issue special GO Zone tax-exempt bonds totaling \$15 billion for use in permanent reconstruction of GO Zone residences and businesses and \$8 billion for the advanced refunding of outstanding bonds, with an additional \$330 million in GO Zone low-income housing tax credits. Many GO Zone residents (for example those working in construction) are likely to have indirectly benefited from increased spending on reconstruction. Construction could occur anywhere in the GO Zone, and the Government Accountability Office noted that:

With some process variations, the three eligible states with GO Zones generally allocated bond authority on a first-come, first-served basis without consistently targeting the allocations to assist recovery in the most damaged areas. Officials in Louisiana and Mississippi acknowledged that the first-come, first-served approach led to allocating bond authority to less-damaged areas at the start of the program (GAO, 2008).

The total cost of federal and private insurance programs, then, exceeded \$100 billion, and was of similar magnitude to the estimated financial cost of the physical damage caused by the storm. In this paper, we examine the net or combined effect of Hurricane Katrina and the public and private responses that attempted to stabilize the socioeconomic livelihood of impacted residents.

A major challenge in identifying these impacts are the pre-existing differences in the characteristics of residents living in the more and less-affected areas. In order to attribute post-storm differences in outcomes to the combined effects of the storm and subsequent aid programs, it is important to account for such pre-storm differences as economic outcomes may have evolved differently in affected and non-affected areas even in absence of the storm.

### 3. Data

#### 3.1. The Consumer Credit Panel

The Federal Reserve Bank of New York's Consumer Credit Panel (CCP) is an individual-level longitudinal dataset on consumer liabilities, repayment and location. It is built from anonymized quarterly consumer credit report data collected and summarized by Equifax Inc. Data are collected quarterly since the first quarter of 1999, and the panel is ongoing. Sample members have Social Security numbers ending in one of five arbitrarily selected pairs of digits (for example, 10, 30, 50, 70, or 90), which are assigned randomly within the set of Social Security number holders. Therefore, the sample of approximately 12 million individuals comprises 5 percent of U.S. individuals with credit reports (and Social Security numbers). The CCP sample design automatically refreshes the panel by including all new reports with Social Security numbers ending in the above-mentioned digit pairs. Therefore the panel remains representative for any given quarter, and includes both representative attrition, as the deceased and emigrants leave the sample, as well as representative entry of new consumers, as young borrowers and immigrants enter the sample.<sup>11</sup>

Each quarter, the CCP includes the birth year and present location of each individual down to the Census Block, in addition to an anonymous street address identifier (allowing us to identify residency change within Census Block).<sup>12</sup> It includes loan counts, balances, and repayment statuses of consumer debt by type—including auto, mortgage (and other home-secured), and consumer credit (credit card, retail, and consumer finance) debt—as well as bankruptcy and foreclosure indicators. Credit card balances represent the most recent credit card statement balances as of the last day of the quarter, hence contains both carried balances and new charges that will be repaid during the billing cycle, with the latter representing the larger share. Changes in aggregate consumer credit debt balances therefore can be seen as capturing changes in consumption.

In combination with residential mobility, we use housing debt information to define homeownership as holding non-zero home-secured debt (including mortgage, HELOC, and home installment loans), and define bankruptcy and foreclosure by an individual's experiencing a bankruptcy or foreclosure event in the past three years.<sup>13</sup> While CCP data are not top-coded, we winsorize the top one percent of debt balances to avoid our estimates' being driven by outliers. The CCP also includes each individual's Equifax risk score, which (like the FICO score) models 24 month default risk as a function of credit report measures, and which is our measure of creditworthiness and financial health and

<sup>11</sup> See Lee and van der Klaauw (2010) for details on the sample design.

<sup>12</sup> Nonempty Census Blocks in the US had a median of 52 inhabitants in the 2010 Census.

<sup>13</sup> Bankruptcy events include discharges arising from either Chapter 7 or Chapter 13 bankruptcy. Both bankruptcies and foreclosures include those reported at the account level and in public record.

<sup>10</sup> See JCX-68-05 and JCX-89-05R. These estimates exclude tax provisions in the GO Zone Act targeted at victims of Hurricanes Rita and Wilma and the federal bond subsidies discussed in the next paragraph.

also serves as a strong proxy for income.<sup>14</sup> Finally, our data also includes these same characteristics for all sampled individuals' covered household members.<sup>15</sup> The CCP defines household members as individuals with the same full mailing address (as recorded by financial institutions); following [Bleemer et al., 2014](#), we define parental coresidence (a possible outcome of interest, signaling economic distress) as an individual who shares a residence with at least one adult between 15 and 45 years older than her. With household members included, the CCP includes credit report data on over 40 million individuals.

While the sample is representative only of those individuals with Equifax credit reports, the coverage of credit reports is fairly complete for American adults. Aggregates extrapolated from the data closely match those based on the American Community Survey, Flow of Funds Accounts of the United States and the Survey of Consumer Finances.<sup>16</sup> In sum, the CCP permits unique insight into questions of geography-specific mobility, debt and consumer behavior, and household composition as a result of the size, representativeness, frequency, and recency of the dataset. Its sampling scheme allows extrapolation to regional aggregates and spares us most concerns regarding attrition and representativeness over the course of a long panel.

We construct two subsamples of CCP data for our analysis. First, we construct a 1999–2016 panel of all individuals whose mailing addresses were located in Orleans Parish on the 30th of June 2005 (the end of the second quarter), our last data record before Hurricane Katrina. The data's panel structure allows us to follow a random 5 percent of adults who lived in New Orleans when Hurricane Katrina hit, both during the years prior and continuing for 11 years after the storm, tracking the evolution of their consumption behavior, financial health, mobility, and household composition. Second, we construct a similar panel of all individuals whose mailing address was located in the Five State Region of our broad analysis—which we define as the full states of Louisiana, Alabama, and Mississippi as well as the Texas and Florida counties with centroids bounded between the 82nd and 99th west meridians—on the 30th of June 2005.<sup>17</sup> To enable analysis of the storm's immediate and longer-term effects, both panels were collected biannually (first and third quarters) in the years immediately before and after Hurricane Katrina, and collected annually (first quarter) for earlier and later years.<sup>18</sup> The total sample size in the second quarter of 2005 is about 19,000 in the city of New Orleans and 1.49 million in the Five States region. In the first quarter of 2016, about 80 percent of the sample continued to be covered by the CCP, with the remainder either deceased, moved outside the US, or without sufficient recent credit history to generate an Equifax credit report (a relatively rare event).<sup>19</sup> [Fig. 1](#) shows the set of variables constructed for our analysis of these two panels.

<sup>14</sup> See Appendix II of [Albanesi and Nosal \(2015\)](#), which matches a small subset of CCP data to 2009 income data collected by Equifax Workforce Solutions to show the strength of the Equifax risk score as a proxy for income. The consumer credit score provided by Equifax is based on a different methodology than the FICO score, but it predicts the same probability of severe delinquency over the next 24 months (see [Lee and van der Klaauw \(2010\)](#)).

<sup>15</sup> A household member is covered if she has an Equifax credit report, for which even a loan application or listing on an authorized-user account is sufficient.

<sup>16</sup> See [Lee and van der Klaauw \(2010\)](#) and [Brown et al. \(2015\)](#) for details.

<sup>17</sup> The 82nd and 99th meridians were chosen to symmetrically include the Hurricane Katrina GO Zone plus additional four degrees longitude for the control group (see [Fig. 1\(b\)](#)). All qualitative results presented below are robust to the inclusion of all of Texas and Florida, and analysis restricted to the GO Zone's 40-mile border provides similar results.

<sup>18</sup> The reason for not including all quarters was purely computational, given the already huge sample size. Additional exploration confirmed fairly stable and smooth trends in estimated impacts.

<sup>19</sup> Note that the population of credit report holders consist mainly of people who are at least 18 years of age, with many only starting to build a credit history in their late teens/early twenties.

### 3.2. Additional data sources

We use two sources of data to delineate the regions affected by Hurricane Katrina. To identify the New Orleans residents who were hardest-hit by Katrina, we use geospatial flood inundation data estimated by the United States Geological Survey's Center for Earth Resources Observation and Science (see [Gesch, 2007](#)) and aggregated to the 2000 Census Block level in Orleans Parish by [Sastry \(2009\)](#). Following Sastry, we define a Census Block as inundated if it experienced at least four feet of flooding on 31 August 2005.<sup>20</sup> Though these inundation data are largely estimated from detailed topological data and water level readings from Lake Pontchartrain, the agency notes that they compare well with aerial and satellite photographs from the days after the storm. [Fig. 1\(a\)](#) shows a map of the 49 percent Census Blocks in Orleans Parish (51 percent of households) that were inundated by Hurricane Katrina.

For the Five States region, we define the broad region affected by the storm by the Hurricane Katrina GO Zone defined by the Gulf Opportunity Zone Act of 2005, as discussed above. [Fig. 1\(b\)](#) shows a map of the 89 counties and parishes in the Five State region that fall within the GO Zone (shown in blue), out of 401 total counties in the region.<sup>21</sup> Due to our singular focus on New Orleans above, we will first exclude New Orleans residents from the Five States analysis, but add them back in later to assess the impact of the storm on the GO Zone area overall.

While the CCP provides sufficient information to produce subsamples by age and financial health (as proxied by credit score), it does not include race information, so we use 2000 Census data to geographically categorize individuals by the racial makeup of their Census Block. Census Blocks are the smallest regional designation assigned by the US Census, and had a mean (median) population of 19 (38) across the Five States region in 2000; even the 7200 Census Blocks in New Orleans contained an average of 49 residents (median 39).<sup>22</sup> The white (black) subsample comprises all residents of 2000 Census Blocks that were at least 75 percent non-Hispanic white (black).<sup>23</sup> About 69 percent of sampled New Orleans residents live in such neighborhoods (50 percent black, 19 percent white), as do 61 percent of residents of the Five States region. Remaining residents—most of whom live in racially-diverse neighborhoods—are omitted from our race subsamples.<sup>24</sup> Because residents non-randomly select their neighborhoods' characteristics, we refer to these subsamples as “White Neighborhoods” and “Black Neighborhoods”, which may not broadly represent white and black residents.

[Table 1](#) provides pre-storm sample characteristics by treatment status, while [Table 2](#) summarizes the observed pre-storm characteristics of our overall samples by geographically-defined demographic subpopulations. The second and third columns of [Table 1](#), which describe the pre-Katrina individual-level credit report records used in our analysis below, show that residents of inundated portions of New Orleans that experienced the greatest hurricane damage tended to have lower economic status—19 percent less likely to be homeowners, \$500 lower average consumer credit balance, higher delinquency rates and significantly lower

<sup>20</sup> We define inundation at four feet of flooding to capture only residents of the most-damaged sections of New Orleans, though some comparison group residents also experienced lower (and less damaging) flood levels. [McCarthy et al. \(2006\)](#) categorize residences with greater than four feet of flooding as having experienced “severe damage”, though homes with 2–4 feet of flooding also have “serious damage”. [Sastry \(2009\)](#) notes that housing units in “areas with  $\geq 4$  feet of flooding ... suffered serious damage, with many units experiencing severe structural and integrity damage”.

<sup>21</sup> Louisiana parishes correspond with the counties of all other states. We will refer to all such geographical units as ‘counties’ for the remainder of the paper.

<sup>22</sup> These figures omit unpopulated Census Blocks.

<sup>23</sup> The results presented below are largely insensitive to 10 percentage point changes in these cut-off values.

<sup>24</sup> Fewer than five percent of New Orleans and Five States residents lived in either 75-percent-Hispanic Census Blocks or Blocks that had no residents during the 2000 Census.

**Table 1**  
Pre-Katrina sample characteristics and inverse propensity weights.

	New Orleans					Five States				
	Unweighted			Weighted		Unweighted			Weighted	
	Overall	Inund.	Non-Inund.	Inund.	Non-Inund.	Overall	GO Zone	Non-GO	GO Zone	Non-GO
State change (3 Years)	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.11*	0.11	0.11
County change (3 Years)	0.22	0.22	0.22	0.22	0.22	0.25	0.24	0.26*	0.26	0.25†
Address change (3 Years)	0.39	0.39	0.38†	0.39	0.39	0.44	0.43	0.45*	0.45	0.45
Credit score	656	633	668*	656	656	663	658	666*	663	663
Subprime credit score	0.45	0.55	0.40*	0.45	0.45	0.42	0.44	0.41*	0.42	0.42
Has mortgage	0.24	0.21	0.26*	0.24	0.24	0.27	0.26	0.28*	0.27	0.27
Mortgage balance	16,201	14,086	17,484*	16,477	16,329	17,283	15,920	17,928*	17,781	17,308
Has delinq. mortgage	0.017	0.024	0.013*	0.017	0.017	0.012	0.013	0.012†	0.012	0.012
Has auto	0.22	0.19	0.25*	0.22	0.22	0.29	0.27	0.29*	0.29	0.29
Auto balance	2,697	2,266	2,959*	2,682	2,693	3,685	3,580	3,734*	3,698	3,688
Has delinq. auto	0.011	0.012	0.011	0.011	0.011	0.015	0.015	0.015	0.015	0.015
Has consumer debt	0.50	0.45	0.54*	0.51	0.50	0.52	0.51	0.53*	0.52	0.52
Consumer balance	2,633	2,325	2,819*	2,666	2,638	2,912	2,810	2,960*	2,928	2,912
Has delinq. consumer debt	0.10	0.12	0.096*	0.10	0.10	0.099	0.10	0.097*	0.099	0.099
Delinq. consumer balance	316	324	311	309	315	355	352	356	353	354
Household size	2.84	2.86	2.83†	2.84	2.84	2.73	2.78	2.71*	2.73	2.73
Live Alone	0.19	0.20	0.18*	0.19	0.19	0.19	0.18	0.19†	0.19	0.19
Live with parents	0.17	0.19	0.15*	0.17	0.17	0.14	0.15	0.14*	0.14	0.14
Live with partner	0.30	0.27	0.31*	0.30	0.30	0.34	0.32	0.35*	0.34	0.34
Bankruptcy rate	0.017	0.017	0.017	0.017	0.017	0.018	0.017	0.018*	0.018	0.018
Foreclosure rate	0.018	0.029	0.013*	0.018	0.018	0.013	0.014	0.013	0.013	0.013
Number of observations	19,204	10,308	8,896	10,308	8,896	1,492,900	226,459	1,266,441	226,459	1,266,441

Weighted and unweighted average values by group and four-foot Census block inundation (New Orleans) or GO Zone inclusion (Five States). Inverse propensity weights generated from first-stage logit; see paper. Credit Score measures an individual's Equifax risk score, which is comparable to a FICO credit score; a credit score is subprime if it is less than 640. An individual 'has a mortgage' if they hold any home-secured debt—mortgage, HELOC, or other home equity loan—and 'has an auto' if they hold an auto loan. Consumer debt includes credit and bank cards, retail debt, and consumer finance debt. A loan is delinquent if it is more than 90 days past due. Adults in household includes all individuals covered by Equifax (see the paper). Partnership is defined as living with only one additional covered individual, parental coresidence as sharing a residence with at least one adult between 15 and 45 years older. Bankruptcy indicates chapter 7 and 11 filings in the past three years, and foreclosure indicates having foreclosed on a mortgage in the past three years and is conditional on homeownership. T-tests by treatment (inundation or within GO Zone); \* 1%, † 5%. Source: FRBNY Consumer Credit Panel/Equifax.

**Table 2**  
Pre-Katrina sample characteristics by demographic group.

Variable	New Orleans						Five states					
	By age		By credit score		By race		By age		By credit score		By race	
	18–40	60+	Low	High	White	Black	18–40	60+	Low	High	White	Black
Address change (3 Years)	0.55	0.35*	0.42	0.36*	0.41	0.39*	0.6	0.38*	0.509	0.37*	0.43	0.401*
State change (3 Years)	0.209	0.086*	0.105	0.11*	0.15	0.101*	0.16	0.085*	0.108	0.091*	0.11	0.093*
County change (3 Years)	0.33	0.24*	0.19	0.26*	0.26	0.21*	0.35	0.26*	0.24	0.24*	0.24	0.22*
Credit score	599	693*	538	783*	715	601*	617	720*	539	782*	687	599*
Subprime credit score	0.68	0.32*	1.0	0.0	0.21	0.69*	0.59	0.209*	1.0	0.0	0.32	0.69*
Has mortgage	0.14	0.14*	0.15	0.205*	0.29	0.17*	0.23	0.15*	0.19	0.28*	0.33	0.14*
Mortgage bal.	11,537	6,330*	8,118	14,861*	28,024	7,658*	15,424	6,398*	9,152	18,195*	20,639	4,384*
Has delinq. mortgage	0.030	0.018*	0.080	0.0*	0.010	0.036*	0.017	0.0075*	0.059	0.00001*	0.0096	0.025*
Has auto	0.21	0.095*	0.22	0.11*	0.21	0.17*	0.34	0.14*	0.32	0.203*	0.31	0.201*
Auto balance	2,365	1,038*	2,299	1,296*	2,570	1,988*	4,068	1,520*	3,530	2,466*	3,824	2,151*
Has delinq. auto	0.016	0.0035*	0.029	0.0*	0.0014	0.016*	0.024	0.0048*	0.049	0.00001*	0.011	0.023*
Has consumer debt	0.56	0.41*	0.63	0.404*	0.68	0.49*	0.64	0.47*	0.71	0.51*	0.66	0.507*
Consumer balance	2,238	1,958*	2,601	1,657*	4,237	2,083*	2,915	2,087*	3,481	1,941*	3,827	2,122*
Has delinq. consumer debt	0.207	0.079*	0.403	0.0001*	0.063	0.21*	0.19	0.065*	0.44	0.00007*	0.11	0.23*
Delinq. consumer bal.	393	188*	869	0.0005*	201	420*	401	191*	1107	0.11*	312	462*
Household size	2.82	2.78*	2.93	2.65*	2.48	2.96*	2.77	2.69*	2.89	2.6*	2.63	3.04*
Live alone	0.23	0.22	0.21	0.23*	0.23	0.205*	0.204	0.205	0.21	0.18*	0.17	0.208*
Live with a partner	0.27	0.28*	0.25	0.31*	0.36	0.25*	0.32	0.34*	0.28	0.39*	0.38	0.24*
Bankruptcy rate	0.017	0.0079*	0.031	0.0016*	0.0077	0.020	0.017	0.0097*	0.035	0.0011*	0.019	0.019
Foreclosure rate	0.034	0.018*	0.083	0.0*	0.0078	0.036*	0.016	0.0093*	0.058	0.00008*	0.010	0.029*
Observations	6,466	6,181	7,444	6,882	3,494	9,720	487,730	464,558	447,354	618,562	802,336	111,482

Unweighted average values by group and subgroup. High (low) credit score is defined as being in the top (bottom) Equifax riskscore tercile, with break point at 735 (610). Race is defined as individuals living in Census blocks in which, as of the 2000 Census, at least 75 percent of residents were white or black. Credit Score measures an individual's Equifax risk score, which is comparable to a FICO credit score; a credit score is subprime if it is less than 640. An individual 'has a mortgage' if they hold any home-secured debt—mortgage, HELOC, or other home equity loan—and 'has an auto' if they hold an auto loan. Consumer debt includes credit and bank cards, retail debt, and consumer finance debt. A loan is delinquent if it is more than 90 days past due. Adults in household includes all individuals covered by Equifax (see the paper). Partnership is defined as living with only one additional covered individual. Bankruptcy indicates chapter 7 and 11 filings in the past three years, and foreclosure indicates having foreclosed on a mortgage in the past three years and is conditional on homeownership. T-tests within subgroups; \* 1%, † 5%. Source: FRBNY Consumer Credit Panel/Equifax.

average credit scores and higher proportion with subprime credit scores (scores below 640), and more than twice as likely as homeowner to have experienced a foreclosure in the previous three years -exacerbating challenges in recovery efforts. While smaller, we see similar pre-storm differences between residents of the broader impacted GO Zone and residents of nearby regions.

#### 4. Empirical strategy

The goal of our analysis is to estimate the short- to long-run average “treatment effect” of Hurricane Katrina—and the associated policy response—on a large set of economic and demographic statistics measured at regular intervals after the storm. The framework of our analysis will be difference-in-differences regressions, in which we compare pre- and post-Katrina outcomes of those living in the impacted areas to outcomes for those living in similar but not- or less-impacted areas. As we are interested in geographic heterogeneity in the storm’s impact, control and treatment areas are chosen to be relatively close in proximity. Moreover, in applying the differences-in-differences approach we use propensity score weighting (Hirano et al., 2003; Abadie, 2005) to account for the non-random selection of individuals that were impacted by Hurricane Katrina due to the storm’s geographic containment, thereby assuming that geographic residence selection conditional on (financial) observables is independent of long-run outcomes.<sup>25</sup> We follow Hirano et al. by estimating propensity scores using a logit model relating the likelihood of an individual being impacted by the storm to a large set of observed individual characteristics and outcomes, including consumption, mobility, and household composition levels and changes measured in the first quarters of 2002–2005 (prior to Hurricane Katrina’s impact).<sup>26</sup> A complete list of observed characteristics is available in Table 1. While our approach only accounts for selection on observables, by making affected and unaffected samples more comparable in terms of a large set of observables, we also hope to make them more comparable in terms of unobservables; this naturally remains untested.

Let  $Y_{it}$  be one of the economic and demographic outcomes listed in Table 1 for individual  $i$  in time  $t$ . Let  $K_i$  be an indicator for whether  $i$  was living in a location impacted by Hurricane Katrina, either an inundated New Orleans Census Block or a county in the federal Katrina GO Zone. We estimate the following model for all observed quarters  $\mathbb{T}$  (the first quarter of every year from 1999–2016 and the second and third quarters of 2005 and 2006), omitting the interaction term between  $K_i$  and the indicator dummy for the second quarter of 2005 (the final quarter of data before Hurricane Katrina’s impact):

$$Y_{it} = \delta_i + \gamma_t + \sum_{\tau \in \mathbb{T}} K_i 1_{\{t=\tau\}} \beta + \epsilon_{it}$$

where the  $\{\beta\}$  coefficients—the linear effect of living in an impacted locality in quarter  $t$  relative to the second quarter of 2005—are the coefficients of interest.<sup>27</sup> The model includes both individual fixed effects  $\delta_i$  and time fixed effects  $\gamma_t$  (which will capture aggregate business cycle fluctuations). The regression weighs impacted individuals by the inverse propensity of inundation,  $\frac{1}{\Pr(K_i=1)}$  and non-inundated individuals by the inverse propensity of non-inundation,  $\frac{1}{\Pr(K_i=0)}$ , using propensities estimated by logistic regression of  $K_i$  on the full vector of economic and demographic variables shown in Table A1. Standard errors for the Five

States (New Orleans) model are clustered at the county (Census Block) level.

Table 1 shows the effect of our propensity weights on the mean values of individual-level characteristics captured in our credit report data for the treatment and control populations in both New Orleans (columns 4 and 5) and the wider GO Zone region (columns 9 and 10) just before Hurricane Katrina. In both cases, the control regions had modest economic advantages relative to the treatment regions (e.g. with lower average credit risk scores by 35 points in inundated New Orleans and 8 points in the GO Zone), but those observable differences are equalized by the weights.<sup>28</sup> Since both the treatment and control populations are weighted to the combined sample average across observable characteristics, our estimates can be interpreted as average treatment effects across the respective populations of New Orleans and the Five States region (Hirano et al., 2003).

It is important to note that our estimates of  $\{\beta\}$  will measure *relative* differences in deviations from the pre-storm trajectory of outcomes between residents in control and treated areas. Thus our approach assumes that in absence of the storm, both areas would have experienced common business cycle or time effects. Our estimates will capture the combined impacts of (a) differences in the storm’s intensity and damage and (b) disaster efforts implemented following the storm, including possible control area spillover effects in both cases. These estimates therefore measure the relative effectiveness of disaster aid in returning individuals back to their no-disaster trajectories, and are thus informative of disaster aid’s effectiveness in mitigating the large differences in damage incurred in treatment and control areas.

Importantly, the estimates by themselves do not necessarily capture absolute impacts and cannot directly tell us whether and which group is over- or undercompensated in an absolute sense. For example, finding worse post-storm outcomes in inundated versus non-inundated areas is consistent with inundated residents being undercompensated or non-inundated residents being overcompensated. It is also consistent with both groups being undercompensated or overcompensated.

We conduct two tests to measure the effectiveness of our propensity weight estimation procedure. First, we test the overlap assumption: That all individuals are estimated as having a positive probability of being impacted or not impacted by Hurricane Katrina. We find that no individuals in the New Orleans sample and two individuals in the Five States sample have an impact (or non-impact) probability of less than 0.0001, and omit those individuals from our analysis. Second, we test the common support assumption: That no individual has a propensity score outside the range of propensity scores in the alternative-treatment group. Four individuals in the New Orleans sample and seven in the Five States sample fail the common support assumption, and are omitted. Given our sample’s massive size, these results support the applicability of propensity score weighting in our estimation approach.<sup>29</sup> Despite differences in unweighted means between the two groups, plots of the propensity score distributions for affected and unaffected residents (shown in Figure A1 of the supplementary appendix) show that they largely overlap in both the New Orleans and GO Zone analyses.

Additional evidence of the weights’ effectiveness in balancing the panel is shown in the results below; as expected, nearly all outcomes of interest are balanced in both samples for the five years prior to Hurricane Katrina.

<sup>25</sup> Barone and Mocetti (2014) similarly adopt a synthetic control approach and a within-country perspective to evaluate the impact of two large earthquakes and post-quake financial aid in Italy on local GDP per capita. They find differential short- and long-term effects, and highlight the importance of financial aid in mitigating disaster impacts.

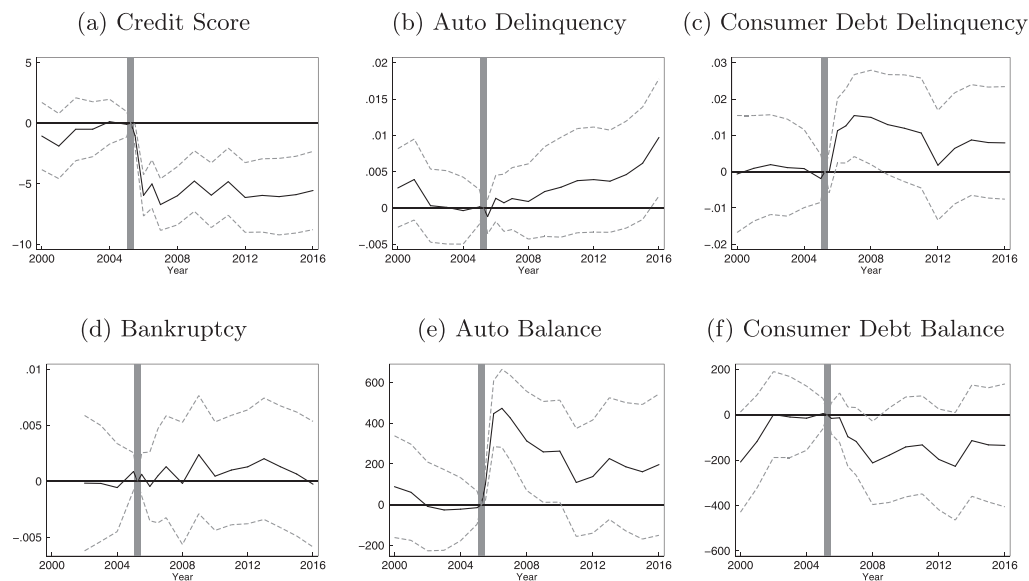
<sup>26</sup> Note that by including annual measures of local conditions, our weighting also accounts flexibly for differences in pre-treatment trends.

<sup>27</sup> We include the second and third quarters of 2005 and 2006 in our analysis to provide finer-detail estimates of the short-term impact of Hurricane Katrina.

<sup>28</sup> As shown in Table A1 when jointly controlling for all pre-storm individual-level characteristics, credit scores, mortgage balances and living alone are the most significant and are most predictive of treatment, all being negatively related to being inundated or being in the affected GO Zone area.

<sup>29</sup> Individuals who fail either the overlap assumption or the common support assumption are omitted from our analysis below.





**Fig. 2.** Income and Consumption Outcomes New Orleans. Propensity-score-weighted effects of Hurricane Katrina inundation in New Orleans. Standard errors clustered by Census tract. Credit Score measures an individual's Equifax risk score, which is comparable to a FICO credit score. Consumer debt includes credit and bank cards, retail debt, and consumer finance debt. A loan is delinquent if it is more than 90 days past due. Bankruptcy indicates chapter 7 and 11 filings in the past three years. *Source:* FRBNY Consumer Credit Panel/Equifax.

## 5. Net impacts of flood inundation in New Orleans

We first present estimated effects of living in an inundated New Orleans Census Block on the various socioeconomic outcomes of interest described in Table 1. Effects are estimated relative to otherwise-similar New Orleans residents who lived in non-flooded regions of the city, who may themselves have sustained substantial water and wind damage in addition to negative externalities from the nearby flooding (for example, through a decline in the local economy). These estimated effects, then, measure only the additional impact of severe inundation in the days following Hurricane Katrina, net the additional federal and private insurance and aid provided to mitigate that impact. These 'intensive-margin' results can be understood to describe insurance programs' effectiveness in targeting more substantial assistance to residents who were hardest-hit by Hurricane Katrina.

In order to convey the magnitudes of these coefficients, we present them unscaled, which describes the average treatment effect in the units of interest (percentage point, dollars, or risk score). In some cases, we also present coefficients scaled by the contemporaneous level in the non-inundated 'control' Blocks, which describes the ATE as a unitless percent difference.<sup>30</sup> In several figures below we show the estimated coefficients from the regression equation discussed above plotted for various outcomes of interest from 2000 to 2016. The results for 2000–2005, which estimate the propensity-score-weighted difference between inundated and non-inundated neighborhoods before the storm, are presented as a validation exercise; we expect that the weighted pre-Katrina impact of Hurricane Katrina will be 0 in those years, as is nearly always the case. While we rarely find statistically significant differences pre-2006, in some cases where we see a small difference 4 or 5 years before the storm the reported estimates may be somewhat less reliable.

We first consider estimates of Hurricane Katrina's impact on risk scores (capturing financial health and creditworthiness) and on new debt originations associated with car purchases or other consumer debt

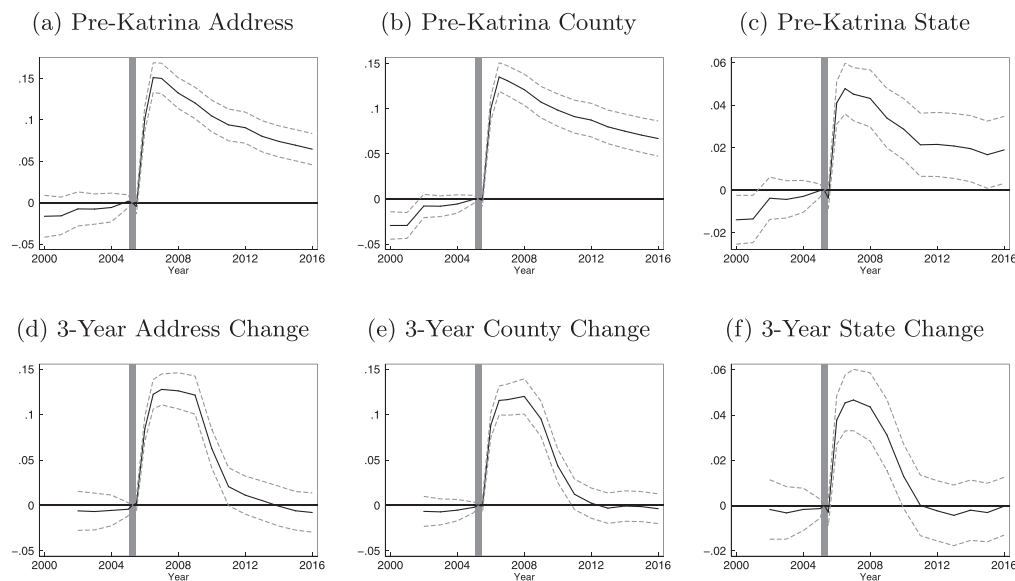
activity (as measures of consumption), some of which are shown in Fig. 2. Inundated residents experienced a short-term negative shock to their Equifax risk score after the storm of about 6.7 points (0.05 standard deviations), and recovered very little over the following ten years, with their average score remaining 5.6 points lower ten years after the storm. This short-term decline corresponded with a two percentage point increase in the fraction of inundated residents with subprime risk scores (scores below 640, the bottom third of risk scores nationwide), though the increase fell into statistical insignificance after 2008. This finding suggests that insurance programs failed to fully prevent and close a gap in creditworthiness between inundated and non-inundated New Orleans residents caused by Hurricane Katrina in the short- or long-term.<sup>31</sup>

Our analysis of consumption yields results in line with the estimated impacts on financial health and creditworthiness. We find evidence of a steady decline in consumer credit balances (with time-variation in consumer debt—defined as aggregate credit card, retail, and consumer finance debt—representing a strong proxy for changes in general consumption, excluding very large purchases) in the three years after the hurricane, without any substantial recovery in the following 5–10 years (though the gap is statistically insignificant ten years later). Inundated residents are far more likely to purchase a car immediately after the hurricane—possibly replacing cars damaged by the storm, likely with newer models—with an increase in average auto debt by over \$400 per adult, but also become steadily more likely to face delinquency on their auto loans—by more than one percentage point in 2016. Other measures of extreme financial hardship, however, suggest some degree of post-Katrina recovery: Inundated residents' increased likelihood of falling into consumer credit delinquency returns to statistical and economic insignificance five years after the storm, and inundated individuals are no more likely to declare bankruptcy than their non-inundated neighbors.

Ten years after the storm, then, the consumption behavior of inundated residents had imperfectly recovered since the storm relative to

<sup>30</sup> We choose to scale by the contemporaneous level in non-inundated regions (the 'control' group), rather than the more typical choice of the level in inundated regions just before Hurricane Katrina in order to account for city- (and nation-) wide trends in our outcomes of interest in the late 2000s (driven most significantly by the Great Recession).

<sup>31</sup> Using a slightly different definition of inundation, Deryugina et al. (2018) find an initial \$2300 decline in 2006 income for inundated residents relative to non-inundated residents due to the storm, but the decline in income is not persistent and by 2008 the estimated impact on income has actually turned positive.



**Fig. 3.** Mobility Outcomes, New Orleans. Propensity-score-weighted effects of Hurricane Katrina inundation in New Orleans. Standard errors clustered by Census tract. Top three figures show the likelihood of having a different residence location than that of June 30, 2005, while the bottom three figures show the likelihood of having changed residence locations in the previous three years. *Source:* FRBNY Consumer Credit Panel/Equifax.

their non-inundated neighbors, with small but persistent gaps in financial health and delinquency.

We turn next to Hurricane Katrina's impact on residential mobility. Fig. 3 shows the impact of the hurricane on inundated New Orleans residents' decision to change their residential address, county, or state, either at any time since the storm or specifically in the most recent three years (a measure of residential 'churn'). Inundation considerably increased residents' likelihood of relocation; within one year, an additional 13.1 percentage points of residents had moved out of Orleans Parish. The effect of the storm peaked in 2006 and diminished thereafter, though by 2016, inundated residents were still 6.7 percentage points more likely to reside outside of Orleans Parish than non-inundated residents. Fig. 3 also shows that the hurricane led to substantial three-year residence-churn at the county level through at least 2011, implying that inundated residents were substantially more likely to relocate even 3–6 years after the storm (in some cases returning to New Orleans after years away). Since 2012, however, inundated and non-inundated residents have had similar levels of mobility: Fig. 3 shows similar trends for impacts on street-address-level and state-level mobility, with inundated Orleans Parish residents remaining about 2 percentage points more likely to have relocated out of the state more than ten years after the hurricane.

Homeownership, and especially homeownership among the pre-Katrina homeowners, faced substantial deterioration due to Hurricane Katrina.<sup>32</sup> At the time of the storm, about one in four residents of New Orleans residents had mortgage debt, our proxy for homeownership. The share with a mortgage dropped suddenly after the storm in both inundated and non-inundated blocks, but fell further and recovered less quickly for inundated residents. As shown in Fig. 4, one year after the storm, the share with a mortgage had fallen by an additional 5.7 percentage points (29 percent) among inundated residents compared to non-inundated residents (who themselves experienced a 2.3 percentage point decline). The gap slowly narrowed in the intervening decade, but

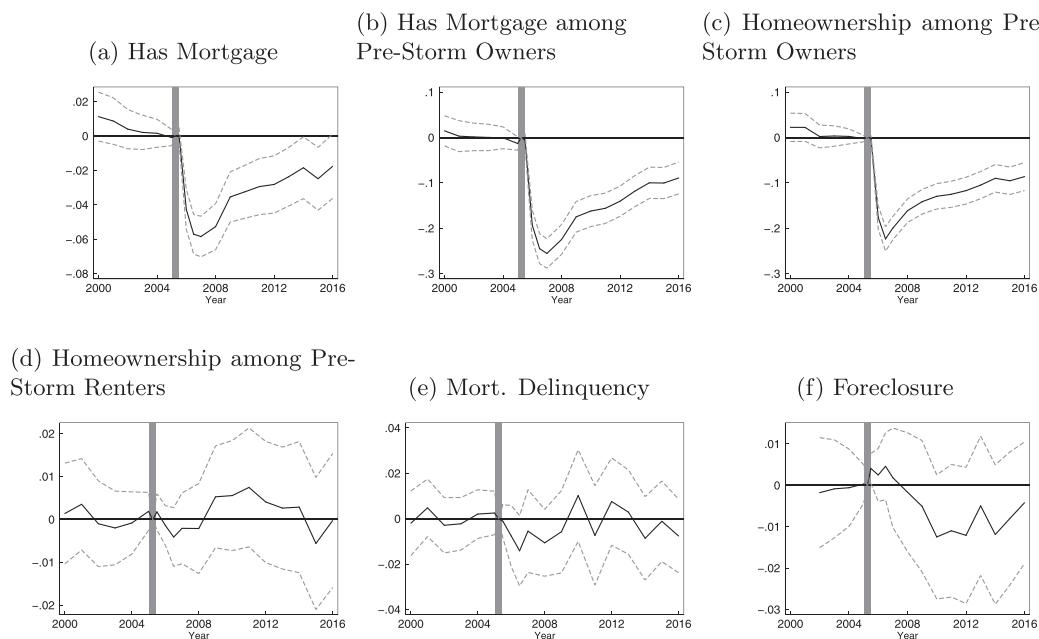
remains around 2 percentage points ten years after the storm. Restricting the sample to pre-Katrina mortgage-holders, the hurricane's impact on mortgage holding was even more striking, decreasing by 25.6 percentage points in the short run and 9 percentage points ten years later.

One potential caveat to this analysis concerns our measurement of homeownership as the resident having non-zero home-secured debt. Evidence provided by Gallagher and Hartley (2017) suggests that many inundated homeowners may have used insurance payouts to pay off their mortgage debt. Our definition could then classify homeowners who paid off their mortgage debt while remaining in their house as no longer owning. To investigate this further we examine the storm's impact separately for those who rented and owned their homes at the time of the storm, and changed our definition of homeownership to include the latter group of homeowners who did not move and reduced their mortgage debt to zero. The estimates shown in Fig. 4 indicate that the estimated homeownership impacts on pre-storm homeowners change only slightly. While they are slightly smaller compared to the estimated drop in mortgage holding, which is consistent with some owners paying off their mortgages while remaining in their homes, we still find a large long-term decline in homeownership among owners of inundated New Orleans homes. Note that this does not contradict the findings by Gallagher and Hartley but is consistent with many inundated homeowners in New Orleans using insurance payouts to pay off their mortgages and subsequently moving to a new location and renting. The share of renters among pre-storm homeowners increased 22 percentage points relative to non-inundated residents, and remained 10 percentage points higher even over a decade later. Finally, Fig. 4 shows no net impact on homeownership (as proxied by having a mortgage) for inundated renters relative to nearby non-inundated renters.<sup>33</sup>

Despite widespread home loss following Hurricane Katrina, the storm had no measurable short- or long-term impact on the proportion of homeowners facing home-secured debt delinquency or foreclosure, though foreclosure was somewhat less common in inundated neighbor-

<sup>32</sup> While generally perceived as a measure of financial independence and success, homeownership is not unambiguously so. However, whether changes in homeownership rates have positive or negative welfare implications broadly, the change in tenancy choice is likely to have negative implications for wealth accumulation (home equity being a prime form of saving) and for the housing market.

<sup>33</sup> Note that we are assuming that pre-storm renters who bought a home, as well as pre-storm homeowners with mortgage debt who bought a new home, all used mortgage financing. While theoretically possible, it is hard to imagine that many in these two groups had sufficient funds to purchase homes debt-free. To the extent that they did, this would imply that we overestimate the magnitude of the decline in homeownership.

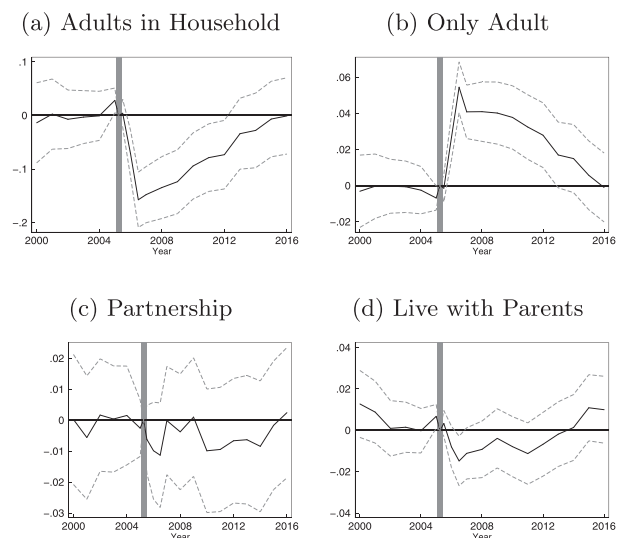


**Fig. 4.** Homeownership Outcomes, New Orleans. Propensity-score-weighted effects of Hurricane Katrina inundation in New Orleans. Standard errors clustered by Census tract. An individual ‘has a mortgage’ if they hold any home-secured debt: Mortgage, HELOC, or other home equity loan. Mortgage delinquency and foreclosure are conditional on having a mortgage. A loan is delinquent if it is more than 90 days past due. Pre-storm homeownership is measured as having a mortgage just prior to Hurricane Katrina, with renters being any non-mortgage-holders; post-storm homeownership is measured as having a mortgage *or* having had a mortgage just before Hurricane Katrina and continuing to reside at the same address. The foreclosure indicator indicates having foreclosed on a mortgage in the past three years. *Source:* FRBNY Consumer Credit Panel/Equifax.

hoods during the Great Recession.<sup>34</sup> Nevertheless, our analysis of homeownership shows that inundated New Orleans residents faced a substantial and persistent negative short-term homeownership shock after Hurricane Katrina.

In addition to the effect on homeownership, we also find substantial effects of Hurricane Katrina on the household composition of inundated residents. Fig. 5 shows that the average household size of inundated New Orleans residents, which was 2.84 adults prior to Hurricane Katrina, declined by about 0.16 adults (6 percent) immediately following the storm and slowly recovered to a null effect over ten years later. While the welfare effects of this change are unclear—shrinking household sizes could reflect either the dissolution or the emancipation of nuclear families or a slower rate of forming or joining multi-person households or extended family households—this is a substantial short-term change in living arrangements caused by Hurricane Katrina. Interestingly, Fig. 5 also shows that the decline in household size does not reflect a decline in partner-households (defined as any household with exactly two covered adult members). Instead, we find strong evidence of a rise in the proportion of single-adult households at the expense of larger households; the proportion of inundated residents living alone increased by 20 percent (5.4 percentage points) immediately after the storm relative to non-inundated residents, though the difference had largely dissipated by 2016.<sup>35</sup>

We have shown in this section that inundated residents of New Orleans faced a short-term increase in mobility and decrease in household size relative to their non-inundated neighbors after Hurricane Katrina, but had fully recovered from those changes in the decade after the storm. More pressingly, however, inundated residents also faced a persistent



**Fig. 5.** Household Composition Outcomes, New Orleans. Propensity-score-weighted effects of Hurricane Katrina inundation in New Orleans. Standard errors clustered by Census tract. Adults in household includes all individuals covered by Equifax (see the paper). Partnership is defined as living with only one additional covered individual. Parental co-residence is defined as living with at least one individual between 16 and 45 years older. *Source:* FRBNY Consumer Credit Panel/Equifax.

<sup>34</sup> The possible decline in foreclosure (conditional on homeownership) during the housing crash may reflect New Orleans subprime homeowners having already lost their homes, by means other than foreclosure, in 2005.

<sup>35</sup> One source of increased single-adult households could have been storm-induced spousal deaths, with more than 700 deaths in New Orleans attributed to Hurricane Katrina.

negative shock to homeownership and credit scores along with substantial permanent changes in their residential location. In this section, we exploit the massive size of our dataset by cutting our sample into six subpopulations of interest: Younger and older residents, under age 40 and over age 60 in 2005; low- and high-income individuals, proxied by having an Equifax risk score in 2005 below 610 or above 735 (the first

**Table 3**  
Treatment Heterogeneity by Age in New Orleans.

Outcome	Oneyear after			Five years after			Ten years after		
	18–40	60+	p-value	18–40	60+	p-value	18–40	60+	p-value
Consumer bal.	–115.826 (93.4)	–48.841 (82.9)	0.592	–216.697 (166.5)	292.1 (182.8)	0.040	–267.544 (205.9)	183.7 (248.0)	0.162
Derog. consumer bal.	50.51 (25.9)	47.25 (24.4)	0.927	–0.340 (56.9)	37.15 (47.9)	0.614	23.26 (49.2)	35.98 (47.3)	0.852
Change county, ever	0.069 (0.01)	0.107 (0.01)	0.017	0.047 (0.01)	0.149 (0.01)	0.000	0.014 (0.01)	0.131 (0.02)	0.000
County change (3 Years)	0.043 (0.01)	0.098 (0.01)	0.001	–0.005 (0.02)	0.002 (0.01)	0.773	–0.010 (0.02)	–0.016 (0.01)	0.783
Live with a partner	–0.000 (0.01)	–0.019 (0.01)	0.352	–0.019 (0.02)	–0.008 (0.02)	0.690	0.001 (0.02)	–0.011 (0.02)	0.655
Homeown. among pre-storm owners	–0.160 (0.03)	–0.173 (0.02)	0.734	–0.041 (0.03)	–0.197 (0.03)	0.001	–0.019 (0.03)	–0.136 (0.04)	0.018
Homeown. among pre-storm renters	–0.004 (0.00)	0.001 (0.00)	0.349	–0.002 (0.01)	0.012 (0.01)	0.322	–0.020 (0.01)	–0.001 (0.01)	0.272
Credit score	–4.103 (1.5)	–8.876 (1.6)	0.026	–7.401 (2.4)	–4.622 (2.8)	0.456	–10.404 (2.7)	–1.805 (3.5)	0.050

Within-subgroup event study impact estimates of the impact of Hurricane Katrina on the stated outcome one, five, and ten years after the storm. Subgroups defined by individual's years of birth. Standard errors clustered by county. P-values from pairwise t-tests assuming independence across subgroup. Pre-storm homeownership is measured as having a mortgage just prior to Hurricane Katrina, with renters being any non-mortgage-holders; post-storm homeownership is measured as having a mortgage or having had a mortgage just before Hurricane Katrina and continuing to reside at the same address. Source: FRBNY Consumer Credit Panel/Equifax.

and second terciles in New Orleans); and the residents of predominantly-white or predominantly-black neighborhoods (defined at the 2000 Census Block level). We estimate the impact of Hurricane Katrina on each subpopulation by modeling each subpopulation independently; the estimates presented below should be interpreted as the impact of the storm on members of a subpopulation relative to non-inundated members of that same sub-population.

Tables 3–5 show treatment heterogeneity for a selection of outcomes of interest one, five, and ten years after Hurricane Katrina. Table 3 shows that Hurricane Katrina increased older New Orleans residents' likelihood of leaving New Orleans more than it did younger residents'; ten years after the storm, inundated older residents were 13 percentage points less likely to reside in New Orleans than non-inundated older residents, while the inundation gap for young residents was a statistically-insignificant 1.4 percentage points. Inundated older pre-storm homeowners experienced a greater fall in homeownership relative to inundated youth residents. Younger residents also faced a more negative consumption shock in the medium-term following the storm, while older residents actually faced a substantial positive consumption shock; however, the gap between the two had shrunk somewhat by 2016. In general, Table 3 provides evidence that older New Orleans residents were more successful in recovering from Hurricane Katrina than younger residents, possibly in part by leaving the city.

Treatment heterogeneity by pre-storm credit score (as our proxy for income) follows an expected pattern; Table 4 shows that higher-income residents were more likely to leave New Orleans following the storm, but were also more likely to lose homeownership—or eliminate all home-secured debt—and experience a credit score decline (since they had far more to lose). The homeownership gap fails to dissipate, but higher-income residents' credit scores had recovered to the same decline experienced by lower-income residents by 2016. Both groups faced similar impacts in consumption behavior.

Finally, Table 5 displays heterogeneity in Hurricane Katrina's treatment effect across white and black New Orleans neighborhoods. Despite sufficient power to detect relatively-small difference in treatment effect, as we did in our other subsample analysis, we find little evidence of treatment effect heterogeneity across these groups, though residents of white New Orleans neighborhoods are far more likely to have left the city following the storm (15.4 vs. 6.6 percentage points ten years after the storm). Pre-storm homeowners from black neighborhoods appear to have faced a smaller negative impact on homeownership than

homeowners from white neighborhoods—in part due to their lower initial homeownership rates. On the other hand, residents of white New Orleans neighborhoods may have experienced a larger decline in consumer debt delinquency, but this difference is statistically insignificant. While these findings are agnostic on whether black residents of New Orleans (in both inundated and non-inundated Blocks) received differential support compared to white residents, they suggest that support targeted at inundated communities similarly-affected white and black New Orleans neighborhoods.

Supplementary Appendix Figs. A2–A8 display event study figures for these selected outcomes of interest for each of the six subpopulations.

Before turning to the New Orleans migration analysis, we consider the sensitivity of our estimates to the way we classify areas as "inundated". First we compared somewhat-flooded areas (1–3 feet) to severely flooded ( $\geq 4$  feet) areas and find effects that are smaller but generally similar to those from comparing severely flooded ( $\geq 4$  feet) with less severely and non-flooded New Orleans areas (see Figs. A9–A12 in the supplementary appendix). Similarly, when comparing non-flooded to slightly-flooded regions (Figs. A13–A16), there is evidence of some financial hardship in the slightly-flooded regions, though not nearly as bad as in the highly-flooded regions. And, as expected, if we omit the slightly-flooded regions from the analysis (Figs. A17–A20), the effects become more pronounced. Finally, when we treat people with 1–3 feet of inundation as belonging to the treatment (originally defined as  $\geq 4$  feet) instead of control group, the estimates are very similar to those corresponding to our initial definition of inundation.

## 6. Post-Katrina mobility

In this section, we specifically consider the subset of New Orleans residents who evacuated the city following the storm, examining their migration decisions geographically. According to the US Census, nearly half of pre-Katrina New Orleans residents no longer resided in (or had not yet returned to) that city two years after the storm (Vigdor, 2008). Analysis of the CPS shows that, of all Hurricane Katrina evacuees who had not returned to their county of residence by the end of 2006, the largest proportion of them had moved to Texas, followed by Louisiana and then other states in the American south-east (Groen and Polivka, 2008). Fig. 6 extends that analysis by mapping the location of the 11 percent of all pre-Katrina New Orleans residents who had fled New Orleans within a year of Hurricane Katrina and remained



**Table 4**  
Treatment heterogeneity by credit score in New Orleans.

Outcome	One year after			Five years after			Ten years after		
	Low CS	High CS	p-value	Low CS	High CS	p-value	Low CS	High CS	p-value
Consumer bal.	55.87 (77.9)	−16.345 (94.1)	0.554	−51.294 (151.9)	−87.163 (178.1)	0.878	6.66 (190.0)	−51.685 (233.7)	0.846
Derog. consumer bal.	43.66 (35.6)	8.72 (9.3)	0.343	−18.039 (60.8)	−12.522 (24.3)	0.933	−31.470 (59.7)	6.99 (26.4)	0.556
Change county, ever	0.046 (0.01)	0.153 (0.01)	0.000	0.055 (0.01)	0.120 (0.01)	0.001	0.027 (0.01)	0.100 (0.01)	0.000
County change (3 years)	0.044 (0.01)	0.130 (0.01)	0.000	0.010 (0.01)	−0.000 (0.01)	0.586	−0.007 (0.01)	−0.020 (0.01)	0.491
Live with a partner	−0.003 (0.01)	−0.038 (0.01)	0.056	−0.001 (0.02)	−0.028 (0.02)	0.258	0.017 (0.02)	−0.011 (0.02)	0.288
Homeown. among pre-storm owners	−0.075 (0.03)	−0.256 (0.02)	0.000	−0.070 (0.03)	−0.182 (0.02)	0.003	−0.010 (0.03)	−0.127 (0.02)	0.004
Homeown. among pre-storm renters	0.002 (0.00)	0.000 (0.00)	0.686	0.007 (0.01)	−0.009 (0.01)	0.261	0.004 (0.01)	−0.023 (0.01)	0.112
Credit score	−2.818 (1.4)	−8.523 (1.4)	0.003	0.247 (2.3)	−6.016 (1.7)	0.029	−3.104 (2.6)	−3.450 (2.0)	0.918

Within-subgroup event study impact estimates of the impact of Hurricane Katrina on the stated outcome one, five, and ten years after the storm. Subgroups defined by Equifax risk score terciles in 2005 New Orleans (high-income is the top tercile; low-income is the bottom tercile). Standard errors clustered by Census tract. P-values from pairwise t-tests assuming independence across subgroup. Pre-storm homeownership is measured as having a mortgage just prior to Hurricane Katrina, with renters being any non-mortgage-holders; post-storm homeownership is measured as having a mortgage or having had a mortgage just before Hurricane Katrina and continuing to reside at the same address. *Source:* FRBNY Consumer Credit Panel/Equifax.

**Table 5**  
Treatment heterogeneity by race in New Orleans.

Outcome	One year after			Five years after			Ten years after		
	White	Black	p-value	White	Black	p-value	White	Black	p-value
Consumer bal.	−84.554 (203.8)	−64.087 (63.5)	0.924	−161.322 (381.4)	19.89 (156.2)	0.660	29.17 (455.9)	177.7 (192.4)	0.764
Derog. consumer bal.	−18.599 (31.8)	26.46 (23.4)	0.254	−50.089 (70.8)	−35.299 (48.8)	0.863	−124.113 (59.3)	20.77 (46.6)	0.055
Change county, ever	0.238 (0.02)	0.044 (0.01)	0.000	0.200 (0.03)	0.086 (0.01)	0.000	0.154 (0.03)	0.066 (0.01)	0.003
County change (3 Years)	0.182 (0.02)	0.043 (0.01)	0.000	0.058 (0.04)	0.019 (0.01)	0.332	0.003 (0.02)	0.000 (0.01)	0.913
Live with a partner	−0.027 (0.02)	−0.009 (0.01)	0.476	−0.028 (0.03)	−0.004 (0.02)	0.409	0.024 (0.03)	0.010 (0.02)	0.674
Homeown. among pre-storm owners	−0.224 (0.03)	−0.114 (0.02)	0.002	−0.166 (0.03)	−0.120 (0.03)	0.259	−0.143 (0.03)	−0.047 (0.03)	0.025
Homeown. among pre-storm renters	0.009 (0.01)	0.001 (0.00)	0.435	0.037 (0.02)	0.016 (0.01)	0.392	0.027 (0.03)	0.016 (0.01)	0.678
Credit score	−5.706 (1.9)	−3.582 (1.4)	0.363	−1.762 (3.1)	1.29 (2.3)	0.427	1.48 (3.7)	−0.909 (2.5)	0.593

Within-subgroup event study impact estimates of the impact of Hurricane Katrina on the stated outcome one, five, and ten years after the storm. Subgroups defined by individuals' neighborhoods: An individual is assumed to be of a certain race if 75 percent of individuals who resided in their 2005 Census block belonged to that race (as of the 2000 Census). Standard errors clustered by Census tract. P-values from pairwise t-tests assuming independence across subgroup. Pre-storm homeownership is measured as having a mortgage just prior to Hurricane Katrina, with renters being any non-mortgage-holders; post-storm homeownership is measured as having a mortgage or having had a mortgage just before Hurricane Katrina and continuing to reside at the same address. *Source:* FRBNY Consumer Credit Panel/Equifax.

outside of New Orleans in 2016, ten years after the storm.<sup>36</sup> By that year, around 13,000 New Orleans evacuees who had not returned to the city of New Orleans lived in Texas, with another 12,000 in Louisiana and more than 1000 evacuees living in each of six other southern states, in addition to California.<sup>37</sup>

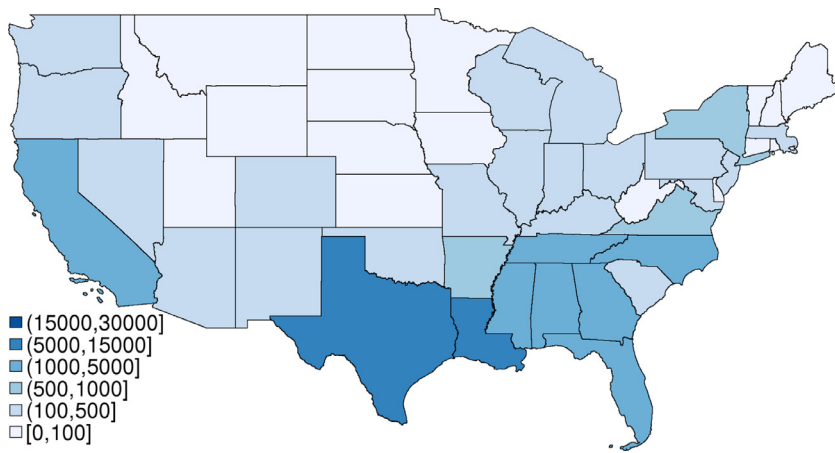
<sup>36</sup> About 23 percent of 2005 New Orleans residents no longer lived in New Orleans in 2016, unconditional on evacuating the city between 2005 and 2006. The percent is calculated as a fraction of all individuals who remain in the CCP in 2016; see Section 3.

<sup>37</sup> For analysis of the impact of these evacuees on the local economies to which they relocated, focusing on the city of Houston, see McIntosh (2008) and De Silva et al. (2010).

In order to estimate the geographic impact of Hurricane Katrina on inundated residents of New Orleans, we extend our model above to estimate the increased likelihood with which inundated residents migrated to each of the 50 states. Since we focus on outmigration of those living in New Orleans at the time of the storm, we must compress our analysis to a single difference, estimating the presence  $M_{sit}$  of pre-Katrina residents in each state  $s$  and time  $t$  using a linear probability model of the pre-Katrina socioeconomic characteristics  $X_{it}$  listed in Table 1 from the first quarters of 2002 to 2005 ( $\mathbb{T}^*$ ), and an inundation indicator:

$$M_{sit} = \alpha_{0st} + K_i \phi_{st} + \sum_{\tau \in \mathbb{T}^*} X_{it} \alpha_{1s\tau} + \epsilon_{sit}$$

estimated using weighted least squares with the same propensity score weights as used above and clustering errors by Census Block. While the



**Fig. 6.** Residence States of Hurricane Katrina Evacuees from New Orleans, March 2016. State map displaying the estimated number New Orleans evacuees living in each state (outside of New Orleans) ten years after Hurricane Katrina. Evacuees are those who resided in New Orleans immediately prior to the hurricane but outside New Orleans one year later. *Source:* FRBNY Consumer Credit Panel/Equifax.

**Table 6**  
Migration destinations from New Orleans after Hurricane Katrina.

One year after		Five years after		Ten years after	
State	Percent mig.	State	Percent mig.	State	Percent mig.
Texas	6.5% [61%*]	Texas	8.0% [39%*]	Texas	8.6% [32%*]
Louisiana	4.7% [97%*]	Louisiana	5.4% [80%*]	Louisiana	5.5% [66%*]
Georgia	2.0% [81%*]	Georgia	2.1% [51%*]	Georgia	2.1% [65%*]
Mississippi	0.97% [81%*]	Mississippi	1.2% [54%*]	Mississippi	1.2% [36%†]
Florida	0.73% [−5%]	Florida	0.97% [−17%]	Florida	1.1% [−15%]
California	0.71% [12%]	California	0.97% [−11%]	California	1.0% [−11%]
Alabama	0.45% [151%*]	Tennessee	0.66% [−8%]	Tennessee	0.64% [−10%]
Tennessee	0.44% [39%]	Alabama	0.62% [70%*]	Alabama	0.61% [43%]
N. Carolina	0.32% [−35%]	N. Carolina	0.51% [−41%†]	N. Carolina	0.49% [−44%*]
Virginia	0.29% [−22%]	New York	0.47% [−32%]	New York	0.45% [−42%*]

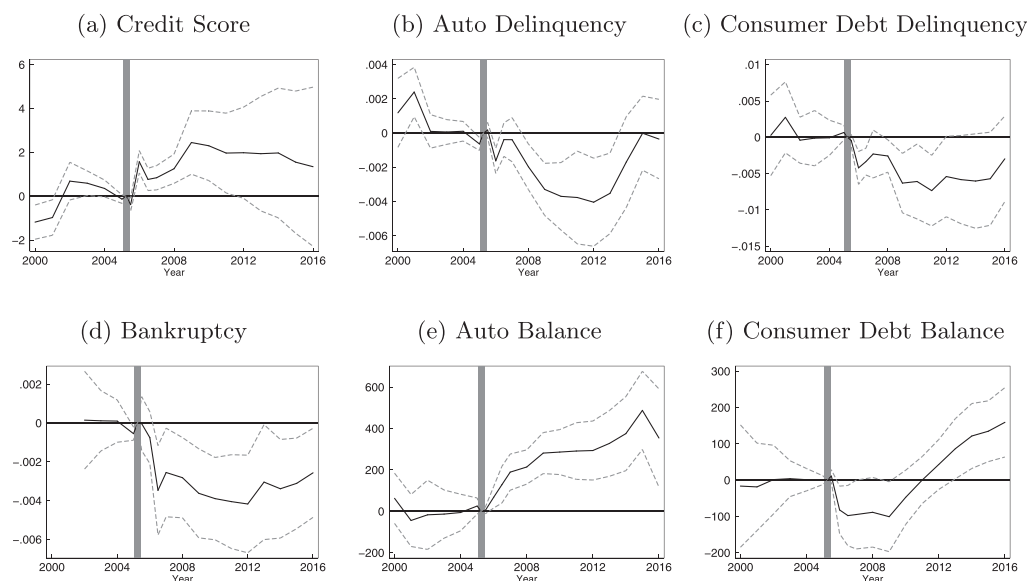
Top ten destination states of New Orleans migrants one, five, and ten years after Hurricane Katrina. The estimated increased likelihood of inundated New Orleans residents migrating to each state is included in brackets (single-difference event study coefficient divided by non-inundated average in that year, with standard errors for the former clustered by Census tract). Time periods are September 2006, March 2011, and March 2016. Louisiana excludes New Orleans. \*  $p < .01$ , †  $p < .05$ . *Source:* FRBNY Consumer Credit Panel/Equifax.

unavailability of an estimate of pre-hurricane differences in long-run outmigration by inundation limits these estimates' causal interpretation, the extensive financial control variables and propensity weights should absorb most relevant pre-hurricane differences. We estimate effects one, five, and ten years following Hurricane Katrina, without restricting the sample to individuals who evacuated New Orleans immediately after the storm.

Table 6 shows the proportion of pre-Katrina New Orleans residents living in each of the top ten states to which they migrated one, five, and ten years after the storm, along with the estimated increased likelihood with which inundated residents moved to that state (in brackets). One year after the storm, Texas was by far the most likely state for New Orleans evacuees to reside in (as previously shown using the CPS; see, e.g., McIntosh (2008)), with 6.5 percent of New Orleans residents having shifted their permanent address to that state. Inundated residents appear more than 50 percent more likely to migrate to Texas,

Georgia, Mississippi, Alabama, and Louisiana (excluding Orleans Parish) than non-inundated residents within a year after the storm, and remained more than 30 percent more likely to have migrated to those states even ten years after the storm (by which time 8.6 percent of pre-Katrina New Orleans residents lived in Texas). Interestingly, inundated residents appear significantly less likely to have moved to distant states like North Carolina and New York ten years after Hurricane Katrina than non-inundated residents, and indeed were 33 percent less likely to have moved to any New England or Mid-Atlantic state (statistically significant at 1 percent), perhaps another indicator of the long-term economic stress faced by inundated residents (even conditional on outmigration).<sup>38</sup>

<sup>38</sup> An alternative explanation would be increased migration to bordering states, at the expense of further migration, due to increased attention or feedback from



**Fig. 7.** Income and Consumption Outcomes, Five States Region. Propensity-score-weighted effects of Gulf Opportunity Zone residence around Hurricane Katrina, excluding New Orleans. Standard errors clustered by county or parish. Credit Score measures an individual's Equifax risk score, which is comparable to a FICO credit score. Consumer debt includes credit and bank cards, retail debt, and consumer finance debt. A loan is delinquent if it is more than 90 days past due. Bankruptcy indicates chapter 7 and 11 filings in the past three years. *Source:* FRBNY Consumer Credit Panel/Equifax.

## 7. Net impacts of GO zone designation

In the previous two sections, we discussed the relative 'intensive' effectiveness of federal and private insurance programs in mitigating long-term negative outcomes for inundated residents of New Orleans relative to their non-inundated neighbors, but found that inundated residents experienced persistent negative shocks in credit score and homeownership and increased outmigration, especially to other parts of Louisiana nearby states. In this section, we turn to a broader analysis of the net Hurricane Katrina impact, comparing residents of the three-state GO Zone, who bore the brunt of Hurricane Katrina's damage but were eligible for a wide variety of government insurance programs, to residents of the Five States region surrounding the GO Zone. These 'extensive-margin' results can be understood to describe insurance programs' broad effectiveness in providing assistance to *all* individuals impacted by Hurricane Katrina, not only those most-severely impacted, with our estimates showing the net effect of the storm's impact and the insurance response. As effectiveness may vary with the severity of the storm's local impact, and given the city's unique circumstances and larger size of the policy response, we first exclude New Orleans residents from the Five States analysis, and refer to this analysis as the Five States border analysis. We then discuss estimates based on an analysis that includes New Orleans, measuring the net impact of the storm for the GO Zone area overall.

We begin with a comparison of the credit score (financial health) and consumption behavior of Five States residents, excluding New Orleans. Fig. 7 shows that GO Zone border residents experienced a small but immediate decline in credit score, followed by a persistent and highly statistically significant rise in credit score by between 1 and 2 points, with the fraction of residents holding subprime risk scores declining about 1.5 percentage points compared to comparable nearby Five States residents. We find higher-magnitude effects on consumer credit balances: Short-term average consumer debt balances fell by about \$100 for GO Zone residents, but the consumption decline begins to attenuate after 2009, and by 2016 the Hurricane's impact on GO Zone residents' con-

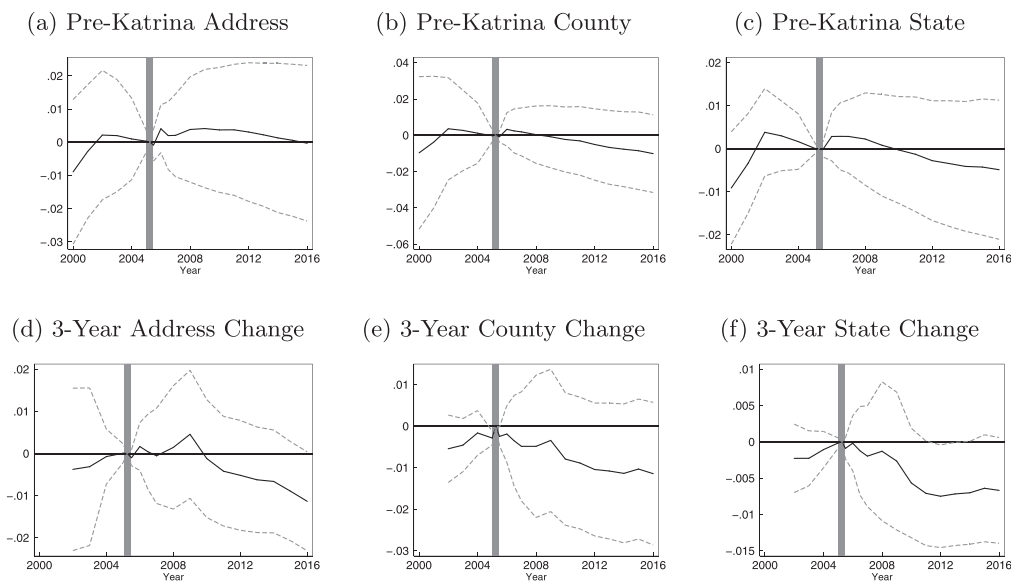
sumption has become large and positive, with an additional \$160 per month in consumer debt (about 4 percent) compared to other Five States residents. As with inundated New Orleans residents, Hurricane Katrina increased GO Zone residents' average auto debt (by around \$400); in addition to a consumption boost, this increase may reflect more frequent replacement of damaged cars with new cars after the storm among GO Zone residents.<sup>39</sup>

Fig. 7 also shows substantial long-term positive effects of living in the GO Zone on derogatory credit behavior. Hurricane Katrina (and the associated policy response) made GO Zone border residents 0.4 and 0.6 net percentage points less likely to hold insolvent auto or consumer debt during the Great Recession, respectively, suggesting that they were more successful in weathering the recession than others in the Five States region (though these impacts attenuate by 2016). They were also substantially and persistently less likely to declare bankruptcy; the 0.4 percentage point decline constitutes a 25 percentage point decline relative to non-GO Zone residents. These results, along with the long-term increases in creditworthiness and consumption, suggest substantial net financial benefits of GO Zone border residents from Hurricane Katrina when compared to outcomes of similar residents outside the GO Zone, which (given the singular destructiveness of the storm) may be attributable to governmental and private over-insurance.

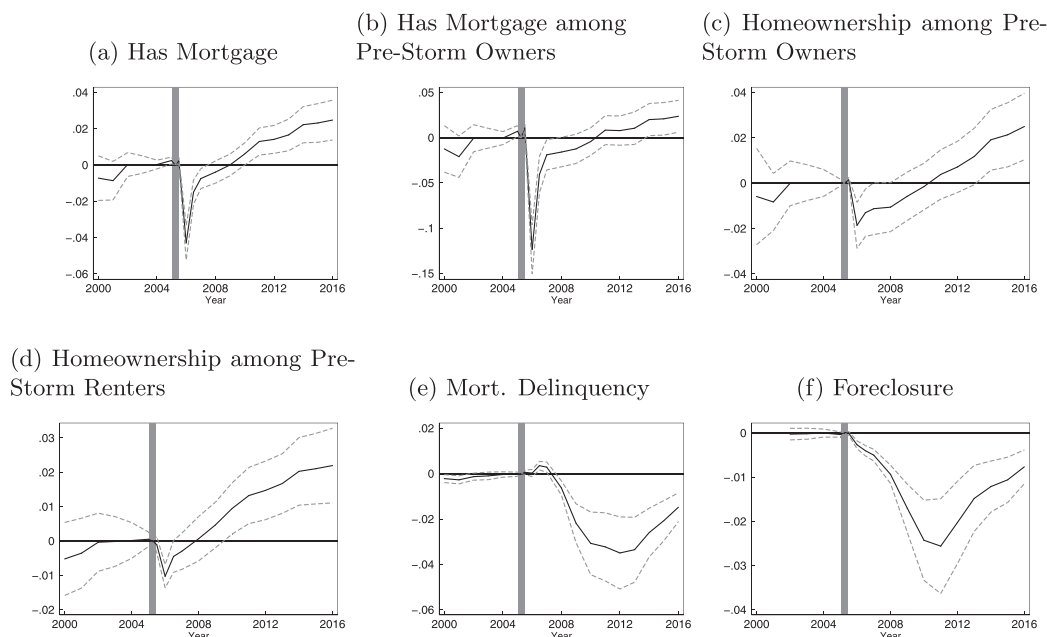
Unlike inundated New Orleans residents, mobility decisions of GO Zone residents outside New Orleans were largely unchanged by Hurricane Katrina. Fig. 8 shows that the storm had no short-term effect on local or cross-state mobility, though we find some evidence that the storm decreased across-state mobility of GO Zone residents years after the storm. This decline in mobility may have been related to homeownership benefits provided by GO Zone residency; Fig. 9 shows that GO Zone border residents experienced a substantial decline in the proportion of residents with housing debt in the short run. Immediately after Hurricane Katrina, mortgage debt holding in the GO Zone declined by 4.3 percentage points (14 percent, likely driven by coastal areas), but it rapidly recovered over the following few years; by 2016, GO Zone residents were 2.5 percentage points more likely than other Five

neighbors or family who moved to bordering states immediately after Hurricane Katrina.

<sup>39</sup> Since GO Zone residents may be replacing older lower-debt cars with newer higher-debt cars, their net automobile wealth may be unchanged.



**Fig. 8.** Mobility Outcomes, Five States Region. Propensity-score-weighted effects of Gulf Opportunity Zone residence around Hurricane Katrina, excluding New Orleans. Standard errors clustered by county or parish. Top three figures show the likelihood of having a different residence location than that of June 30, 2005, while the bottom three figures show the likelihood of having changed residence locations in the previous three years. *Source:* FRBNY Consumer Credit Panel/Equifax.



**Fig. 9.** Homeownership Outcomes, Five States Region. Propensity-score-weighted effects of Gulf Opportunity Zone residence around Hurricane Katrina, excluding New Orleans. Standard errors clustered by Census tract. An individual 'has a mortgage' if they hold any home-secured debt: Mortgage, HELOC, or other home equity loan. Mortgage delinquency and foreclosure are conditional on having a mortgage. A loan is delinquent if it is more than 90 days past due. Pre-storm homeownership is measured as having a mortgage just prior to Hurricane Katrina, with renters being any non-mortgage-holders; post-storm homeownership is measured as having a mortgage or having had a mortgage just before Hurricane Katrina and continuing to reside at the same address. The foreclosure indicator indicates having foreclosed on a mortgage in the past three years. *Source:* FRBNY Consumer Credit Panel/Equifax.

States residents to have housing debt, an eight percent increase. This result applies to both pre-storm renters and homeowners. Mortgage holding by pre-storm homeowners (renters) initially declined by a whopping 12.4 (1.2) percentage points, but after a decade it actually exceeded that for those outside the GO Zone by 2.4 (2.2) percentage points. These dynamics may suggest an (unobserved) drop in GO Zone home prices. Moreover, GO Zone border residents experienced large short- and longer-term declines in rates of home delinquency

(around 1.5 percentage points) and foreclosure (around 0.8 percentage points), each of which constitutes a 25–40 percent decline in their prevalence.

Interestingly, and in sharp contrast to the New Orleans results, when considering the importance of residents paying off mortgage debt while remaining in their homes, we find this to be much more relevant in the GO Zone analysis. While many inundated homeowners in flooded areas in New Orleans paid off their mortgages and became long-time

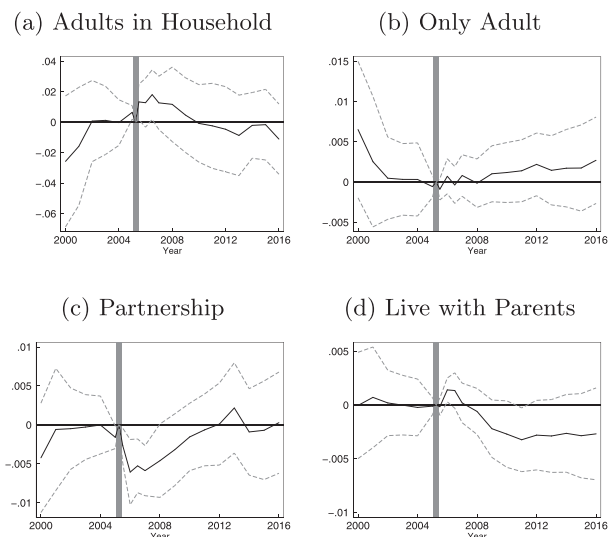


renters elsewhere, more of the affected homeowners in the GO Zone area instead ended up paying off their mortgages faster while remaining in their homes relative to unaffected homeowners. In fact, among pre-storm homeowners we see that most of the decline in mortgage debt holding is due to debt payoffs by those who remain in their homes. For pre-storm homeowners with mortgage debt we now see a much smaller short-term overall reduction in homeownership in the GO Zone border area of just under 2 percentage points, in contrast to the 10 percent decline seen in New Orleans. Insurance programs, then, were successful in accelerating mortgage payoffs and are likely to have helped mitigate the potential long-term effects of Hurricane Katrina on homeownership (as experienced by inundated residents of New Orleans), instead yielding substantial and statistically significant benefits to individuals impacted by the storm relative to those outside the GO Zone.

Unlike in the case of inundated New Orleans residents, we find no statistically-significant evidence of a change in long-term household size among GO Zone border residents caused by Hurricane Katrina, though the proportion of partnerships appears to temporarily fall just after the hurricane. We do find some evidence that Hurricane Katrina decreases the likelihood of parental coresidence among GO Zone residents in the medium-term (by around 0.3 percentage points).

One possible extrapolation of the findings presented above is that individuals residing on the periphery of the GO Zone, who likely faced minimal damage from Hurricane Katrina but were nevertheless eligible for governmental support as GO Zone residents, were able to leverage their geographic position to obtain substantial financial gains, while those on the GO Zone's interior experienced minimal net relative benefits. If the estimated effects presented above are local to the periphery, then restricting our analysis to the periphery would necessarily raise the magnitude of our estimates, tempered as they are by the omitted interior region. In order to test this hypothesis, we restrict our sample to residents of GO Zone counties less than twenty-five miles away from a county outside the GO Zone (centroid to centroid), along with the parallel control group (residents of non-GO Zone counties within 25 miles of a GO Zone county). We then conduct our analysis on this 50 mile-wide band around the boundary of the Hurricane Katrina GO Zone (containing 17.8 percent of GO Zone residents). While the complete output from that analysis is available from the authors, along with the output from alternative specifications (15- and 35 mile bandwidths), Fig. A21 in the supplementary online appendix summarizes our findings. In particular, while Hurricane Katrina increased credit scores, decreased delinquency, and increased consumer credit balances among peripheral GO Zone residents, the magnitudes tend to be somewhat smaller than those estimated for the greater GO Zone border area as a whole, suggesting that peripheral residents cannot wholly account for the regional financial impact presented above. Moreover, the peripheral GO Zone residents experienced no increase in auto balances—likely because their cars were very unlikely to have been damaged by the distant storm—and no increase in homeownership, suggesting that these effects must have been largely driven by residents in the GO Zone's interior.

In order to evaluate the magnitude of spillovers from the GO Zone into the surrounding region contributing to our estimates, we also estimated the impacts on GO Zone residents omitting residents of counties within 10 miles of the GO Zone border.<sup>40</sup> The estimates, available in Figs. A22–A25 in the online supplementary appendix, suggest that interior residents of the GO Zone both faced the short-run costs and reaped



**Fig. 10.** Household Composition Outcomes, Five States Region. Propensity-score-weighted effects of Gulf Opportunity Zone residence around Hurricane Katrina, excluding New Orleans. Standard errors clustered by county or parish. Adults in household includes all individuals covered by Equifax (see the paper). Partnership is defined as living with only one additional covered individual. Parental co-residence is defined as living with at least one individual between 16 and 45 years older. Source: FRBNY Consumer Credit Panel/Equifax.

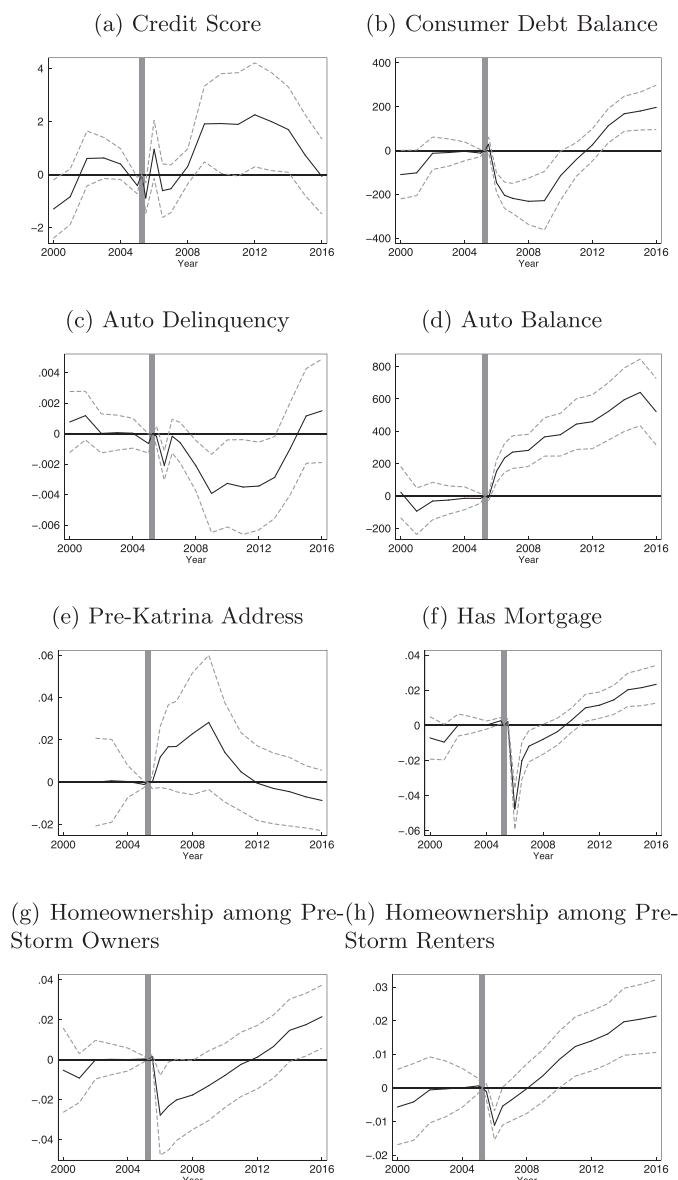
the longer-run benefits of the combined hurricane and disaster insurance, relative to residents outside the GO Zone.

Appendix Figs. A26–A32 and Appendix Tables A1–A3 show Hurricane Katrina's effect on GO Zone outcomes by subpopulation. Younger residents tend to benefit more from GO Zone residence than older residents, with the latter group failing to obtain any long-run increase in consumer debt or homeownership. The same dynamic is true for lower-income GO Zone residents, who obtain statistically-significant increases in consumer debt and homeownership among pre-storm owners, and decreases in parental coresidence (unlike higher-income residents). Outcomes for the residents of white and black neighborhoods are broadly similar and differences statistically-insignificant, though pre-storm renters from white GO Zone neighborhoods experience a larger increase in homeownership and residents of white GO Zone neighborhoods receive a decline in consumer debt delinquency not shared by residents of black neighborhoods.

Finally, our objective in the GO Zone border analysis was to compare residents in the GO Zone area, excluding New Orleans, to similar residents outside the GO Zone areas. The 'extensive margin' results obtained from this analysis captures the net effect of the storm's impact and the insurance response for those who on average experienced less severe damage than New Orleans residents. However, it is also important to learn how residents of the GO Zone area as a whole fared post-Katrina relative to comparable residents just outside the GO Zone area. Accordingly, we repeated the same estimations above but now including New Orleans residents in the GO Zone.

The estimates indicate that the border area estimates we previously found apply more broadly in capturing the net impact of the storm on GO Zone residents overall, relatively to those in the 'unaffected' area, which perhaps is not too surprising given the relatively small size of New Orleans relative to the expansive GO Zone. When comparing the results in Figs. 11 with those in Figs. 7–10, we see slightly larger short- and medium-term negative effects on consumer debt balances, but larger longer-term positive effects on consumer debt and auto debt balances. As expected, we also find much larger increases in relocation rates relative to those living in the "unaffected" area outside the GO Zone.

<sup>40</sup> For example, some federal GO Zone benefits were available to workers who were employed in the GO Zone, whether or not they resided within it; because we cannot observe work locations, to the (likely-small) degree that GO Zone workers are not residents of the GO Zone, our estimates of the true effect of the GO Zone programs will be biased towards finding a zero impact.



**Fig. 11.** Impact estimates for overall GO zone area. Propensity-score-weighted effects of gulf opportunity zone residence around Hurricane Katrina, including New Orleans. standard errors clustered by county or parish. See series-specific notes above. Source: FRBNY Consumer Credit Panel/Equifax.

## 8. Conclusion

This study examines the net intensive impact of Hurricane Katrina on inundated residents of New Orleans, the hurricane's net extensive impact on a large federally-insured region surrounding New Orleans, the breadth of those impacts across demographic groups, and the migration outcomes of New Orleans residents in the ten years following the storm. Each of these measured outcomes can be interpreted as the result of a large set of federal, state, and local policies implemented to insure 'geographically-unlucky' Gulf Coast residents following an unusually-damaging hurricane.

We find mixed evidence of the effectiveness of these policies in New Orleans, with inundated residents having achieved similar levels of financial distress and household size ten years after the hurricane, but also find that inundated residents maintain lower credit scores and homeownership rates—and are far less likely to remain in New Orleans—than their non-inundated neighbors. Inundated New Orleans

residents who have moved out of the city were more likely to remain in Louisiana and the surrounding states, while non-inundated residents were more likely to move to the Northeast, suggesting that mobility may not have provided substantial long-run benefits to inundated residents. Outside of New Orleans, and for the larger three-state GO Zone overall, we find evidence of over-insurance relative to nearby regions that escaped most Katrina-related damage, with program-eligible residents enjoying higher consumption and homeownership but far lower rates of bankruptcy and foreclosure ten years after the storm (despite facing more direct hurricane damage than the more-distant comparison group). A larger share of GO Zone pre-Katrina homeowners paid off their home mortgages after the storm relative to non-GO-Zone residents, presumably using insurance payouts. These effects appear to have been magnified by the Great Recession, with Gulf Coast residents appearing to enjoy effective 'recession insurance' in the name of hurricane insurance in the late 2000s. While older, higher-income, and white residents of New Orleans were more likely to evacuate the city following the storm, we find little evidence of differential policy treatment by race within New Orleans, and find that the broader region's over-insurance most benefited younger and lower-income residents.

Our study shares a number of limitations with earlier studies. Our intensive and extensive analysis is unable to separately identify common or spillover effects, the presence of which would downwardly bias our estimates. Our subpopulation analysis estimates marginal within-group effects of the hurricane, with data limitations prohibiting the identification of cross-group differences in the hurricane's impact (despite their being of substantial policy interest, especially regarding race). Since we do not observe residents' program-specific eligibility or participation, we cannot identify the treatment effect of individual post-Katrina policies. Perhaps most pressingly, we are unable to define the welfare impact of the storm or its subsequent policy response, instead only observing a large number of important social and financial indicators that provide proxies for Gulf Coast residents' post-hurricane welfare. We leave the resolution and transcendence of these limitations to future research.

## Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.jue.2019.01.005](https://doi.org/10.1016/j.jue.2019.01.005).

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