Heterogeneity in the Recovery of Local Real Estate Markets After Extreme Events: The Case of Hurricane Sandy

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Abstract:
This paper examines the effect of Hurricane Sandy on local real estate markets in New York City. A natural disaster, like Sandy, generates two important shocks that can affect real estate markets: it causes physical damage to properties and it provides new information about the risk of future damage. Moreover, these shocks can manifest very differently across sub-markets. We find that the prices of 1-3 family homes on blocks hit by high storm surges drop by about 16 percent and remain 12 percent lower than pre-storm levels six years after the storm. We show that these long-term effects are concentrated in areas *outside* of existing flood zones. Based on analyses of insurance policy take-up, claims and rebuilding activity, this variation in price effects seems to be related to differences in salient information about risk leading up to the storm. We also find heterogenous price effects depending on the income level of the neighborhood outside of the flood zones. Properties in higher income neighborhoods experience large initial price shocks but then start to recover, while those in lower income areas appear to experience a delayed response and exhibit no sign of recovery. These price differentials are more likely driven by differences in the resources to rebuild and optimism about the local market's resilience. Finally, the storm led to a change in the composition of homebuyers in low-income storm surge areas that were outside the flood zone. After the storm, homebuyers in those areas were more likely to be Black and Hispanic, suggesting that the flooding and damage may have changed neighborhood demographic trends.

Keywords:
Hurricane; Price capitalization; risk and information

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1. Introduction

This paper examines the effect of Hurricane Sandy on local real estate markets in New York City. A natural disaster, like Sandy, generates two important shocks that can affect real estate markets: (i) it creates new (and often severe) physical damage and (ii) it provides new information about the risk of future damage. These shocks can manifest very differently across sub-markets. We focus on this heterogeneity in price recovery across neighborhoods and conduct analyses of population shifts that help to unpack the sub-market responses. We also attempt to tease out the mechanisms driving the heterogenous price responses and conclude that differences in both pre-existing knowledge about a neighborhood's risk-level and availability of resources for repair contribute to the variability in price patterns we observe.

We rely on a combination of longitudinal, micro-datasets on property sales transactions, property characteristics, and mortgage application activity in New York City. We overlay these data with spatial information on flood zones to capture the perceived risk prior to Hurricane Sandy, as well as spatially detailed data on storm surge heights. Our results indicate that the prices of properties on blocks that saw high storm surges fell in the immediate aftermath of the storm. In the year after the storm, 1-3 family properties on high-surge blocks saw price declines of about 16 percent compared to properties on blocks without any storm surge. On average, values of these properties remained about 12 percent lower than pre-storm levels six years after the storm. We find that properties located on blocks in low-surge areas also saw a sustained, though more gradual, reduction in value, with property values falling to about 14 percent below pre-storm levels by 2018.

One of our core contributions is to illustrate significant differences in recovery inside and outside of official flood zones, or FEMA zones. Specifically, the prices of properties on high surge blocks located inside FEMA zones saw an initial decline in prices but recovered quickly after the storm. By contrast, prices of properties on both high- and low-surge blocks outside FEMA zones remained depressed six years after the storm. While this difference could partially be driven by more extensive insurance coverage within the flood zone and therefore more rapid repairs, our analysis suggests that information was also an important channel: properties in flood zones were already considered risky before Hurricane Sandy, and the storm provided little additional information to the market.

A second key contribution is our finding that the shock of the storm – perhaps through these reductions in prices – led to significant changes in the composition of households interested in moving into the hard-hit areas. The storm led to a change in both the incomes and the racial composition of households applying for home purchase mortgages in hard-hit areas that were outside the flood zone, especially areas that were low-income. Specifically, after the storm, home mortgage applicants in hard-hit areas had lower incomes and were more likely to be Black or Hispanic.

A third key contribution is our finding of differential recovery in high- and low-income neighborhoods. We find that properties in higher income neighborhoods that were hit by high storm surges outside the designated flood zones experienced larger initial price shocks than those in low-income areas, but prices in higher income areas generally recovered far more quickly. Prices in lower income areas exhibited no sign of recovery and experienced further decline.

As for mechanisms, we use the prevalence of insurance policies, claims and alteration permits to try to tease out the relative importance of direct physical damage compared to new information about risk after the storm. While we cannot rule out the impact of lingering, storm-induced physical damage on house prices, our results suggest that the information channel is also important in causing the persistent price discounts in hard-hit areas outside the flood zones. Most notably, we see persistent price declines outside the flood zone even in areas that saw low levels of flooding and thus could not have experienced much in the way of physical damage. Further the timing of building permit issuances doesn't line up with price recovery inside the zone. That said, the fact that we see more price recovery in high-income areas than in low-income areas may be due to the greater resources that property owners in those neighborhoods have for repairs. It's also possible that owners in higher income areas are more willing to invest in repairs because they are more optimistic that these neighborhoods can recover.

2. Determining storm risk: Information, physical blight, and localized neighborhood conditions

2.1 Background

A natural disaster can affect property prices in several ways. First, a storm provides information to potential buyers of properties in impacted areas about the likelihood of future flood exposure and damage. The value of this information, and how much it is reflected in price changes after the storm, depends on how much information about that risk was available prior to the storm (i.e., was the parcel already in a zone known to be prone to flooding?).

Second, storms can inflict physical damage – both direct damage to the property itself and damage to neighboring properties. Damage to the property itself, from, for example, excessive water or wind, can depress the value of the property due to the costs necessary to make physical repairs. The damage the storm inflicts on neighboring properties can also reduce property values due to physical blight or the illicit activity that might accompany it (Campbell, Giglio, Pathak, 2011; Gerardi et al, 2015; Harding, Rosenblatt, and Yao, 2009; Schuetz, Been and Ellen, 2008; Hartley, 2014).

Past research has not considered how these various mechanisms play out differently in different types of neighborhoods. We first consider how the information provided by the storm differs inside and outside of official flood zones, perhaps the most salient pre-storm signal of risk. Purchasers of properties located in the flood zone are required to buy flood insurance if they obtain a mortgage for their home, and thus they have salient information about the risk of future flooding. This is not the case for properties outside the flood zone. As a result, we expect that prices of properties in the flood zone should have reflected the potential for flooding-related damage even before Sandy occurred, and therefore the storm would not have introduced much new information about risk. By contrast, the storm provided new information to potential buyers of properties outside of the flood zone that experienced storm surge. In addition to this information channel, properties in the flood zone are more likely to be insured. So even if properties inside flood zones experience direct physical damage, the higher insurance coverage in the flood zone might speed up the recovery, assuming insurance provides reasonable coverage.

Further, we build on past research by also considering how these mechanisms can play out differently depending on neighborhood income. We expect that property owners in higher income areas may have more resources for repairing damage after the storm to mitigate the damage (and any price effects), even without insurance. Potential homebuyers and investors may also view higher income areas as possessing other features or fundamentals that signal higher returns on investment in the future (even in the presence of increased flood risk). Accordingly, investors may be more willing to continue to invest in those areas, even after a storm hits.

2.2 Empirical literature

Past researchers have documented negative effects of hurricane and flooding risk on residential property prices (Hallstrom and Smith, 2005; Kousky, 2010; Bin and Landry, 2013; Atreya and Czajkowski, 2019; Gillespie et al. 2020; Hennighausen and Suter, 2020).[1] These studies tend to have two strategies for identifying the risk: they either observe price responses before and/or after an actual storm or flooding event, or they observe price responses after the change in information about the risk of flooding (either from nearby

[1] Among this literature, McKenzie and Levendis (2010) points out higher compliance costs associated with rebuilding under more stringent National Flood Insurance Program (NFIP) guidelines could cause the price reduction as well.

storms or the introduction of new hazard zone maps). The general conclusion from these studies is that any new information about flooding risk is capitalized into prices. The price effects are usually negative in the short run.

For example, Yi and Choi (2020) examine how information about flooding risk is revised after direct experience with inundation (or lack thereof). They observe a rebounding of prices for properties without any inundation after the great Iowa flood of 2008 and attribute this response to changes in information about risk. Properties that were unexpectedly flooded saw more persistent price declines, and those in the flood zones and with inundation saw no price change. McKenzie and Levendis (2010) test for the mediating role of elevation in conveying risk. They find that homes at higher elevations sell for a premium that increased after Hurricane Katrina; they interpret this as reflecting the new information on increased risk at lower elevations as well as the higher compliance costs from insurance for those more exposed homes.

Bernstein, Gustafson, and Lewis (2017) examine the perception of risk and residential mobility rather than property values. They show that households whose residential properties are damaged by hurricanes are more likely to be concerned about flooding risk, and concerned households are more likely to leave coastal areas in the five years after the storm. None of these studies, however, attempt to tease out the way that disrepair, rebuilding and the resources to recover might mediate the price response. For example, Atreya and Ferreira (2015) find that prices drop more for residential properties in inundated areas than comparable properties in flood-prone areas without inundation, but they do not try to disentangle how much of that is due to direct flooding damage versus newly salient risk information.

Similar to our focus, Ortega and Taspinar (2017) look at New York City real estate after Hurricane Sandy. They find that the prices of homes in New York City's evacuation zones (areas that encompass and extend well beyond the FEMA flood zones) that were not damaged by Hurricane Sandy experienced a gradual decline over the five years after the storm, reaching 8% in 2017. Residential properties that were damaged by Hurricane Sandy meanwhile suffered an immediate 17-22% drop; but, by 2017, they had recovered to about the same level as evacuation-zone residential properties that did not suffer damage. The authors argue that the persistent price discount is due to the increase in the perceived risk in areas at risk of flooding. However, they do not separately examine effects on properties inside and outside FEMA flood zone boundaries, which are likely to be more salient to homebuyers than evacuation zones, and nor do they consider heterogeneity across neighborhoods.

A few papers have explored heterogeneity in flooding impacts. Barr, Cohen, and Kim (2017) find that New York City houses, apartments, and commercial properties in census tracts with better subway access and higher incomes were more affected by Hurricane Sandy. They argue that residents in those neighborhoods are more responsive to the shock, but they only examine price effects through 2014 so they are capturing short-term effects. Bakkensen and Barrage (2017) also find that the capitalization of flooding risk is greater among non-owner-occupied properties that are located in wealthier and more educated zip codes. On the other hand, there is ample evidence showing that low-income and minority neighborhoods are typically more vulnerable to the harmful impacts of disasters (for example, Shirley, Boruff, and Cutter, 2012; Van Zandt et. al. 2012).

In the current analysis, we further disaggregate the price responses after a severe flooding event. First, we test for heterogeneity of flooding risk capitalization at the neighborhood level by quantifying how prices and the composition of buyers change in the wake of the storm, across neighborhoods with varying levels of economic resources. Second, we tease out the role of flood hazard zones as salient risk information channels by simultaneously accounting for flood zone boundaries and localized variation in direct damage.

3. Data and analytical strategy

In October of 2012, Hurricane Sandy hit the east coast of the United States. It was the strongest storm on record to hit the coast, and New York City was hit particularly hard. The storm surge covered nearly nine percent of all residential units in the city, and roughly four percent of all households registered with the Federal Emergency Management Agency (FEMA) for post-disaster assistance (Furman Center, 2013). Hurricane Sandy is estimated to be the fourth-costliest hurricane on record in the U.S., after Hurricane Katrina in 2005, Hurricane Harvey in 2017, and Hurricane Maria in 2017.[2]

[2]See the NOAA website for details: https://www.coast.noaa.gov/states/fast-facts/hurricane-costs.html

The sheer scale of New York City provides a sizable and diverse sample of properties and neighborhoods to study. Further, the storm hit the city in both predicable and unpredictable ways: blocks within the same New York City neighborhoods experienced wide variation in levels of flooding and damage. For example, FEMA estimates that within Lower Manhattan, the Bowling Green neighborhood saw 58.1% of its land surface flooded while the nearby Church Street neighborhood experienced a flooding rate of only 19.6%.

3.1 Data

We compile a rich micro-dataset that captures property sales transactions, parcel characteristics, and block-level flooding risk and storm surge across New York City. The heart of our data is the universe of property sales transactions provided by New York City's Department of Finance. These data include the date and price for each transaction and extend from 2006 to 2018. We focus on 1-3 family properties because their lower height (as compared to condos, coops, and multifamily rental buildings) makes them more vulnerable to damage.[3] They are also more likely to be owner-occupied and subject to flood insurance requirements if mortgaged and located in the FEMA flood zones. While we focus on 1-3 family properties, we also test for price effects for different property types (displayed in Appendix A).

We supplement the sales data with parcel characteristics, like year built, height, size, and number of residential and commercial units, from the Department of Finance's Real

[3] Note that we exclude a few census tracts in the Rockaways where a large number of city-subsidized homes were sold around the time that Sandy hit (but unrelated to the storm).

Property Assessment Dataset (RPAD). These data also track information on the universe of parcels in the city from 2006 through 2018.

Third, we obtain maps with the boundaries of the 100-year flood zones in effect at the time of Hurricane Sandy, as well as information on surge levels during the storm. Both are obtained from FEMA and displayed in Figure 1. We obtain the surge map from the FEMA Modeling Task Force (MOTF), which uses high-water marks and surge sensor data to interpolate water surface elevation after the storm.[4] MOTF reports surge levels at a very micro level (one- or three-square meter), and we use them to calculate surge levels at both the block- and census tract-level. The surge heights across blocks vary widely. Note that we use surge heights rather than FEMA's assessment of property damage because the surge heights are more clearly exogenous, though there is a high level of correlation between the two measures.[5] We also use census tract median household income from the 2007-2011 American Community Survey to capture baseline differences in neighborhood income.

Fourth, we merge in information on mortgage applicants from the Home Mortgage Disclosure Act (HMDA) data for the same time period. They include information on the census tract of the property, the loan amount, the loan provider, and the mortgage applicant's race, income, and sex. We rely on these data to observe changes in the composition of homebuyers in areas hard hit by the storm.

[4]Surge levels for the boroughs of Manhattan, Brooklyn, Queens, and Staten Island are based on 1-meter digital elevation model (DEM) resolution and for the Bronx, 3-meter resolution. Information on the FEMA MOTF is available here: http://www.arcgis.com/home/item.html?id=307dd522499d4a44a33d7296a5da5ea0.

[5] The damage reports generated by FEMA are partially determined by surge information, as well as other inputs, like interpretations of visible aerial imagery, that can introduce bias and noise into the indicators. 8.62% of damaged properties in the FEMA damage map are outside the surge areas.

Finally, to shed light on mechanisms, we use data on building permits for home alterations or repairs from the New York City Department of Buildings as well as insurance policies and claims through that National Flood Insurance Program (NFIP) that are available from FEMA. We can observe the exact timing of building permit issuance at the individual building level, but we only have data on insurance policies and claims aggregated to the census tract level.

3.2 Estimation

We estimate two sets of models, the first using the natural logarithm of sales price as the dependent variable and the second using information on mortgage applicants (such an income and race) as the dependent variable.

3.2.1 Prices

For the price models, the unit of analysis is the parcel-sale. The sample is restricted to sales in sub-borough areas with either at least one block with surge or at least one property in the flood zone.[6] We have an unbalanced panel of sales, since parcels sell at different frequencies. The baseline price regression model takes the following general form:

$$ln(price)_{int} = \lambda_1 HighSurge_i + \beta_1 LowSurge_i + \gamma_1 FloodZone_i + \lambda_2 HighSurge_i *PostSandy_t + \beta_2 LowSurge_i * PostSandy_t + \gamma_2 FloodZone_i*PostSandy_t + \delta B_{i,n} + N_n + \varphi Q_t + \theta D_{b,t} + e_{it} \quad (1)$$

[6]Sub-borough areas are groups of census tracts summing to at least 100,000 residents, determined by the New York City Department of Housing Preservation and Development.

where *PostSandy* takes on a value of 1 starting in 2012 Quarter 4; *HighSurge* is 1 if the property is on a block that experienced an average surge of over two feet; *LowSurge* is 1 if the property is located on a block that saw, on average, some level of surge, but less than two feet.[7] We initially include a variable (*FloodZone*) to identify properties that are located in the FEMA flood zone, pre- and post-Sandy. This allows us to test whether high storm surges led to a reduction in property values controlling for location in the flood zone, or the degree of pre-storm knowledge of flood risk.

We include $B_{i,n}$, a set of building characteristics (number of units, size, height, age, building class). While we cannot employ property-level fixed effects, we are able to include census tract fixed effects, and thus we are able to identify effects from differences in price changes for properties in the same census tracts facing varying degrees of storm surge. Specifically, N_n is a vector of census tract fixed effects; Q_t a vector of Year-Quarter dummies, and $D_{b,t}$, a vector of borough-year dummies to control for broader neighborhood changes over time.

3.2.2 Dimensions of heterogeneity

As discussed above, we consider several dimensions of heterogeneity in price effects. First, we test for differences with respect to location in the FEMA flood zone. To do so, we estimate separate versions of regression (2) on samples stratified by location in the FEMA zone. In these models we no longer control for *FloodZone*:

[7] We also run models where we control for a continuous variable calculated as the share of damaged properties on the same block as property i (excluding parcel i). The results are consistent with those presented: a higher share of damage yields bigger price declines.

$$ln(price)_{int} = \lambda_1 HighSurge_i + \beta_1 LowSurge_i + \lambda_2 HighSurge_i *PostSandy_t + \beta_2 LowSurge_i * PostSandy_t + \delta B_{i,n} + N_n + \varphi Q_t + \theta D_{b,t} + e_{it} \quad (2)$$

We also run versions of this regression interacting *HighSurge* and *LowSurge* with year-specific dummies instead of a single *PostSandy* dummy to estimate prices effects over time and to test for pre-existing trends.

Finally, we test for differential price effects and recovery across neighborhoods with different income levels. Specifically, we estimate separate versions of regression (2) on samples stratified by census tract median income. We divide our sample into two groups, depending on whether their census tract has a median income above or below $76,808, the median for all census tracts in our sample.

3.2.3 Buyers' response

To understand how the storm-induced price changes might influence the composition of the neighborhood, we use HMDA data to test for changes in the property buyers. Here, the unit of analysis is the mortgage applicant, and we model two applicant attributes: income and race. The general regression model takes the following form:

$$ApplicantChar_{it} = \beta_1 TractHighSurge_i *PostSandy_t + \beta_2 TractLowSurge_i *PostSandy_t + \delta S_i + \theta D_{b,t} + e_{it} \quad (3)$$

where *Sandy* takes on a value of 1 starting in 2013; *TractHighSurge* is 1 if the average surge level in census tract *i* is higher than 2, and *TractLowSurge* is 1 if the average surge level in census tract *i* is lower than 2 feet and higher than 0 feet. We include S_i, census tract fixed effects, and $D_{b,t}$, a vector of borough-year dummies, to control for broader neighborhood trends over time. The sample is restricted to sub-borough areas with at least one damaged property or one property within the flood zone. We separately estimate for census tracts inside and outside of the FEMA zone and for tracts outside the flood zone with median incomes above and below $76,808, the median for all census tracts in our sample. Again, we also run versions of this regression interacting *TractSurge* dummies with year-specific dummies instead of a single *PostSandy* dummy to estimate prices effects over time and to test for pre-existing trends.

3.2.4 Identifying mechanisms

Finally, to explore mechanisms (and distinguish between the new information and lingering blight channels), we examine the timing of the issuance of alteration permits and insurance policy claims in hard-hit neighborhoods inside and outside of the flood zone. We also lower the maximum height of the low-surge category to six inches, thus capturing surge areas that likely saw minimal physical damage.

4. Findings

4.1 Composition of the sample

Our estimation strategy requires variation in the degree of flooding, both inside and outside of the flood zone. Table 1 shows cross-tabulations across our main indicator of risk exposure (location in the flood zone) and surge heights for 1-3 family properties. The correspondence between *FloodZone* and both *HighSurge* and *LowSurge*, is naturally positive, but there are actually more properties located on high-surge blocks outside the flood zone than inside, suggesting there is sufficient variation to separately estimate the effects of surge heights inside and outside of the flood zone.

We also test for pre-existing differences between properties inside and outside the flood zone and across surge categories. Table 2 displays these summary statistics, based on sales that transacted before Hurricane Sandy took place. There are differences, albeit modest in most cases, across properties selling in the various areas of risk and flood exposure. As expected, differences by location in the flood zone are larger than those by storm surge. The properties outside of the flood zones tend to be bigger and older. They also tend to sell for higher prices. Since there are some baseline differences, we control for these property-level characteristics in the analysis to ensure they are not driving any price differentials.

4.2 Testing for price effects

We first examine the extent of price declines for 1-3 family properties affected by the storm. These results are displayed in Table 3. As an initial estimation, we just control for location inside of flood zone, following most previous research. The results in column 1 show that the residential properties located in the flood zone sold at a 10.9% discount after the storm relative to properties outside of the flood zone. This difference, however, could be due to the degree of flooding from the storm. Therefore, in second column we introduce controls for the degree of storm surge. There is a 14% discount after the storm in high-surge areas, and an 11% discount in low-surge areas, compared to areas without any flooding.[8] As shown in column 3, this price effect is similar with and without controls for location in the flood zone, and we see no change in the flood zone discount after the storm, once we control for storm surge, suggesting that the storm did little to change the risk premium buyers demanded for properties in the flood zone. It appears that the price response is largely driven by the degree of storm impact. This could include the new information about risk that it introduces as well as the physical damage incurred by the flooding. Note that the coefficients on other variables are consistent with expectations. For example, larger and newer properties all sell for higher prices.[9]

Figure 2 shows results from regressions with individual year dummy variables and confirms that there were no pre-existing trends in prices of properties that were located on blocks that saw flooding during the storm, relative to those on blocks without any surge. The figures also show that impacts are persistent. In the year after the storm, 1-3 family properties located on blocks that experienced high storm surges saw a 16 percent decline relative to similar properties on blocks that saw no flooding. On average, values of these properties remained about 12 percent lower than pre-storm levels six years after the storm. Impacts on prices of properties located on blocks that saw low surge levels were initially

[8] By contrast, as shown in Appendix A, other types of properties in surge areas -- coop and condo buildings and larger rental properties -- saw no significant change in value except for a marginally significant increase for condos and coops in the high-surge areas. We are cautious in our interpretation of that coefficient, as the sample size is quite small, with less than 1,000 properties in the high-surge category across the five years after the storm.

[9] The age dummy indicates whether the building age is missing. Many properties do not have an accurate build year because they are extremely old.

much smaller but then fell to about the same level as prices on high-surge blocks six years after the storm.

4.3 Testing for heterogeneity in price effects and changes in neighborhood composition

These citywide average effects may conceal considerable heterogeneity in the price response. We explore both heterogeneity inside and outside the flood zone and across neighborhoods with different economic resources. We then test if there is a corresponding change in the profile of buyers who opt into the neighborhoods hit hard by the storm.

4.3.1 Flood Zone

We first consider whether prices respond differently inside and outside of the FEMA flood zones. We consider zone designation to be one of the most salient indicators of risk, as flood insurance is required if financing a home inside the zone. Figure 3 distinguishes between the effects of storm flooding inside and outside of the flood zone and shows variation in price responses that was obscured in the pooled results. The properties on high-surge blocks inside the flood zone experienced an immediate price decline after the storm but then recovered right away. Low-surge blocks in the flood zone meanwhile saw no price declines at all in the aftermath of the storm. By contrast, price effects are large and persistent outside of the flood zone, both for properties on high-surge blocks and those on low-surge blocks (again, we see no significant pre-trends.) These results are also evident in the coefficients displayed in the last two columns of Table 3.

As validation, we run a similar stratified regression restricting the sample to only sales within immediate proximity of the border of the flood zone (properties located 400 meters inside and outside of the zone). By narrowing the sample, we can better control for any locational differences between properties that may be driving any differences in price responses apart from the storm's impact. These results are displayed in Table 4. They confirm the results from the full sample. The magnitudes of price discounts outside of the flood zone are similar to those in the full sample analysis (even larger for the high-surge classification). The price response inside the flood zone is both smaller and insignificant.

4.3.2 Neighborhood income

When we consider heterogeneity across neighborhoods with different economic circumstances, the regression results confirm theoretical expectations. The coefficient on *HighSurge*PostSandy* in Table 5, which shows results for the sample of 1-3 family properties stratified by the income of the neighborhood, is significantly larger in low-income than in high-income areas. This difference holds when we restrict the sample to properties outside of the FEMA flood zone, where we observed the most pronounced and durable decline in prices. By contrast, we see virtually no difference in the coefficient on *LowSurge*PostSandy* across income categories, suggesting that income differences only matter when damage is more substantial and calls for significant repairs, which owners in higher income areas can more readily afford.

When we look at the time path of prices (see Figure 4), the story is somewhat more nuanced: properties on high-surge blocks in higher income neighborhoods suffer a significant price discount immediately after the storm for being damaged (22 percent). These properties partially recover their values over time though never quite get back to pre-storm (2011) levels. In low-income areas, by contrast, we see only a modest immediate impact on prices, which appears to grow over time and shows no sign of recovery. We see similar differences, though less pronounced, between impacts on low-surge blocks in high- and low-income neighborhoods.

Furthermore, for areas outside the FEMA zone, we confirm that the difference in price discounts across neighborhood with different income levels is not due to varying degrees of storm damage. The distribution of severely damaged properties (i.e., those whose repair may be delayed or more comprehensive than an alteration) is similar across low- and high-income neighborhoods (see Appendix B). [10] This suggests that higher income neighborhoods may instead have more resources to rebuild, driving a faster price rebound compared to lower-income areas with similar storm damage.[11]

4.3.3 Buyer composition

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[10] However, we do see that the uptick in building permits happens somewhat more quickly after the storm in higher income areas. We address this pattern more directly in the mechanisms section below.

[11] Policy coverage is generally very low outside of the flood zone, and the rate of policy coverage in high-income neighborhoods with high surge levels is only slightly higher than those in similarly inundated low-income neighborhoods (the absolute number of policies is actually lower). In addition, the number of claims after the storm is the same across low- and high-income neighborhoods with high surge levels (they are actually higher for low-income neighborhoods with lower surge levels). Therefore, it is unlikely that any difference in price rebound for high-income neighborhoods is driven by insurance-funded repairs. It is still possible that high-income neighborhoods have other resources to rebuild and recover, which would mitigate price declines more than low-income neighborhoods without the same resources.

We also examine changes in the composition of those interested in investing or buying in Sandy-affected areas using HMDA.[12] We test specifically for shifts in the income and race of the households applying for mortgages (using mortgage applicants as a proxy for the universe of homebuyers interested in the neighborhood).[13] The dependent variable in our first regression is the log of applicant income. Table 6 displays these results. Recall, for these data we cannot identify the parcel or block of the applicant; the finest geographic identifier available is the census tract. Thus, we create tract-level metrics of storm surge by calculating the average surge level by census tract. The results provide evidence of a decline in the income of mortgage applicants in areas that suffered more flooding from the storm but were outside of the FEMA flood zone.[14] We further disaggregate the price declines outside of the flood zone and find that applicant income went down in neighborhoods classified as both high- and low-income though the decline was the most pronounced in lower-income neighborhoods among blocks hit hardest by the storm. However, Figure 5 shows the time path of effects and suggests that some of this reduction in income may have simply been a continuation of a pre-existing trend.

Table 7 and Figure 6 display results from similar models predicting the probability that an applicant is Black or Hispanic, controlling for their income.[15] The effects here are stronger,

[12] We recognize that we are only capturing those buyers who take out mortgages to finance their home purchases, and we may be under-representing more affluent (and possibly white) buyers. If the prevalence of such high-income, cash buyers increases after the storm, we could be overstating any income declines.
[13] Note that effects are qualitatively the same when we analyze shifts in the composition of actual borrowers rather than applicants. Ratnadiwakara and Venugopal (2020) conduct a similar analysis, but do not distinguish effects across neighborhoods of different income levels; they find increased demand among lower-income borrowers and not change in the likelihood of minority borrowers.
[14] Census tracts within FloodZone are either high-surge or low-surge, and so we do not have the comparison group for sample within FloodZone.
[15] The results are consistent when we do not control for the income.

especially in low-income areas. We see evidence that the storm triggered a racial shift in the composition of homebuyers: the likelihood that a borrower is Black or Hispanic increases after the storm in neighborhoods outside of the flood zone that experienced more flooding relative to other nearby neighborhoods. Isolating the price declines outside of the flood zone, we find that the effects are similarly sized in high- and low-surge areas and are largest in lower income tracts outside the flood zone.[16]

4.4 Robustness checks

We run several robustness tests. First, immediately after Sandy, new, expanded flood zone boundaries were proposed in 2013 (Toure, 2018). They were not officially finalized or approved during our study period, but the proposal itself could have introduced new information. It is possible that the effects we observe outside the flood zone reflect the new boundaries that were proposed in 2013 but never adopted. To tease out this influence, we re-estimate our models controlling for the new flood zone boundaries, and, as shown in Table 8, we find very similar results. While the results in the first column suggest that the introduction of the new flood zone boundaries could be pushing prices down, apart from any effect from the pre-existing boundaries, the negative coefficient on the 2013 flood zone indicator becomes insignificant once we control for the degree of surge. Indeed, while the magnitudes for the coefficients on the original 2007 flood zone indicators reduce slightly, the story remains the same. The final two columns display regression results from samples stratified by location inside and outside of the 2007 flood zones (there were virtually no blocks de-designated as risky according to 2007 or 2013 mappings). Again, while the magnitudes for the coefficients on the original 2007 flood zone indicators reduce slightly, the patterns of price declines remain the same. While there is an independent price discount for properties in the newly proposed flood zone boundaries, it is not bigger than that observed for the rest of the areas outside the 2007 flood boundaries and therefore not driving the price discounts we see outside of the original flood zone. It appears that the information provided by storm surge was far more salient than the information provided by the proposed new flood zone boundaries.

Second, in order to confirm that our use of flood surge as a proxy for direct impact on properties is credible, we replicate our baseline model using FEMA's estimate of property damage instead of the surge levels. These replications produced very similar results, as shown in Figure 7.[17]

Finally, we re-estimate our models after excluding properties in Staten Island, as the government buy-out offers were concentrated in Staten Island, and those buyouts may not have been arms-length transactions. Their inclusion could therefore bias the price response estimates. Figure 8 shows that we obtain similar results without sales in Staten Island, suggesting these buyouts do not bias our results.

4.5 Exploring the mechanisms for price discounts

[17] FEMA determines the damage at the building level based on visible aerial images and surge heights. We categorize a property as damaged if it has any degree of damage (affected, minor, major, or destroyed). We also calculate, for every property, the share of other properties on its block that suffered damage in the storm.

In this final section we attempt to disentangle the channels through which the price discounts take place. The more modest impacts inside the flood zone could reflect both greater knowledge about flood risk leading up to Sandy and also a greater ability to recoup losses (via insurance payouts). As noted, properties located in the flood zone are required to purchase flood insurance (if purchases are financed by a federally backed mortgage). Insurance policies come with financial coverage for repairs, and these improvements can mitigate price discounts for the damaged properties and those nearby. But location in the flood zone can also indicate pre-existing knowledge, such that the flood risk was already capitalized into the value of the home. In that case, a hurricane event would not introduce new information about risk to potential buyers of properties in the flood zone, meaning small or no new price discounts. We conduct several tests here to try to disentangle these two mechanisms.

First, we look at the distribution of insurance policies across census tracts inside and outside of the flood zone (see Table 9). We find that, consistent with expectations, the prevalence of flood insurance among properties sold in the designated flood zones is much higher. This suggests that those properties in the flood zone were privy to information about risk (e.g., through mandated insurance) before the storm took place.[18]

[18] We also access information on claims data to test if prior damage would inform prices leading up to Sandy (not shown here, but available upon request). Specifically, we can look at claims after the most recent storm preceding Sandy, Hurricane Irene. In aggregate, there are less than two dozen claims across the sample area (10 inside flood zone and 22 outside). This is in contrast to over 14,000 claims filed in the two months immediately following Sandy. These numbers are so small that it's unlikely that they are providing meaningful information about risk across the zones or blocks subject to different degrees of inundation (and damage) due to Sandy.

Still, the prevalence of insurance could also mean greater resources to fund physical repair in addition to pre-storm risk salience. We run two other tests to try to dissect these mechanisms. First, if differences in market responses are driven by differences in the degree of damage, then we would expect the coefficients on the high-surge indicators to be consistently larger than those on low-surge indicators. But this isn't what we observe. Differences are often small. Further, when we lower the high/low surge cutoff from 2 feet to 0.5 feet, we still observe significant impacts in the low surge area, and the magnitude is largely unchanged, and still very similar to that in the high surge area (see Appendix C). In other words, the impact on house prices of less than six inches of flooding appears to be just as large and sustained as the impact of more than 2 feet. This suggests that the price discount channel may be driven more by information about future risk, separate from any price effects from flood-induced physical disrepair.

Second, we explore changes in building alteration permits, which we can observe over time. We acknowledge that building permits likely undercount actual repair activity, as some share of alterations will not be formally filed with the City. Nonetheless, as an additional test, we run similar regressions with the number of alteration permits as the dependent variable (see Figure 9). We see a relative increase in permits in the year after Sandy on high-surge blocks, but then the filing activity rises for all surge blocks and then peaks in 2016, four years after the storm.[19] Repairs are concentrated inside the FEMA zone, suggesting that more repairs were made inside the flood zone, perhaps because of the

[19] This timing is consistent with when funding arrived through the Build-it-Back post-Sandy aid program.

availability of insurance.[20] This increase in alteration permits suggests that some portion of the greater price declines outside the flood zone may reflect persistent and unaddressed physical damage. However, we also note that the timing of the permit peak (around 2016) is inconsistent with our finding that prices of properties on surge blocks inside the FEMA zone appear to fully recover by 2014. In addition, even the small bump in permits outside the flood zone does not correspond with a price rebound.

We do, however, see a correspondence between the time trend of permits (Figure 9) and prices in high-income neighborhoods outside the flood zone (Figure 4). Therefore, the smaller and less sustained impacts we observe in high-income neighborhoods outside of the FEMA flood zones (relative to low-income neighborhoods) may be better explained by differences in the availability of resources for repair. However, greater investor optimism about the recovery of higher income areas may also play a part in the differential price rebound.

In sum, the evidence on mechanisms is mixed. On balance, our findings seem to suggest that new information about risk likely explains the bigger shifts in price and demand for housing outside the flood zone as compared to inside (where flood risk was salient and internalized before the storm). But the heterogeneity in impacts with respect to income outside the flood zone may be driven by differential resources for repairing storm damage.

[20] This is consistent with the higher absolute number of claims filed inside the FEMA flood zone as well. While, as a share of policies in place, the claims are no more prevalent than those filed outside the FEMA flood zone, their absolute numbers indicate more pervasive damage (which, if the claims are satisfactorily reimbursed, will ultimately get repaired).

5. Conclusions

In this paper we consider the impact of Hurricane Sandy on real estate prices in New York City. We find significant price effects: 1-3 family properties on blocks experiencing high surges saw price declines of about 16 percent in the first year after the storm. On average, the value of these properties remained about 12 percent lower than pre-storm levels six years after the storm. These citywide effects, however, obscure a great deal of heterogeneity at more localized scales.

These price declines were largely concentrated on blocks outside the federally designated flood zones. Indeed, we see nearly full recovery in the value of properties that are located inside FEMA zones. We also see that the price changes were uneven across neighborhoods with different economic resources. The findings indicate that properties in higher income neighborhoods that saw high storm surges experienced large initial price shocks but then recovered over time. By contrast, those in lower income areas experienced a delayed response and have exhibited no sign of recovery. Finally, the storm led to a change in the composition of homebuyers in hard-hit areas that were outside the flood zone, especially those that were low-income. After the storm, the income of homebuyers went down in those areas, and buyers were more likely to be Black or Hispanic. Therefore, a storm like Sandy can affect both the fiscal and demographic trajectory of neighborhoods.

Our results also shed light on whether changes in salience of risk or sustained property damage drive the price discounts. The persistent price declines on blocks outside of the designated flood zones contrast starkly with the relatively immediate recovery of prices inside the flood zone. While the greater impacts outside the flood zone could be due to less insurance to cover repairs, the fact that we see similarly sized impacts in high-surge and low-surge areas (even those seeing surge heights of less than 6 inches) suggests that new information about risk may be driving impacts. Further, the timing of building permits issued in the flood zone, one of our most direct measures of physical repair, is not consistent with the timing of the price recovery. That said, the more sustained impacts we observe in lower income neighborhoods outside of the flood zone, with fewer resources to rebuild, suggests that lingering physical damage may play a role in explaining persistent price drops too.

In sum, we find robust evidence that Hurricane Sandy led to substantial and sustained reductions in property values in flooded neighborhoods. But unlike past research, we uncover considerable heterogeneity in response. Properties on hard-hit blocks inside the flood zone and in higher income areas had largely recovered their value by 2014. Properties on blocks located in low-income neighborhoods outside the FEMA flood zone were hit particularly hard. Altogether, these results suggest that mandated flood insurance in designated high-risk areas not only plays an important role in funding physical rebuilding after the storm, but it also reflects knowledge about flooding risk in the market even before extreme events take place. Outside of the designated flood zones, where information about risk was less salient before the storm and insurance take-up less prevalent, prices fell significantly after the storm. However, neighborhoods with higher incomes were able to mediate the price decline, probably through self-financed repairs and a more optimistic outlook about the local market's resiliency. This variation at the sub-municipal level has important implications for the distribution of risk from extreme events, and in turn the policy and financial remedies to aid the recovery of the city overall.

6. References

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Table 1: Cross-tabulation of Flood Zone and Surge Heights

1-3 families			
Frequency	*HighSurge*	*LowSurge*	*NoSurge*
FloodZone=0	5,174	14,313	174,019
(%)	2.67	7.40	89.93
FloodZone=1	4,168	1,204	271
(%)	74.86	21.34	4.80

Table 2: Summary Statistics, Pre-Sandy Sales

		# units		**sqft**		**# stories**		**age**		**price**		**price/sqft**		**# sales**
	Surge category	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	
FloodZone=0	*HighSurge*	1.62	0.67	1981.62	859.33	1.94	0.59	62.62	25.73	$540,318	$246,569	$298	$135	2584
	LowSurge	1.56	0.61	2031.85	840.27	1.93	0.54	55.29	37.21	$550,295	$443,117	$287	$138	6585
	NoSurge	1.60	0.67	2011.06	907.37	2.13	0.53	69.29	34.54	$570,933	$669,244	$294	$175	96327
FloodZone=1	*HighSurge*	1.44	0.65	1798.71	892.71	2.08	2.50	50.75	36.72	$461,846	$354,527	$280	$144	2131
	LowSurge	1.45	0.57	1930.89	899.05	1.99	0.54	49.11	35.62	$498,129	$259,282	$279	$116	628
	NoSurge	1.43	0.59	2441.30	1047.49	2.08	0.48	36.20	33.66	$760,023	$512,967	$317	$161	191

Table 3: Price effects for 1-3 family properties

ln(sales prices)	(1) NYC	(2) NYC	(3) NYC	(4) Inside FloodZone	(5) Outside FloodZone
ln(# of units)	0.0318	0.0329	0.0334	-0.0795	0.0379
	(0.0315)	(0.0315)	(0.0315)	(0.161)	(0.0315)
ln(building area)	0.266***	0.266***	0.266***	0.337***	0.262***
	(0.0147)	(0.0144)	(0.0144)	(0.0519)	(0.0148)
# of stories	-0.00431	-0.00414	-0.00421	-0.00145	-0.00547
	(0.00401)	(0.00398)	(0.00396)	(0.00179)	(0.00529)
Building age	-0.00263***	-0.00262***	-0.00261***	-0.00224***	-0.00259***
	(0.000170)	(0.000167)	(0.000167)	(0.000689)	(0.000168)
Building age square	6.35e-06***	6.27e-06***	6.26e-06***	6.25e-06	6.20e-06***
	(1.60e-06)	(1.56e-06)	(1.56e-06)	(7.03e-06)	(1.56e-06)
Building age dummy	-23.85***	-23.51***	-23.46***	-23.08	-23.25***
	(6.393)	(6.263)	(6.263)	(28.43)	(6.264)
HighSurge		0.00915	-0.00884	-0.0593	0.00284
		(0.0200)	(0.0182)	(0.0483)	(0.0215)
*HighSurge*PostSandy*		-0.146***	-0.142***	-0.0906**	-0.142***
		(0.0212)	(0.0179)	(0.0411)	(0.0221)
LowSurge		0.0537***	0.0499***	-0.0241	0.0527***
		(0.0143)	(0.0140)	(0.0508)	(0.0146)
*LowSurge*PostSandy*		-0.113***	-0.112***	-0.0324	-0.116***
		(0.0151)	(0.0146)	(0.0519)	(0.0153)
FloodZone	-0.00926	-0.0437**			
	(0.0195)	(0.0209)			
*FloodZone*PostSandy*	-0.109***	0.00930			
	(0.0189)	(0.0215)			
Constant	11.28***	11.25***	11.25***	15.36***	11.24***
	(0.282)	(0.275)	(0.274)	(2.931)	(0.268)
Observations	199,149	199,149	199,149	5,643	193,506
R-squared	0.251	0.253	0.253	0.314	0.251
Number of tract	1,500	1,500	1,500	114	1,496

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

Table 4: Price effects for 1-3 family properties, Boundary Sample

	(1)	(2)
ln(sales prices)	**Inside FloodZone**	**Outside FloodZone**
ln(# of units)	-0.230	-0.0370
	(0.139)	(0.0694)
ln(building area)	0.253***	0.339***
	(0.0558)	(0.0248)
# of stories	-0.000856	-0.0236**
	(0.00108)	(0.0103)
Building age	-0.00317***	-0.00259***
	(0.000873)	(0.000398)
Building age square	7.89e-06	6.52e-06*
	(8.76e-06)	(3.33e-06)
Building age dummy	-23.85	-18.81
	(33.89)	(12.82)
HighSurge	-0.0146	0.0560**
	(0.0500)	(0.0276)
*HighSurge*PostSandy*	-0.0564	-0.177***
	(0.0403)	(0.0378)
LowSurge	-0.0280	0.0539***
	(0.0612)	(0.0179)
*LowSurge*PostSandy*	-0.00528	-0.0924***
	(0.0604)	(0.0183)
Constant	11.23***	10.84***
	(0.428)	(0.203)
Observations	3,320	23,456
R-squared	0.311	0.291
Number of tracts	99	459

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

Table 5: Heterogeneity in Price Effects by Neighborhood Income

	(1)	(2)	(3)	(4)
ln(sales prices)	**Low-income**	**High-income**	**Outside FEMA& Low-income**	**Outside FEMA& High-income**
ln(# of units)	-0.0123	0.0647	-0.00889	0.0734
	(0.0341)	(0.0463)	(0.0346)	(0.0462)
ln(building area)	0.248***	0.268***	0.245***	0.264***
	(0.0184)	(0.0198)	(0.0187)	(0.0202)
# of stories	0.0103**	-0.0111	0.0112**	-0.0202**
	(0.00504)	(0.00688)	(0.00523)	(0.00788)
Building age	-0.00332***	-0.00248***	-0.00331***	-0.00243***
	(0.000235)	(0.000202)	(0.000237)	(0.000204)
Building age square	1.27e-05***	3.56e-06*	1.26e-05***	3.56e-06*
	(1.92e-06)	(2.00e-06)	(1.95e-06)	(1.97e-06)
Building age dummy	-49.82***	-12.53	-49.25***	-12.54
	(7.810)	(7.968)	(7.935)	(7.856)
HighSurge	0.0330	-0.0376*	0.0358	-0.0386
	(0.0243)	(0.0224)	(0.0267)	(0.0273)
*HighSurge*PostSandy*	-0.174***	-0.104***	-0.177***	-0.0740***
	(0.0232)	(0.0215)	(0.0274)	(0.0210)
LowSurge	0.0488**	0.0448***	0.0473**	0.0473***
	(0.0223)	(0.0162)	(0.0230)	(0.0169)
*LowSurge*PostSandy*	-0.109***	-0.103***	-0.114***	-0.104***
	(0.0234)	(0.0165)	(0.0238)	(0.0173)
Constant	12.87***	11.37***	12.96***	11.34***
	(0.792)	(0.387)	(0.801)	(0.394)
Observations	71,744	114,611	70,345	110,367
R-squared	0.253	0.266	0.254	0.263
Number of tracts	619	668	615	668

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes. The income cutoff is $76,808, which is the median tract median income for the sample.

Table 6: Analysis of Mortgage Applicants' Income

ln(Applicant income)	**(1)** NYC	**(2)** Inside FEMA	**(3)** Outside FEMA	**(4)** Low-income Outside FEMA	**(5)** High-income Outside FEMA
*HighSurge*PostSandy*	-0.0188	0.0109	-0.0945***	-0.133***	-0.0520
	(0.0137)	(0.0339)	(0.0245)	(0.0264)	(0.0383)
*LowSurge*PostSandy*	-0.0352**	0.000937	-0.0681***	-0.0838***	-0.0424
	(0.0145)	(0.0381)	(0.0202)	(0.0262)	(0.0310)
Constant	4.132***	3.179	4.558**	1.254	5.930**
	(1.567)	(2.167)	(2.045)	(2.332)	(2.838)
Observations	345,379	70,052	275,327	161,006	114,321
R-squared	0.026	0.024	0.026	0.041	0.015
Number of tracts	1,756	242	1,514	1,149	365

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Controlling for Borough*Year and SBA dummies. The median tract median income cutoff is $76,808, which is consistent with price hedonic regressions.

Table 7: Analysis of Mortgage Applicants' Race

	(1)	(2)	(3)	(4)	(5)
Probability of being Black or Hispanic	**NYC**	**Inside FEMA**	**Outside FEMA**	**Low-income Outside FEMA**	**High-income Outside FEMA**
*HighSurge*PostSandy*	0.0268***	0.00456	0.0401***	0.0613***	0.0121
	(0.00654)	(0.0131)	(0.0133)	(0.0225)	(0.00764)
*LowSurge*PostSandy*	0.0421***	0.0190	0.0548***	0.0782***	0.0137
	(0.00671)	(0.0142)	(0.0101)	(0.0130)	(0.0127)
ln(income)	-0.0107***	-0.00707*	-0.0116***	-0.0187***	-0.00497**
	(0.00176)	(0.00398)	(0.00195)	(0.00344)	(0.00193)
Constant	-0.00195	0.167	-0.0670	-2.654	0.823
	(0.663)	(1.194)	(0.805)	(1.956)	(0.883)
Observations	279,276	56,292	222,984	133,245	89,739
R-squared	0.005	0.003	0.006	0.010	0.002
Number of tracts	1,754	241	1,513	1,148	365

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Controlling for Borough*Year and SBA dummies. The median tract median income cutoff is $76,808, which is consistent with price hedonic regressions.

Table 8: Controlling for 2013 Proposed Flood Zone Boundaries

ln(sales prices)	(1) NYC	(2) NYC	(3) NYC	(4) Inside FloodZone	(5) Outside FloodZone
ln(# of units)	0.0413	0.0422	0.0429	-0.0780	0.0482
	(0.0329)	(0.0328)	(0.0328)	(0.160)	(0.0329)
ln(building area)	0.264***	0.264***	0.264***	0.338***	0.260***
	(0.0152)	(0.0150)	(0.0150)	(0.0519)	(0.0154)
# of stories	-0.00667	-0.00651	-0.00660	-0.00141	-0.00928*
	(0.00448)	(0.00444)	(0.00443)	(0.00182)	(0.00555)
Building age	-0.00272***	-0.00271***	-0.00271***	-0.00222***	-0.00268***
	(0.000174)	(0.000172)	(0.000172)	(0.000693)	(0.000173)
Building age square	6.32e-06***	6.35e-06***	6.38e-06***	6.10e-06	6.27e-06***
	(1.65e-06)	(1.62e-06)	(1.62e-06)	(7.05e-06)	(1.62e-06)
Building age dummy	-23.74***	-23.86***	-23.98***	-22.51	-23.54***
	(6.613)	(6.514)	(6.513)	(28.53)	(6.509)
HighSurge		-0.00222	-0.0170	-0.0595	-0.0188
		(0.0209)	(0.0179)	(0.0484)	(0.0233)
*HighSurge*PostSandy*		-0.104***	-0.122***	-0.0907**	-0.0706***
		(0.0209)	(0.0167)	(0.0412)	(0.0236)
LowSurge		0.0446***	0.0419***	-0.0237	0.0410***
		(0.0143)	(0.0137)	(0.0508)	(0.0147)
*LowSurge*PostSandy*		-0.0887***	-0.0947***	-0.0329	-0.0859***
		(0.0149)	(0.0136)	(0.0520)	(0.0150)
FloodZone	-0.0365*	-0.0346			
	(0.0214)	(0.0215)			
*FloodZone*PostSandy*	-0.105***	-0.0178			
	(0.0189)	(0.0211)			
FloodZone_2013	0.0102	-0.00603			0.00299
	(0.0120)	(0.0125)			(0.0146)
*FloodZone_2013*PostSandy*	-0.105***	-0.0229			-0.0529***
	(0.0169)	(0.0181)			(0.0193)
Constant	11.31***	11.30***	11.30***	11.03***	11.34***
	(0.112)	(0.111)	(0.111)	(0.428)	(0.113)
Observations	186,355	186,355	186,355	5,643	180,712
R-squared	0.252	0.253	0.253	0.314	0.251
Number of tracts	1,287	1,287	1,287	114	1,283

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

Table 9: National Flood Insurance Program (NFIP), Policies and Coverage

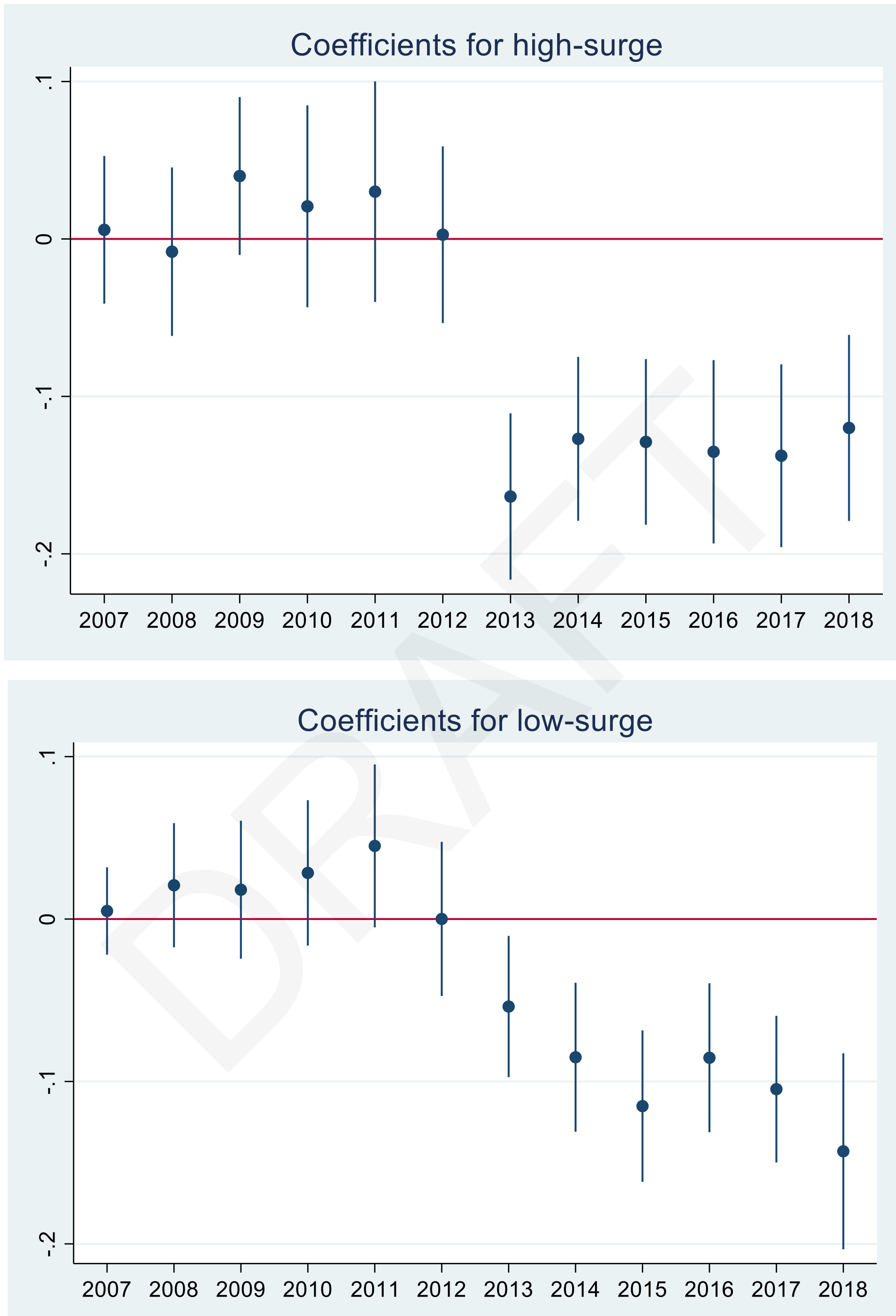
		Q1 2012		Q2 2012		Q3 2012		Q4 2012	
	# 1-4 family properties	**# Active policies**	**% covered**	**# Active policies**	**% covered**	**# Active policies**	**% covered**	**# Active policies**	**% covered**
FloodZone=0	521027	5016	1.0%	5269	1.0%	5720	1.1%	5827	1.1%
FloodZone=1	142144	21225	14.9%	21330	15.0%	21999	15.5%	23616	16.6%

Figure 1: New York City FEMA maps

Note: The left map is FEMA 100-year flood zone as of 2012. The right map shows properties damaged by Hurricane Sandy – black points are “major damaged” or “destroyed”, and grey points are “minor damaged” or “affected”.

Figure 2: 1-3 family properties sales prices across year

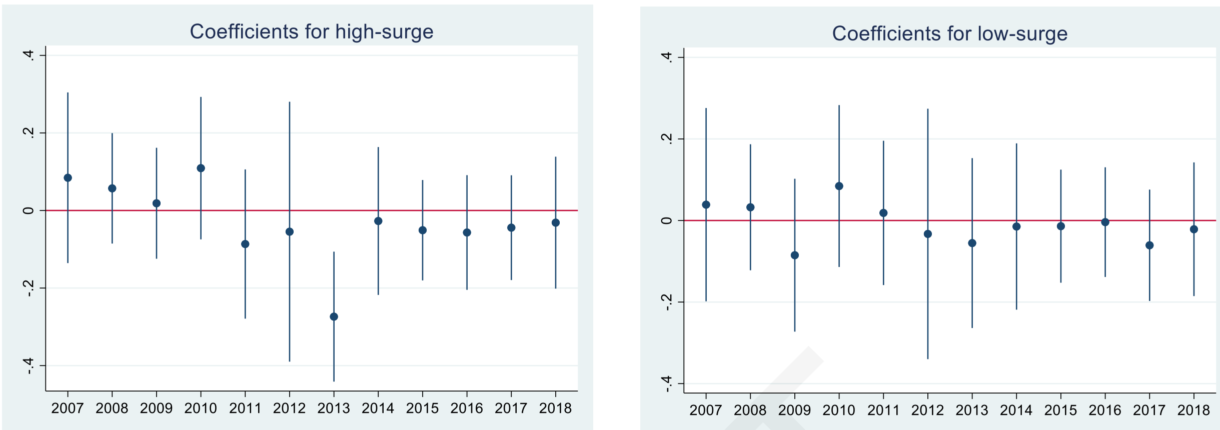
NYC



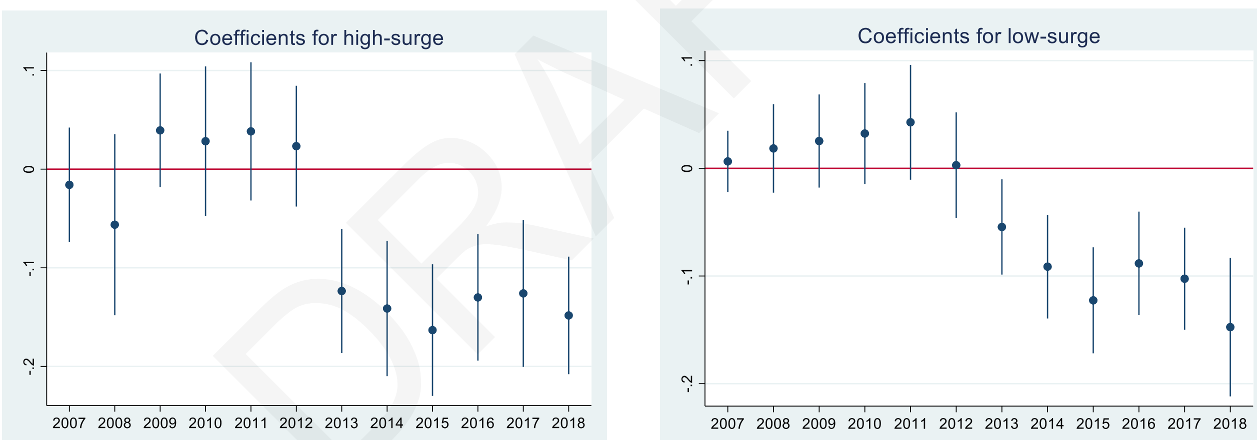
Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

Figure 3: 1-3 family properties inside/outside FEMA zone

Inside FEMA zone



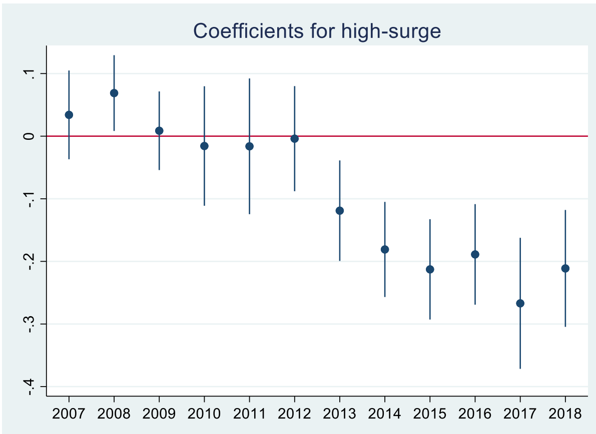
Outside FEMA zone

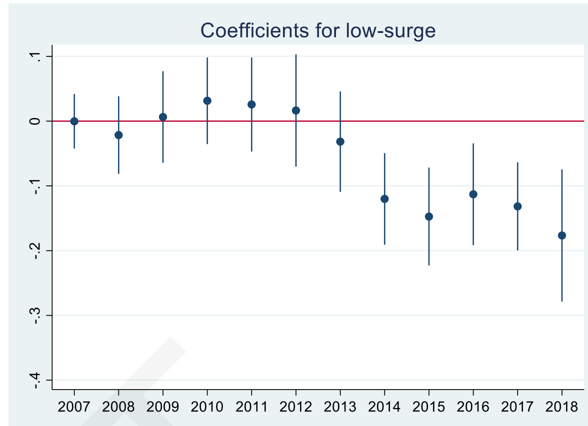


Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

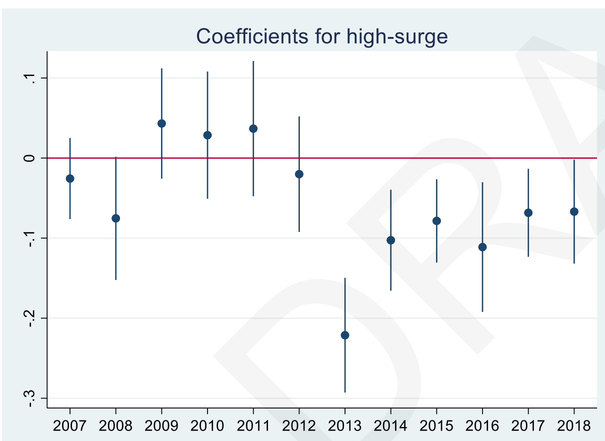
Figure 4: 1-3 family properties by neighborhood income level

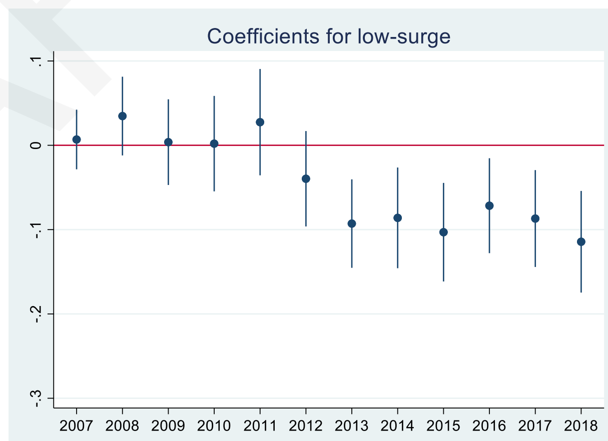
Low-income





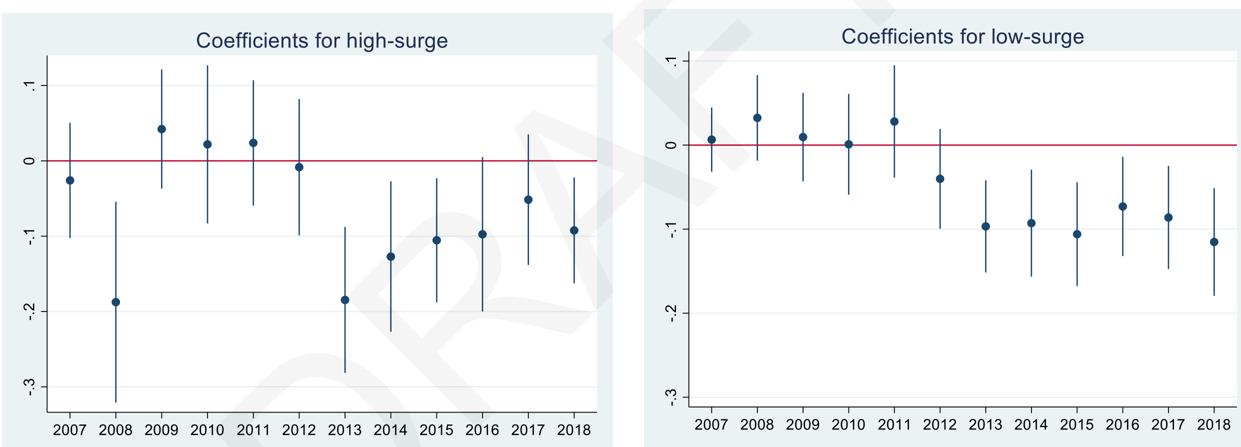
High-income





Outside FEMA zone & Low-income

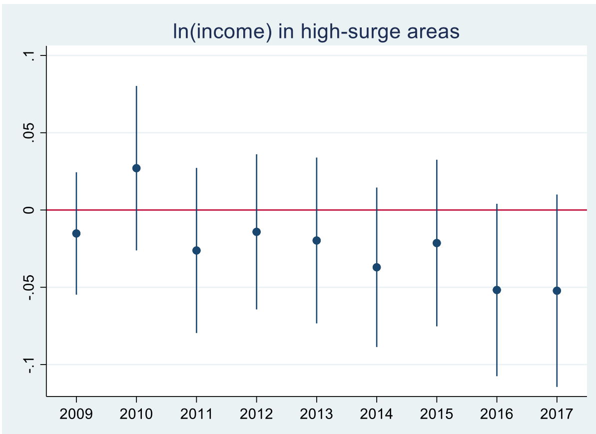
Outside FEMA zone & High-income

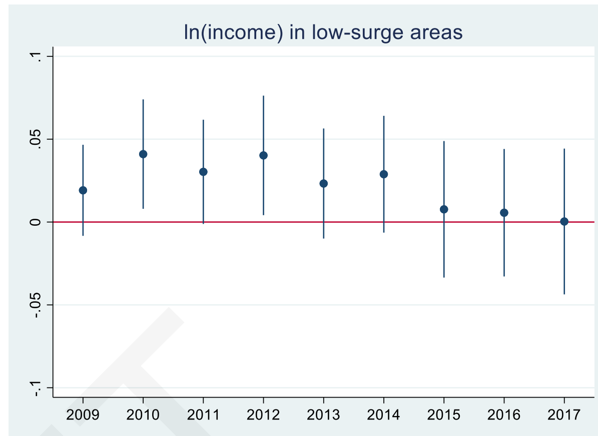


Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

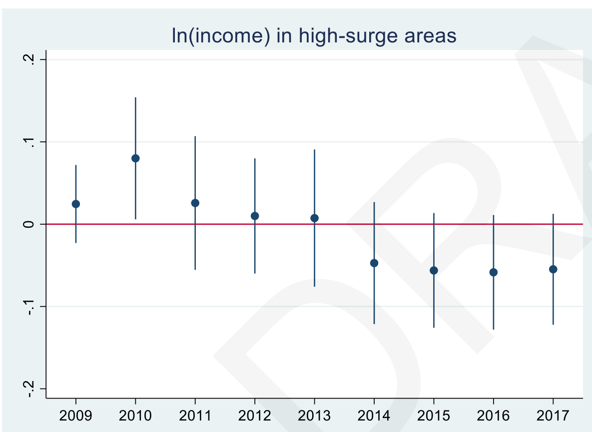
Figure 5: HMDA Applicant Income Analysis

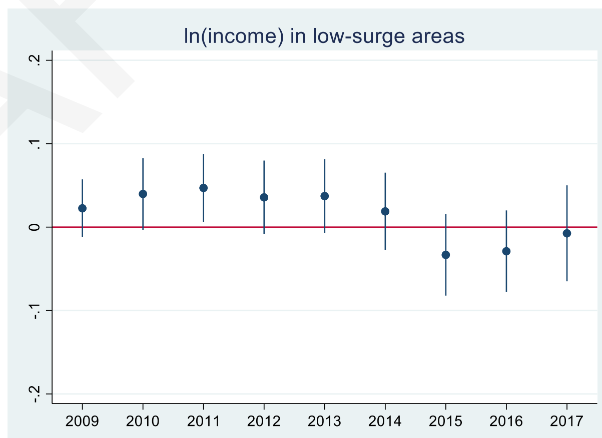
NYC



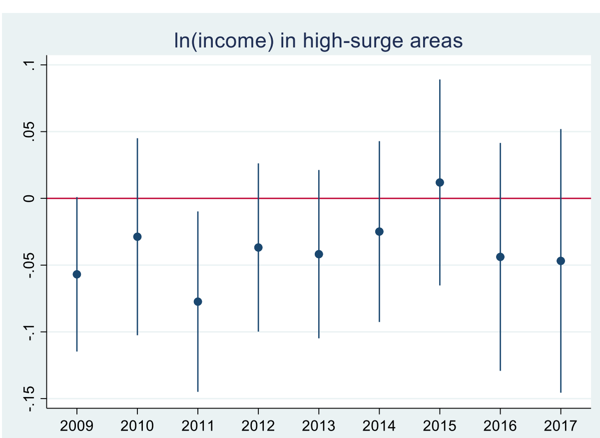


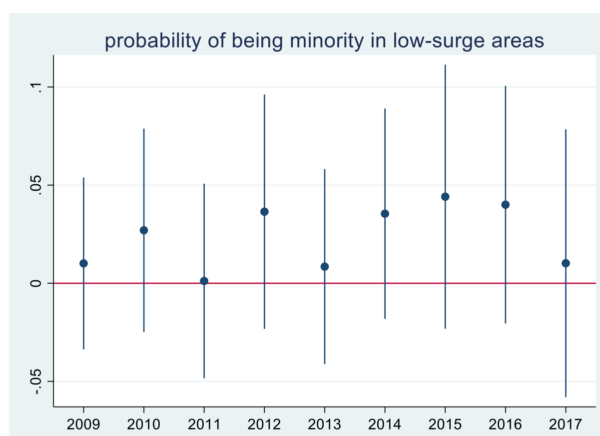
Low-income



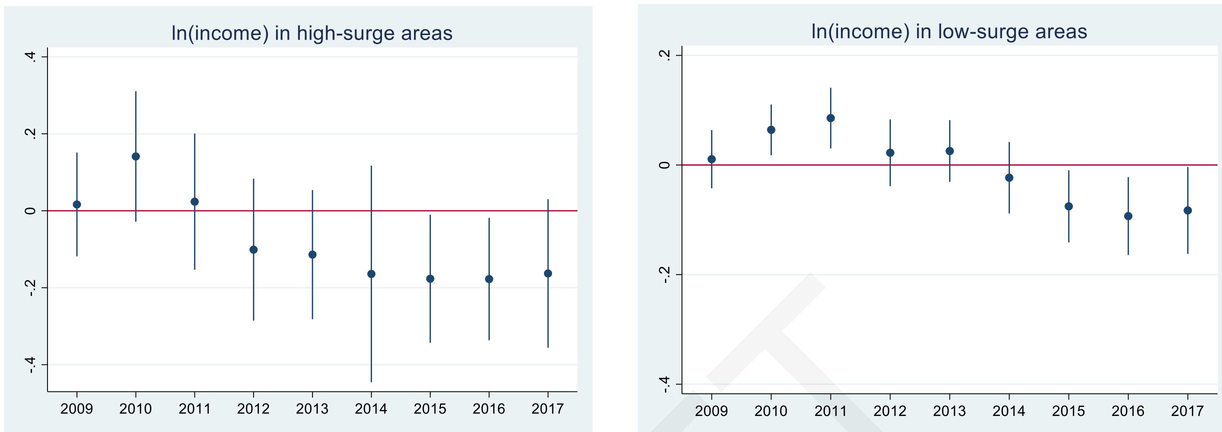


High-income

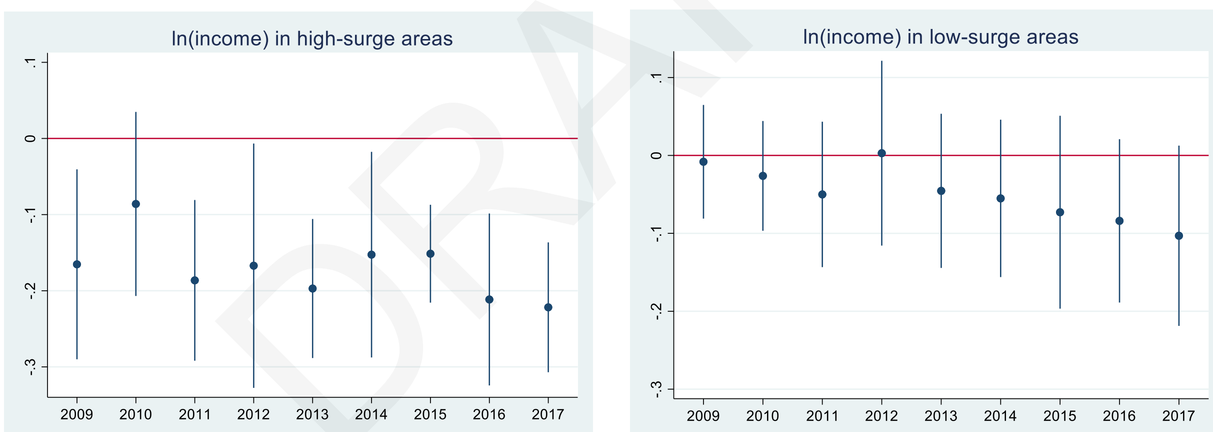




Low-income neighborhoods outside FEMA zone



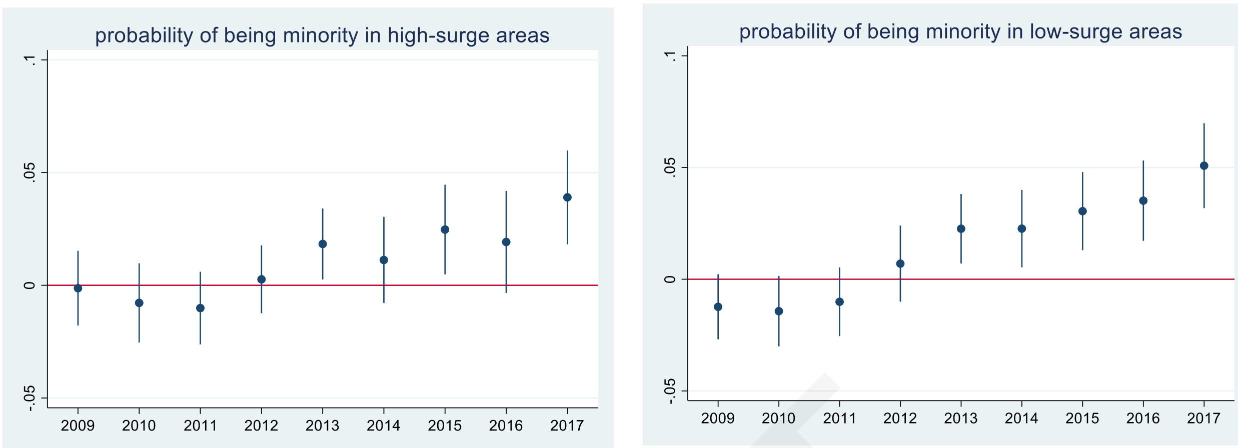
High-income neighborhoods outside FEMA zone



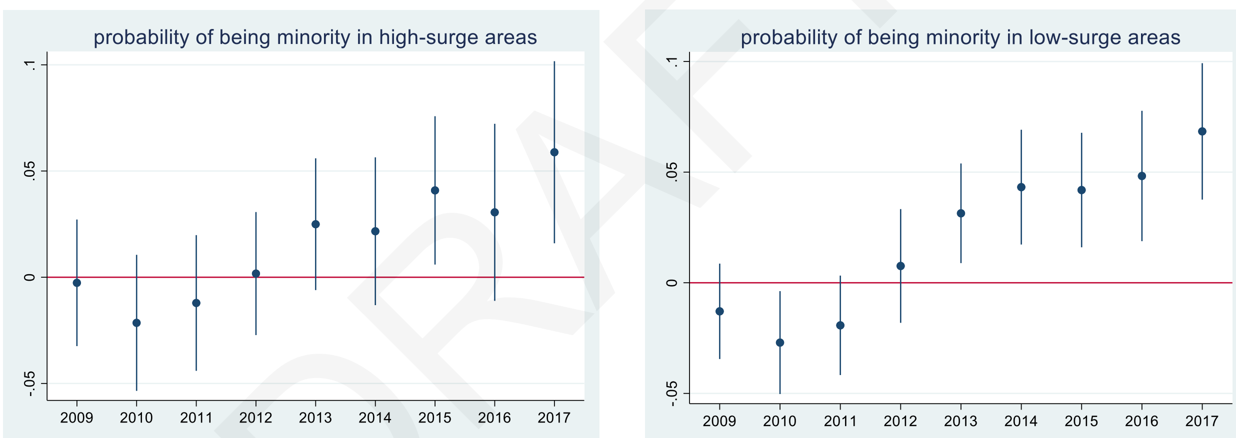
Note: Controlling for Borough*Year and SBA dummies.

Figure 6: HMDA Applicant Race Analysis

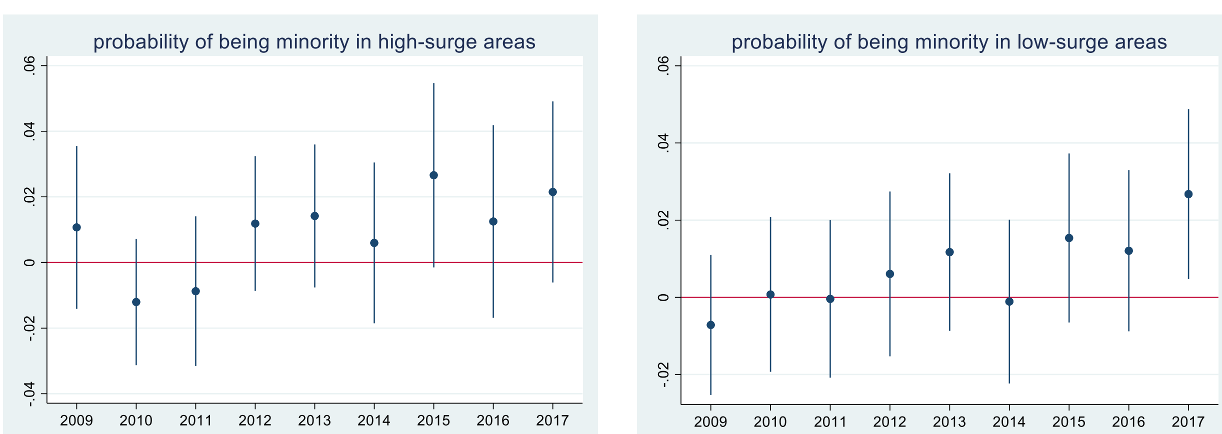
NYC



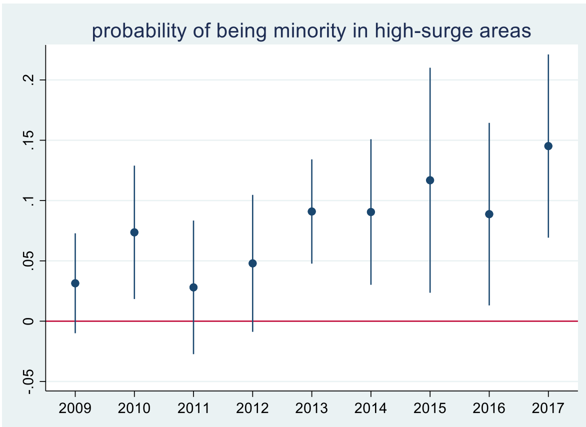
Low-income

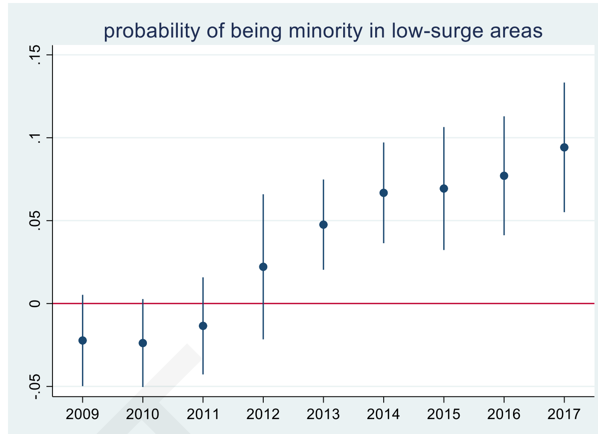


High-income

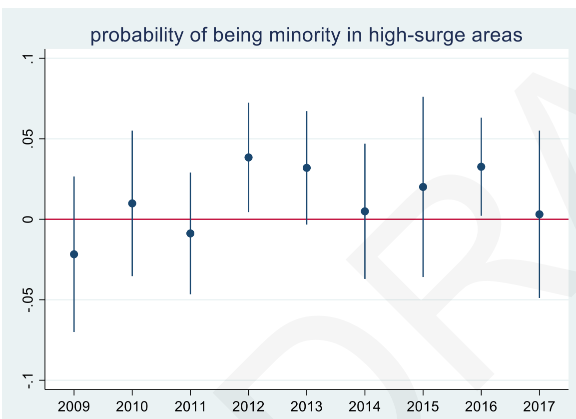


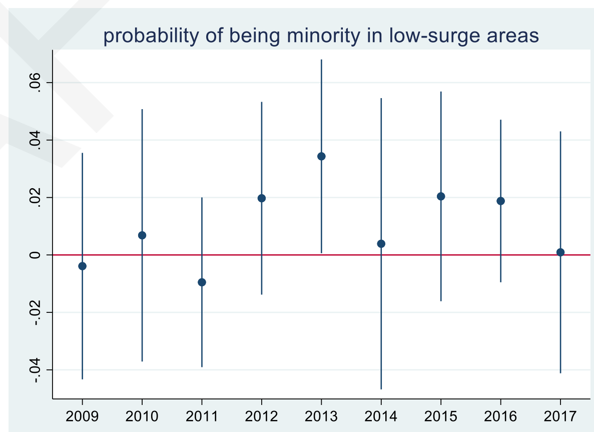
Low-income neighborhoods outside FEMA zone





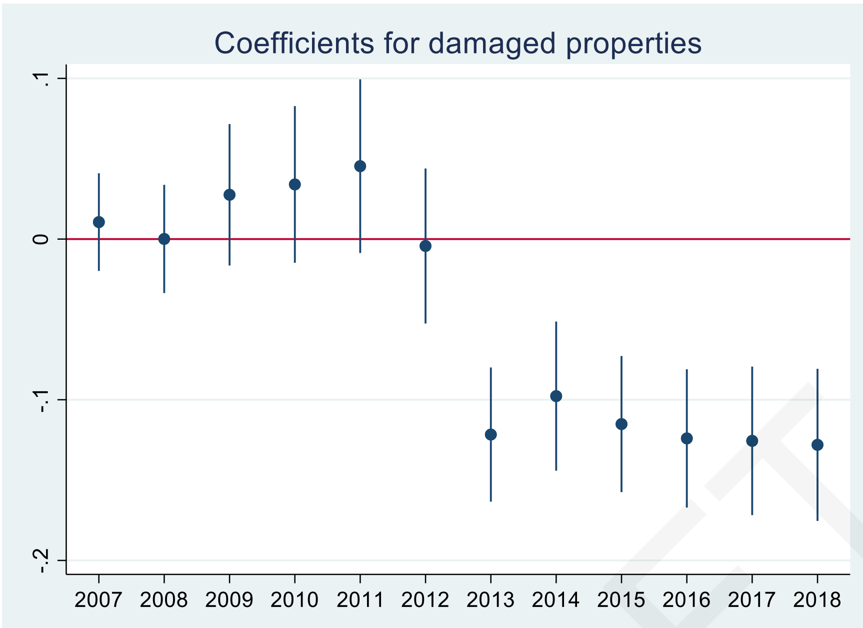
High-income neighborhoods outside FEMA zone





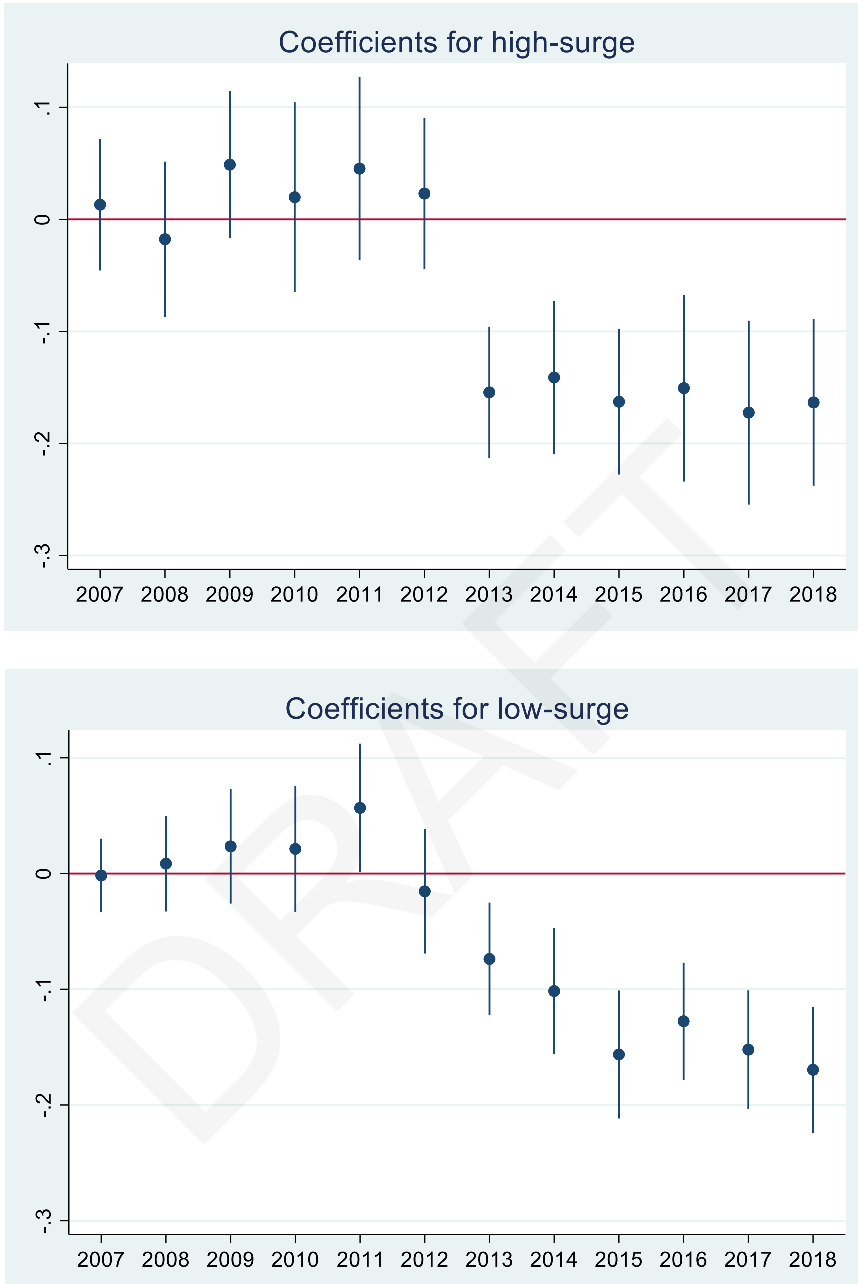
Note: Controlling for Borough*Year and SBA dummies.

Figure 7: Price Effects using Damage Points



Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

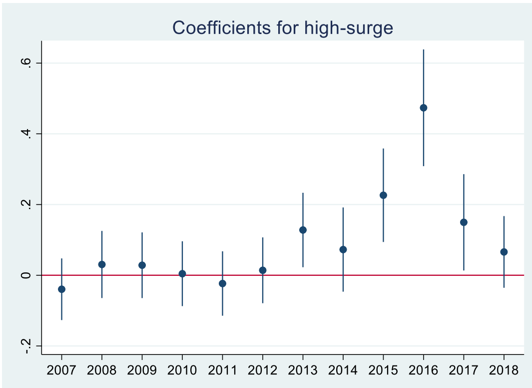
Figure 8: Price Effects excluding Staten Island

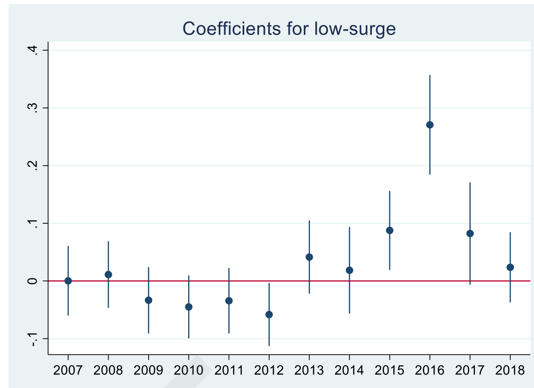


Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

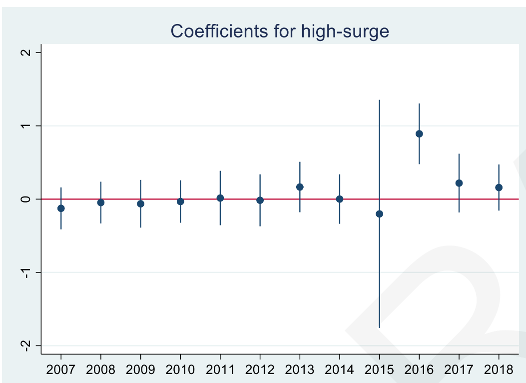
Figure 9: Annual Alteration Working Permits

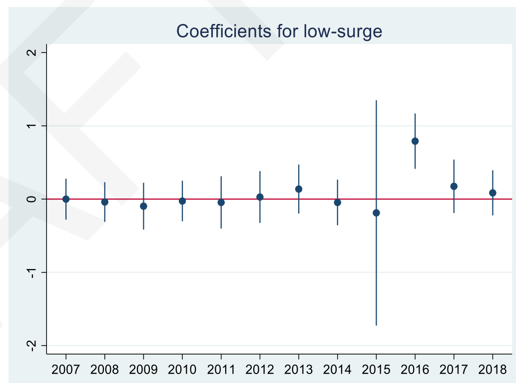
NYC



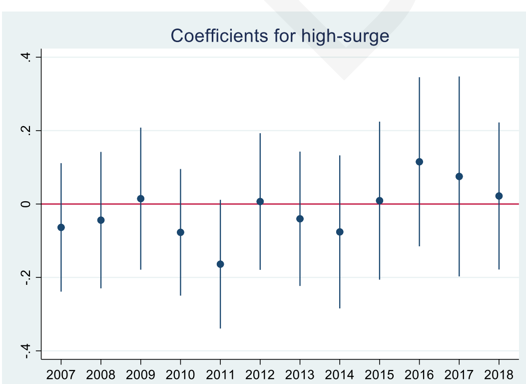


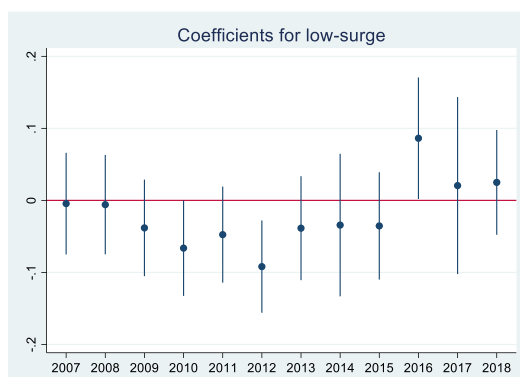
Inside FEMA zone



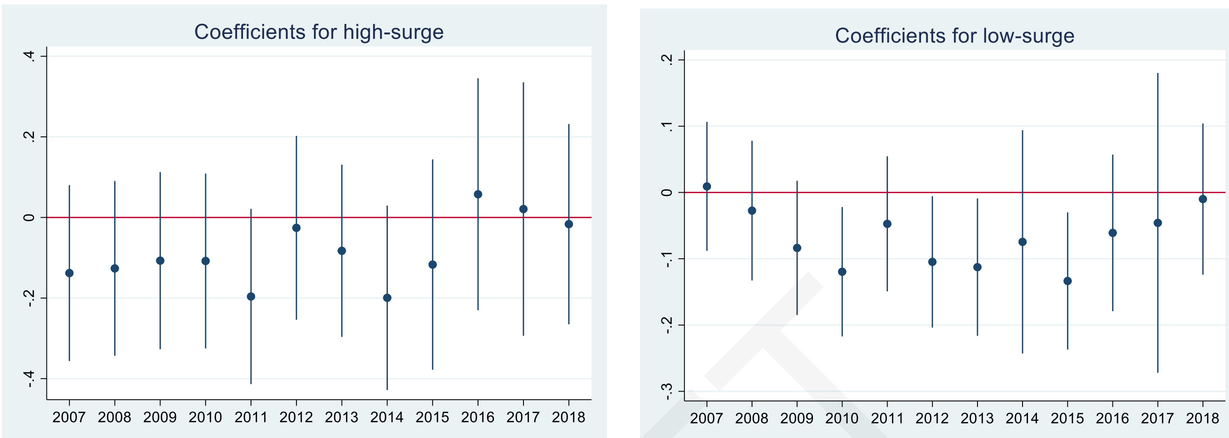


Outside FEMA zone

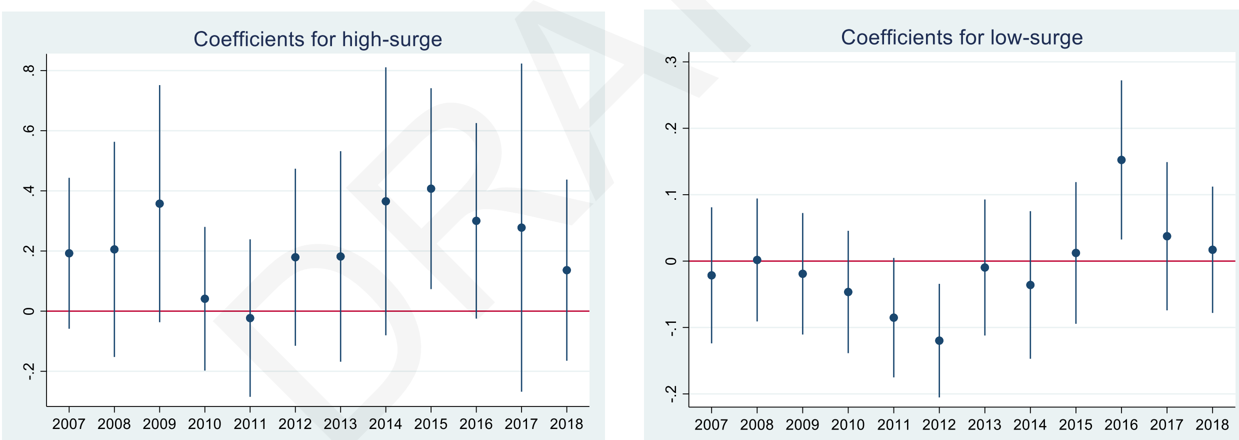




Low-income Neighborhoods outside FEMA



High-income Neighborhoods outside FEMA



Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.

Appendix A: Price Effects by Property Type

	Rental/Multifamily					**Condo & Coop**				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
ln(sales prices)	**NYC**	**NYC**	**NYC**	**Inside FloodZone**	**Outside FloodZone**	**NYC**	**NYC**	**NYC**	**Inside FloodZone**	**Outside FloodZone**
ln(# of units)	0.570***	0.570***	0.570***	0.888***	0.562***	0.00569	0.00514	0.00418	-0.0952	0.00480
	(0.0364)	(0.0366)	(0.0366)	(0.141)	(0.0378)	(0.0180)	(0.0181)	(0.0182)	(0.0846)	(0.0193)
ln(building area)	0.254***	0.254***	0.254***	0.0917	0.258***	0.0822***	0.0833***	0.0835***	0.869***	0.0817***
	(0.0347)	(0.0349)	(0.0349)	(0.129)	(0.0361)	(0.00897)	(0.00906)	(0.00889)	(0.0956)	(0.00915)
# of stories	0.0101	0.0100	0.0100	-0.0239	0.00955	0.0115***	0.0115***	0.0115***	0.0158***	0.0120***
	(0.00710)	(0.00713)	(0.00713)	(0.0558)	(0.00727)	(0.00143)	(0.00145)	(0.00147)	(0.00318)	(0.00142)
Building age	-0.000363	-0.000373	-0.000374	0.0104**	-0.000940	-0.00119***	-0.00118***	-0.00119***	-0.00142	-0.00105***
	(0.00159)	(0.00159)	(0.00158)	(0.00408)	(0.00162)	(0.000386)	(0.000390)	(0.000390)	(0.00100)	(0.000365)
Building age square	5.06e-06	4.99e-06	4.99e-06	-7.57e-05***	7.99e-06	9.68e-06***	9.70e-06***	9.76e-06***	-1.20e-06	9.90e-06***
	(8.48e-06)	(8.48e-06)	(8.46e-06)	(1.66e-05)	(8.68e-06)	(9.43e-07)	(9.36e-07)	(9.27e-07)	(1.24e-06)	(9.61e-07)
Building age dummy	-18.49	-18.21	-18.23	306.3***	-30.35	-39.02***	-39.12***	-39.37***	4.846	-39.89***
	(34.38)	(34.38)	(34.31)	(66.86)	(35.20)	(3.802)	(3.777)	(3.739)	(5.015)	(3.878)
HighSurge		0.0310	0.0173	-1.099	-0.0877		0.0372	0.0686	-0.0115	0.123
		(0.145)	(0.131)	(0.677)	(0.153)		(0.0861)	(0.0834)	(0.260)	(0.0952)
*HighSurge*PostSandy*		-0.187	-0.185	0.0628	-0.0943		0.145**	0.111*	0.0556	0.131*
		(0.170)	(0.129)	(0.244)	(0.199)		(0.0639)	(0.0598)	(0.108)	(0.0752)
LowSurge		-0.0886	-0.0918	-1.695**	-0.0876		0.0571	0.0769*	0.0539	0.0894**
		(0.0958)	(0.0973)	(0.691)	(0.0994)		(0.0396)	(0.0407)	(0.245)	(0.0401)
*LowSurge*PostSandy*		0.0192	0.0194	0.669***	-0.00152		0.000994	-0.0199	0.0937	-0.0169
		(0.0722)	(0.0687)	(0.231)	(0.0737)		(0.0302)	(0.0326)	(0.0997)	(0.0313)

FloodZone	0.00232	-0.0277				0.0855	0.0808			
	(0.132)	(0.145)				(0.0827)	(0.0868)			
*FloodZone*PostSandy*	-0.107	0.00545				-0.0480	-0.0901			
	(0.122)	(0.161)				(0.0649)	(0.0636)			
				-						
Constant	10.07***	10.06***	10.06***	15.61***	10.06***	12.32***	12.32***	12.32***	7.970***	12.34***
	(0.512)	(0.517)	(0.517)	(4.884)	(0.521)	(0.168)	(0.171)	(0.172)	(0.769)	(0.169)
Observations	23,350	23,350	23,350	365	22,985	182,058	182,058	182,058	7,694	174,364
R-squared	0.514	0.514	0.514	0.729	0.512	0.176	0.177	0.177	0.585	0.180
Number of tracts	1,324	1,324	1,324	67	1,312	881	881	881	69	872

Robust standard errors in parentheses

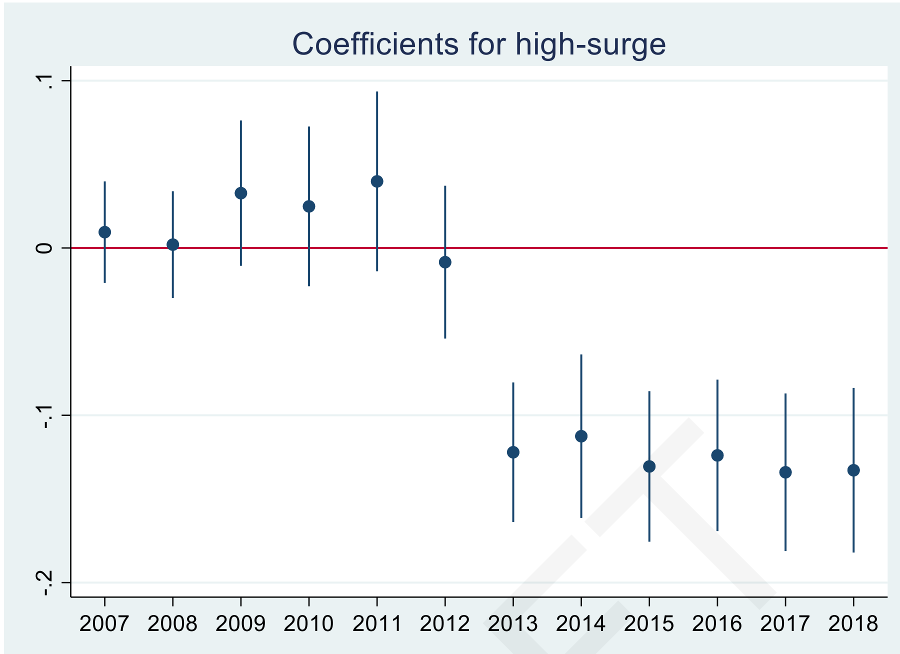
*** p<0.01, ** p<0.05, * p<0.1

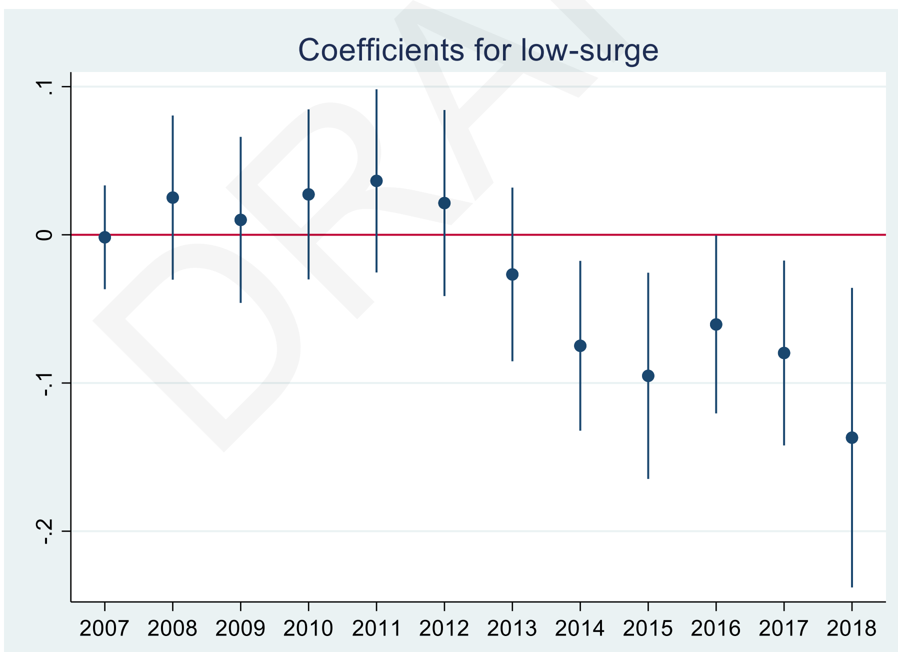
Note: Census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes are controlled.

Appendix B: FEMA-designated damaged properties, by Income Level

	Income category	**# Damaged Properties**
FloodZone=0	*Low Income=1*	125
	Low Income=0	114
FloodZone=1	*Low Income=1*	5
	Low Income=0	22

Appendix C: Change the High/low Surge Cutoff from 2 feet to 0.5 feet





Note: Controlling for census tract fixed effects, YearQtr dummies, Year*Boro dummies, building classes.